How Europe Applies the **Geographic Approach** for **Infrastructure Management**

Creating the Modern, Resilient,
and Sustainable Future of Infrastructure

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Making Infrastructure Smart and Sustainable—

Now and for the Next Generation

How a Geographic Approach Supports Modernisation, Climate Risk Mitigation, and Day-to-Day Operations

EXECUTIVE SUMMARY

The Big Idea

The ability to turn on a tap to get clean drinking water, flick a switch to have brilliant light, or work remotely in a connected environment has become a common way of life for many.

Behind these everyday transactions are millions of miles of roads, pipes, networks, and other assets. And in communities where the infrastructure that supports these essential services is inadequate, quality of life and economic viability suffer.

Despite consensus around the criticality of infrastructure, historical investments and practices have resulted in much of it falling into disrepair, nearing end of life, or no longer meeting modern requirements.

Consider the detailed bridge survey that France conducted that found 10 percent of bridges required immediate attention and another 21 percent required significant repairs. Add to this the jarring statistic that, in Europe, 25 percent of all water is lost to leaks, and an estimated 2,700 cubic metres of treated water are lost each year, according to EurEau.

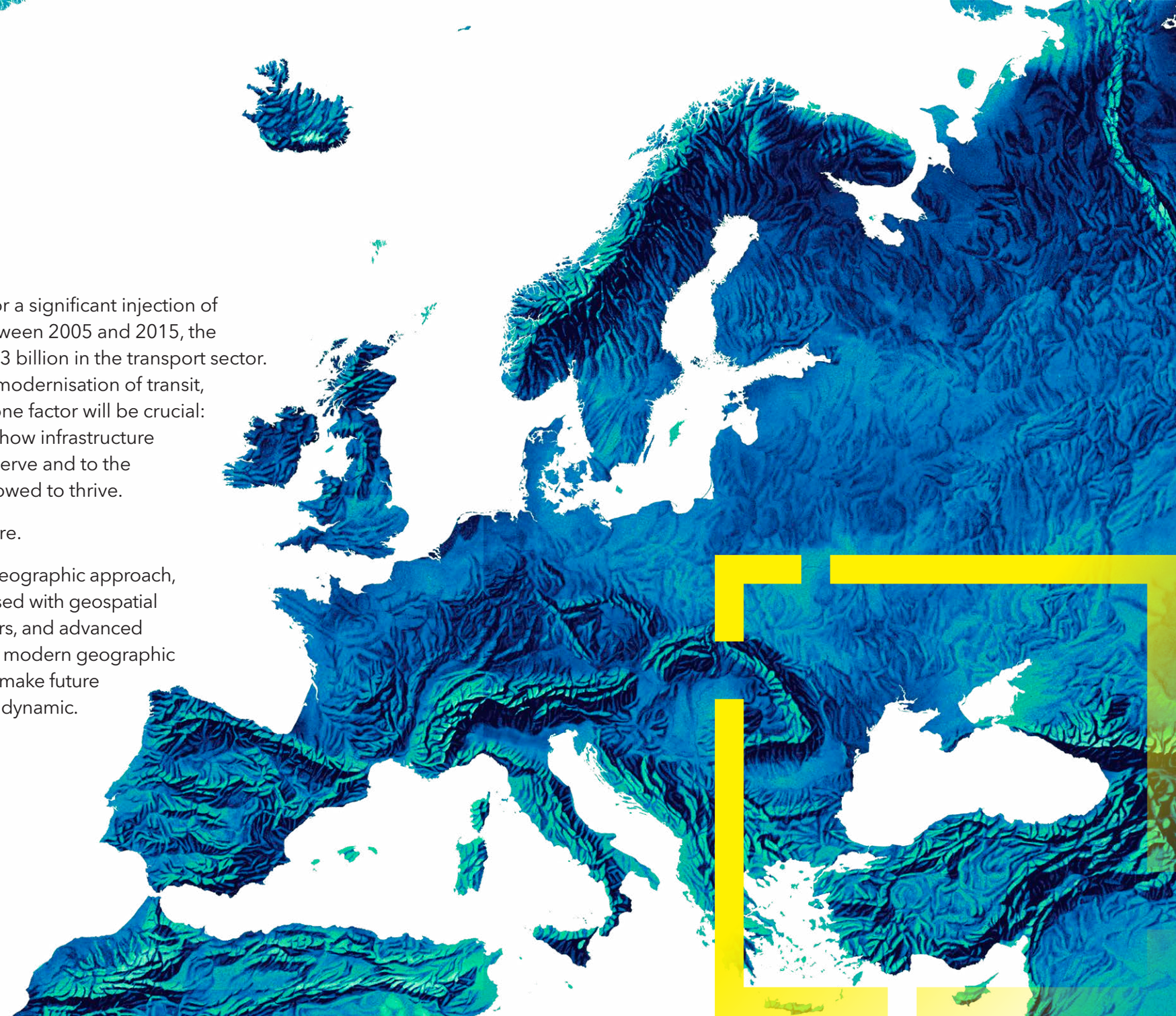
Not only is it aging and failing, but infrastructure is also being challenged and strained in new ways by climate change, security threats, and increasingly severe natural disasters.

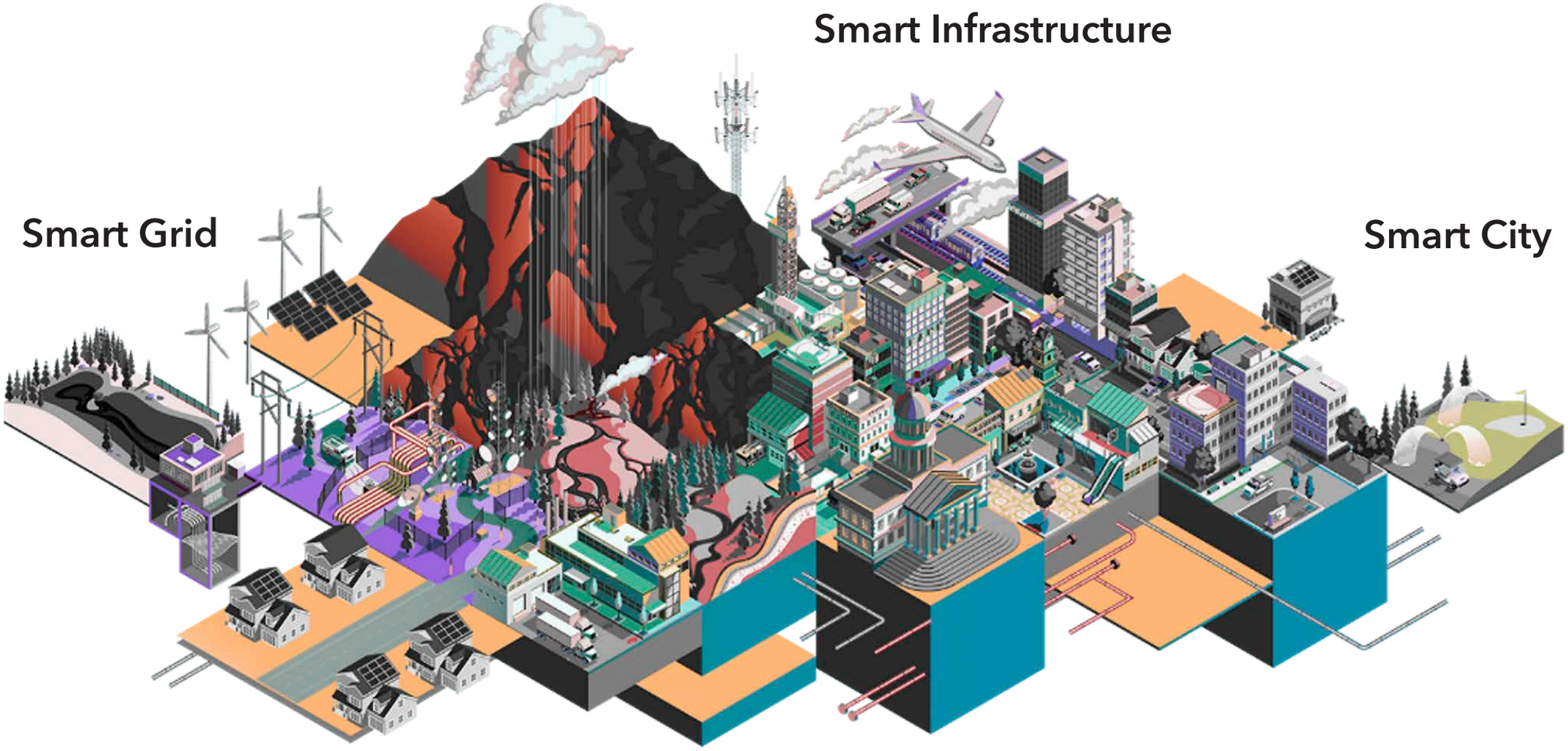
The result is a resounding call to action: We must make infrastructure assets and the services they support resilient, sustainable, and equitable.

Most countries have realised the need for a significant injection of funding to modernise infrastructure. Between 2005 and 2015, the European Investment Bank invested €153 billion in the transport sector. As the EU moves forward on continued modernisation of transit, connectivity, energy, power, and water, one factor will be crucial: geography. We will need to understand how infrastructure systems relate to the communities they serve and to the nearby ecosystems that must also be allowed to thrive.

We need to see what is happening where.

Decision-makers are already taking this geographic approach, and infrastructure systems are being infused with geospatial technology, including digital twins, sensors, and advanced analytics. A location context, delivered by modern geographic information system (GIS) technology, will make future infrastructure intelligent, datacentric, and dynamic.



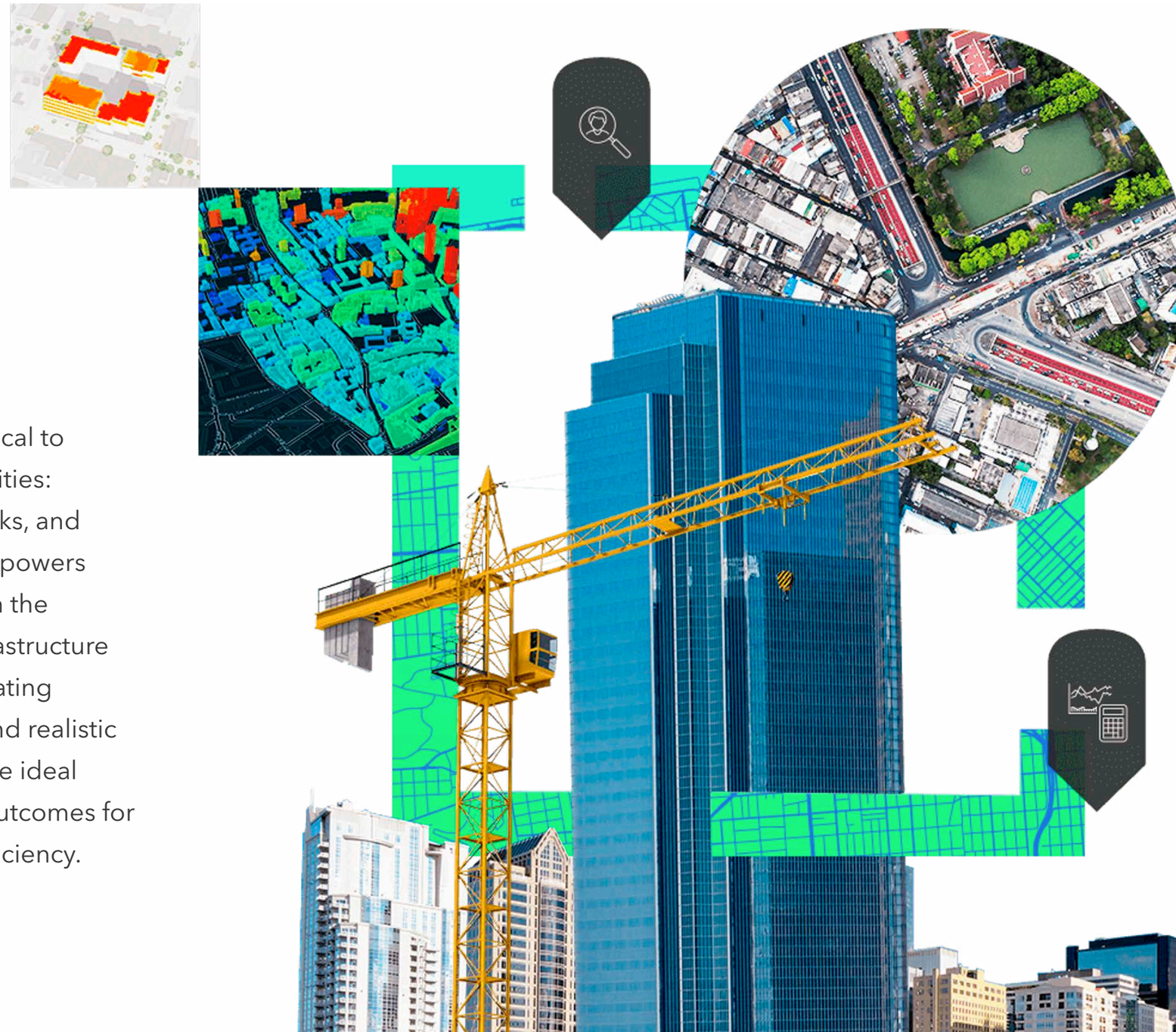


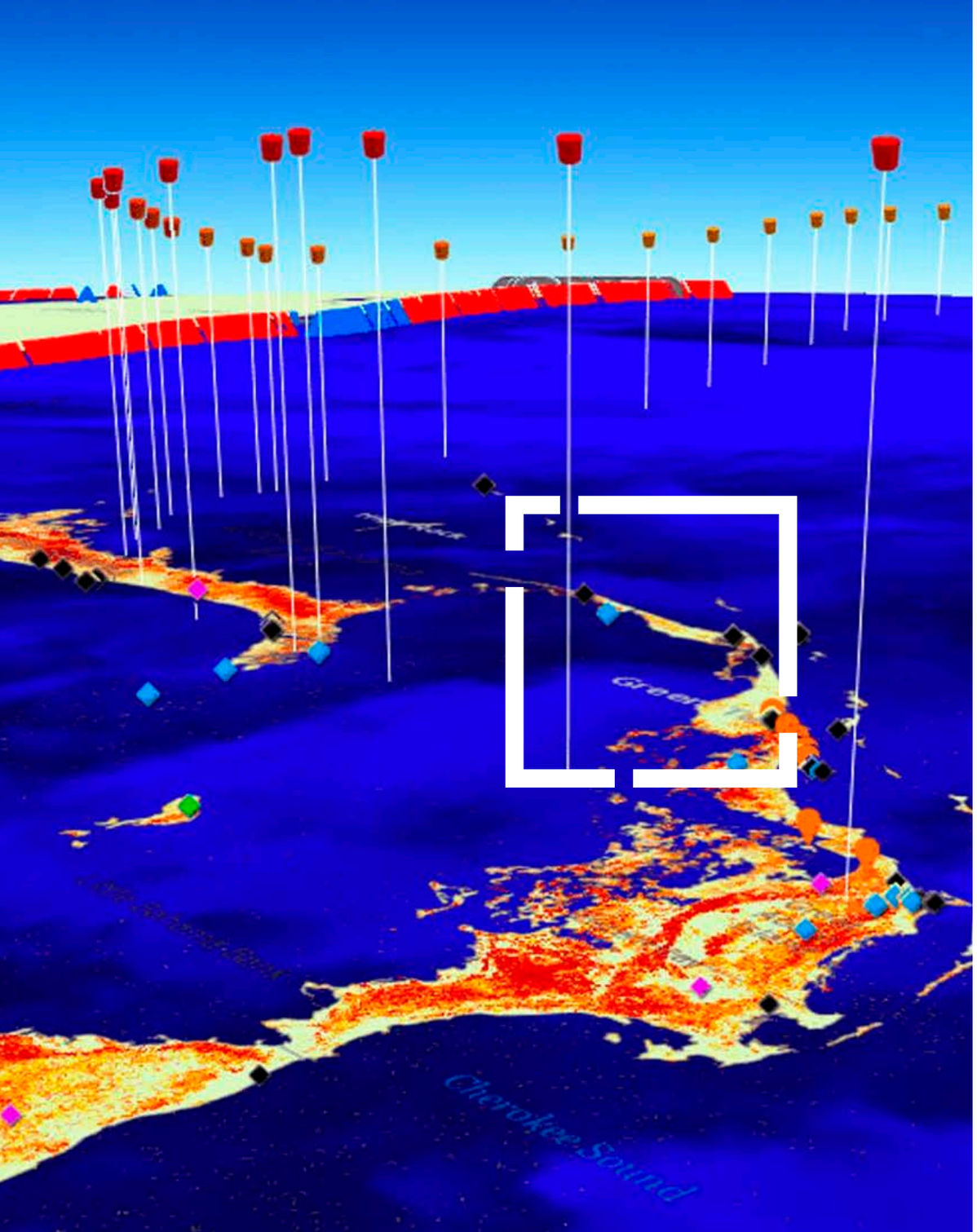
GIS technology has the power to layer volumes of data—including energy and transit networks, historical and predicted usage, imagery, sensor inputs, weather patterns, demographics, animal migration patterns, and native plant populations—onto a smart map or dashboard and update it in real time.

When we combine geography and data to look at vital parts of our everyday world, we can both manage and rebuild infrastructure for the greatest impact. This underscores the need to be smart about where we choose to invest in infrastructure assets.

The Geographic Approach

Here's the *why*—A geographic approach is critical to addressing the life cycle of infrastructure activities: managing assets, operations, projects, networks, and information technology. An enterprise GIS empowers visualisation and analysis of all relevant data in the specific context of location—key to setting infrastructure priorities, then planning, delivering, and operating safely and efficiently. By providing a holistic and realistic view, down to hyperlocal details, GIS is also the ideal technology for setting goals and measuring outcomes for sustainability, resilience, equity, safety, and efficiency.





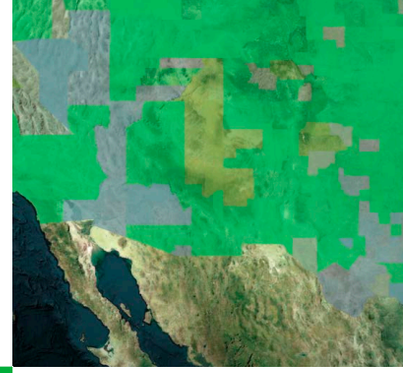
Here's the *how*—People simply understand data better when they see it on a map. For organisations, a modern GIS makes it possible to discern the precise location and details of every facet of infrastructure, both above or below the ground, inside or outside facilities. Employing GIS technologies to design, plan, visualise, and collaborate in real time with maps, dashboards, and apps can improve and optimise public and private infrastructure investments, avoiding inefficiency and waste:

- Plan, build, and manage infrastructure assets and projects through the entire life cycle using GIS and building information modelling (BIM) as a single integrated system. Enable workers to update information in real time via connected apps to boost data accuracy, eliminating paper-based workflows or multiple systems. Visualise future maintenance and additional infrastructure needs with a location-enabled digital twin. Uncover patterns and trends by utilising GIS dashboards populated with key data and built-in analytics, visualised on a smart map with results that can be easily shared.
- Prioritise repair work and predict issues before they happen with GIS tools for automated inspection and maintenance. Deploy image-capturing drones to inspect difficult-to-reach infrastructure and train artificial intelligence (AI) and machine learning to recognise issues in need of repair—all within one system. Automate workflows, including the ingestion and analysis of sensor and imagery data on a shared map, saving time during construction and ongoing operations.

- Deliver new infrastructure on time and on budget by conducting GIS-based modelling in the planning phase and geospatial analysis of imagery data to validate those plans during construction. Rely on precise locations of assets to prevent unnecessary digging or drilling to reach underground infrastructure. Visualise cost and time calculations on a shared map that allows stakeholders to track and predict the impact of changes so that they can adjust accordingly.
- Optimise logistics operations by facilitating efficient routes for fleets, workers, and materials to reduce carbon emissions. Real-time knowledge of worker whereabouts can also cut labour costs for inspections and repairs. Capture institutional knowledge about an asset or project by using GIS to collect, manage, and share data and store it securely in the cloud.
- Bounce back after disruptions and natural disasters with accurate modelling based on the locations of customers and infrastructure assets. Face climate-related challenges, including extreme weather, sea level rise, and population migrations, by using predictive location analytics to fortify vulnerable networks and plan expansion.
- Build essential infrastructure equitably by using location intelligence to decide where to expand transit or broadband, how to protect communities from fire or flood, and when to replace outdated water systems. Managers can use smart maps to identify gaps in service coverage and spatial analysis to prioritise upgrades based on need.
- Manage risks to people, property, and the environment by using a location-based system to collect data and meet regulatory requirements. Accurate maps and location analytics of performance and operations benefit infrastructure projects by speeding repairs during service interruptions, saving money as issues are addressed proactively, improving customer service, and keeping workers safe.

What Is Infrastructure Management?

In all aspects of modern living, the role that infrastructure plays is essential. Modern infrastructure comprises an interconnected ecosystem of assets, networks, and supply chains that provide essential services in your home, in your community, and around the world.



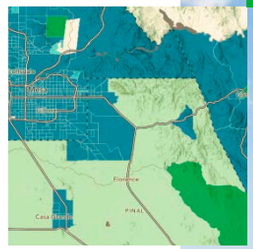
> *Infrastructure management is the systematic planning, design, delivery and operations of assets, facilities, networks, and IT that provide essential services across the areas of transportation, water, utilities, telecoms, and governments.*
>
> *GIS models, connects, and enables relationships of the built, social, and natural world . . . providing advanced visualisations and analytics across the entire infrastructure life cycle.*

In recent decades, the term infrastructure has primarily been associated with managing the complex IT hardware and software for organisations. Infrastructure management is the administration and management of essential operational elements to utilise technology, information, and data effectively and efficiently.

How infrastructure management is defined has evolved in recent years as a result of the investment and realisations by organisations on the criticality of the broader infrastructure industries. This is further emphasised as organisations rally to align and achieve their desired sustainable and economic goals.

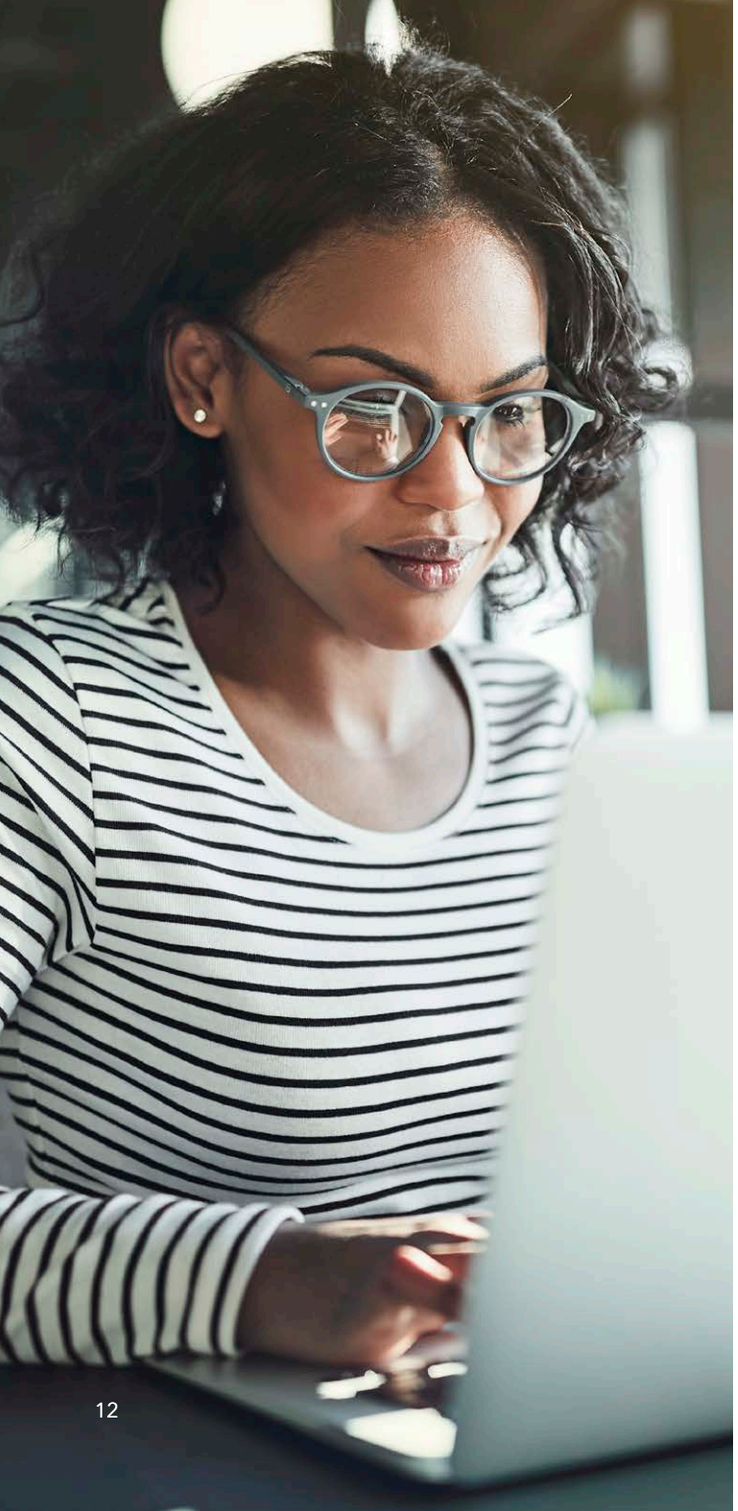
Infrastructure management is more than just IT—it is a life cycle of activities including the following:

- Asset management
- Operations management
- Project management
- Network management
- Information technology management



Modern infrastructure management requires holistic thinking on both micro and macro scales. Inasmuch as all infrastructure and the challenges being addressed are spatial, infrastructure management is giving rise to the application of a geographic approach enabled through GIS technology. GIS is the nervous system for modern infrastructure management connecting systems, workforces, organisations, and communities.

GIS is the connectivity that traverses all the phases of infrastructure management and connects enterprise systems and information to enable holistic decision-making. ArcGIS® software makes it easier to discern and understand the precise location and details of every facet of infrastructure, both above and below the ground, and inside or outside facilities. Employing GIS technologies to design, plan, visualise, and collaborate in real time with maps, dashboards, and apps can improve and optimise public and private infrastructure investments, avoiding inefficiency and waste.



SECTION 1 |

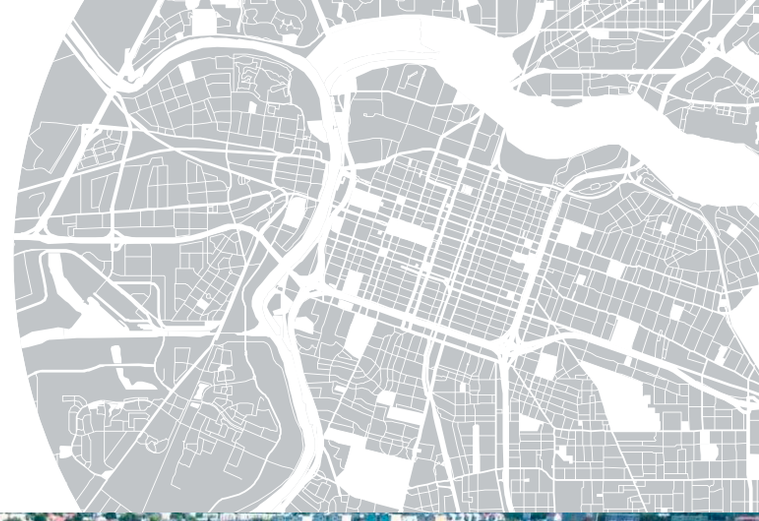
ASSET MANAGEMENT

Most infrastructure organisations use GIS for asset management in some capacity. Yet how they use the technology is evolving. Now required to modernise how they manage their assets, organisations are applying GIS to their best practice strategies with the ability to

- Perform real-world modelling, access rich analytics with artificial intelligence, and collaborate seamlessly through mobile apps and web browsers.
- Maintain and understand key asset information and distribute it to everyone who needs business intelligence.
- Unite different types of information, such as asset health data and real-time sensor feeds, to monitor system performance.
- Achieve a complete view of maintenance, capital, and operational priorities to improve key performance indicators (KPI) and business results.

CASE STUDY

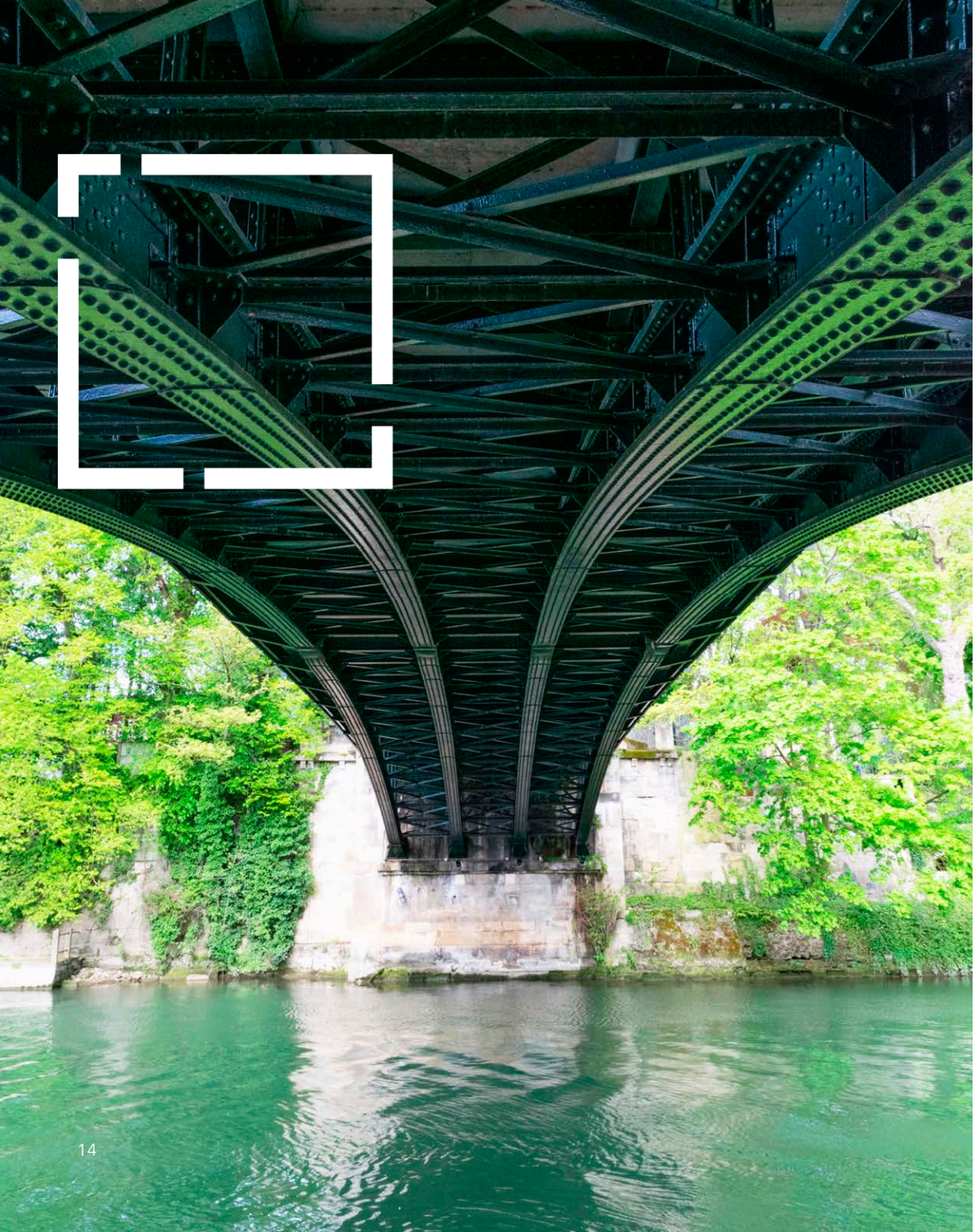
France: Inspecting and Mapping 45,000 Bridges to Prioritise Repairs



After several studies warned of the risks associated with a lack of monitoring and maintenance of local bridges, the French government launched its National Bridges Program. Leading the effort is the Centre for Studies and Expertise on Risks, the Environment, Mobility, and Urban Planning (Cerema). The agency's first step was to identify most of the country's municipal bridges and determine their condition, collecting data and mapping results with GIS.

The assessment task met with three major obstacles. First, the country has more than 36,000 road authorities, including many smaller municipalities, towns, and villages with limited financial and technical resources. Second, the sheer number of bridges that needed evaluation was staggering, with estimates of as many as 100,000. Third, the French government didn't have an inspection program in place to determine the condition of local bridges. Cerema staff also had to factor in the age of each bridge as well as inconsistencies in ongoing maintenance.

To tackle the scope of the bridge census and assessment, Cerema staff coordinated 250 agents from 30 different contractors over a two-year period that wrapped up in 2023. Cerema also needed to establish ongoing communication with many local authorities from the 11,500 participating municipalities.



To execute the complex bridge assessment survey, Cerema gave crews access to ArcGIS Survey123, a mobile GIS app for phones or tablets. The survey included about 150 questions for each type of structure. In total, the team of 250 field agents surveyed 45,000 of France's bridges and retaining walls. Office staff created interactive dashboards using ArcGIS Dashboards to display inspection progress and results. Operators in the field were able to quickly adapt to the digital tools.

At the end of the census, Cerema had provided a comprehensive picture of the current conditions of thousands of bridges and retaining walls across France. The assessment showed that 10 percent of the structures surveyed required immediate attention to ensure public safety, and 21 percent need significant repairs. Enabled by these data-driven results, renovations have already begun. Cerema has also created guides and videos to help local authorities maintain bridges into the future.

SECTION 2 |

OPERATIONS MANAGEMENT

To justify huge workforce investments, infrastructure companies and agencies must capture as much value as possible. GIS helps managers and crews deliver return on investment (ROI), strengthening operations by providing a clear picture of assets and work in progress, plus the real-time status of conditions and activities for benefits such as the following:

- Insight into past and present work to support effective scheduling and prioritisation
- Seamless communication, collaboration, and coordination for all participants, both inside and outside the organisation
- Improved situational awareness and a common operating picture that can be updated, viewed, and shared as a dashboard, KPI, or map visualisation
- Models of infrastructure information with customer data, Internet of Things (IoT) sensor feeds, and imagery

CASE STUDY

Switzerland: Zurich Airport Embraces Digital Twins

Zurich Airport, Switzerland's busiest international airport, is among the 20 busiest airports in Europe. Every year, nearly 23 million people pass through on more than 700 flights daily. It also serves as an important link for overland freight transit.

A few years ago, the airport authority overhauled the paper-based workflow it used to repair and maintain runways, taxiways, and service routes. The authority adopted a GIS-based application that allows maintenance workers can access on iPad devices.

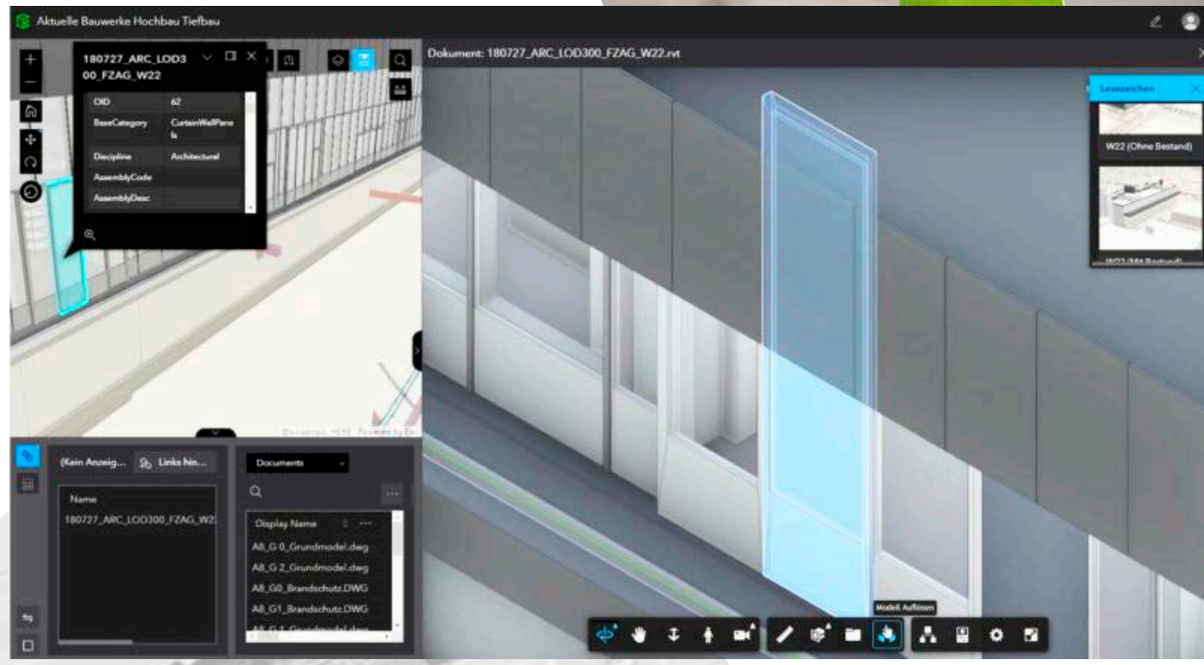
Maintenance crews could now record pavement damages as points on a map, and even include relevant photos with their reports. The field data could automatically synchronise with the rest of the airport's asset infrastructure data.

More recently, the airport embraced the next step in GIS evolution by constructing a digital twin of the airport. Using a holistic model of the airport, the twin links important data related to construction and operations within the airport.

The previous system was, in a sense, already a digital twin in that it presented up-to-date data and information that corresponded to the airport's physical system. This twin, however, could not readily be perceived for what it was.

The new model explicitly models the physical reality of the airport. It provides maximum context by displaying, in a visually intuitive manner, the spatial relations that, together, comprise the airport. Three-dimensional models of the buildings and facilities, when combined with ArcGIS, can be integrated into a map to provide a comprehensive visualisation of the entire airport.

The core concept behind the airport's original digital transformation has not been lost, however. The comprehensive visualisation helps optimise maintenance and repairs. This work can be planned more effectively, because the twin monitors the condition of the equipment and buildings in real time. The integration of ArcGIS makes it possible to link data on the location and condition of assets and buildings with other data-based information, such as the weather, to perform preventative maintenance.Energy costs have also been reduced. By allowing airport managers to visualise real-time data on energy consumption, they are able to optimise the way the facility uses energy. When used in conjunction with ArcGIS, information on solar radiation and ambient temperature can be used to further improve energy efficiency.



SECTION 3 |

NETWORK MANAGEMENT

Modern network management requires holistic analysis—understanding the needs and behaviours of the network today while planning for tomorrow, and maintaining balance between the natural and built worlds. Because failure of a single asset can amplify impacts to the entire network—as well as to communities, the environment, and the business's bottom line—many organisations employ GIS to

- Model, manage, and provide an inclusive view of the complex infrastructure networks required to transfer resources for electric, gas, water, and telecommunications.
- Manage connectivity and relationships among customers, communities, and local ecosystems.
- Gain a comprehensive framework of functionality for the modelling and design of all the components that make up an infrastructure network.

CASE STUDY

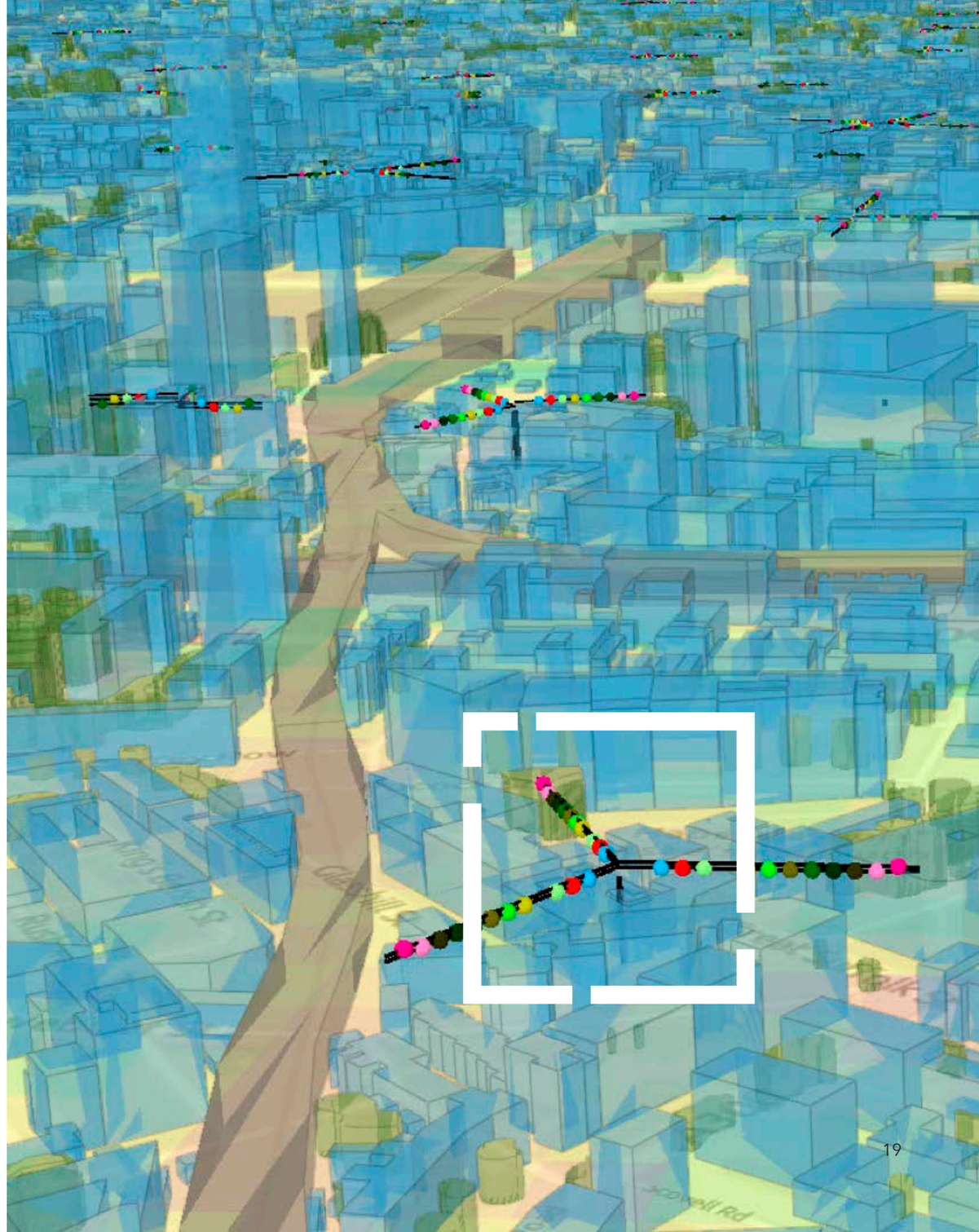
United Kingdom: Vodafone Creates Country-Scale Digital Twins to Engineer Better Networks

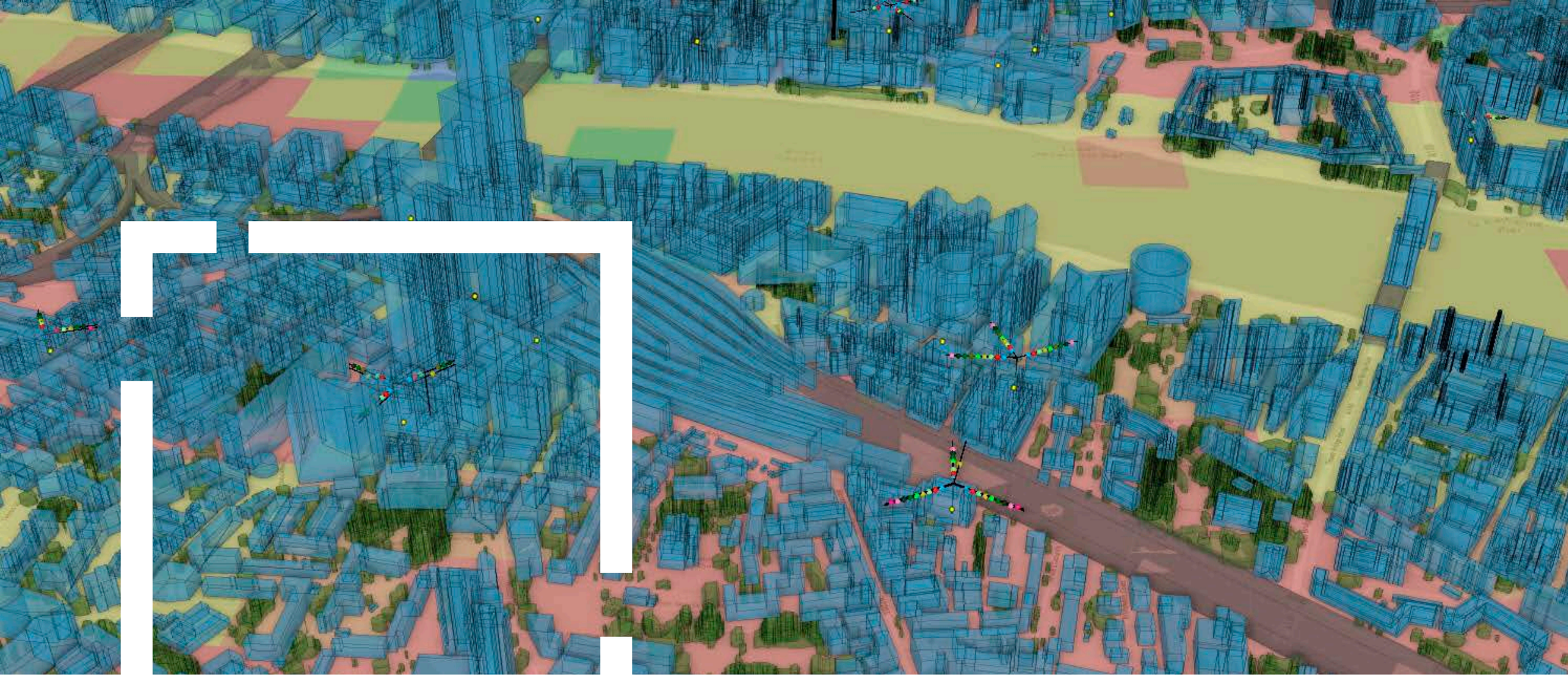
All mobile network operators offer a coverage map that allows anyone to see where signals reach; the quality of coverage (2G, 3G, 4G, 5G); and signal strength, both indoors and out. At Vodafone, a high-resolution digital twin provides a far more granular understanding of the network than was possible previously.

Wireless telecommunications companies create and sell invisible signals. Engineers who build the network have the practice and tools to intuit what they're building. But for other people, the company's signals remain abstract.

With the move to 5G, signals travel shorter distances and aren't as strong. Trees and buildings get in the way—resulting in what is called "clutter" in the industry—and more base stations are required. To combat clutter, Vodafone needed a way to see in 3D and model tree growth, with details about seasonal changes that impact signal.

Vodafone created a digital twin for Britain—representing 245,000 square kilometers—using GIS. The digital twin captures topography, cell towers, and the equipment on each tower. It contains immersive 3D detail, giving anyone at the carrier the ability to see the company's infrastructure, signal strength, and customers. It integrates and correlates network assets, signals, and user knowledge.





The digital twin enables engineers to measure infrastructure remotely, which saves time and money because they don't need to go to the field every time to take a measurement. It can also be used to direct them to the cell tower in the middle of a field or in a dense urban environment, where finding the path or access road can be tricky.

The amount of place-, equipment-, and signal-related data that the digital twin integrates is staggering, but perpetually incomplete as the world changes. Vodafone has learned that the more people with access to the digital twin within the company, the better, because they can correct inaccuracies and fill in missing information.

SECTION 4 |

PROJECT MANAGEMENT

The drive to deliver on the forecasted goals of sustainability, modernisation, and resilience has resulted in many consecutive projects being initiated in overlapping areas across different industries. GIS supports the management of these projects and their interdependencies with a new level of understanding and collaboration:

- Communication within and among agencies—such as telecom, gas, water, and electric—to prevent unnecessary construction, digging, and service interruptions
- A shared map, dashboard, or digital twin as an authoritative and iterative source of truth
- Tools to ease collaboration among stakeholders, both internal and external, including crews, contractors, managers, and leadership

CASE STUDY

3D GIS Supports Decision-Making for Smart Urban Planning and Design

Gensler, the largest architecture, design, and planning firm in the world, designs unique, large-scale, mixed-use urban communities that are inviting places for people to live, work, and play.

The long-standing approach for architecture firms to present their design visualisations to clients has been through slide presentations or printed drawings. Unfortunately, these methods provide only static illustrations. Gensler was interested in new ways to digitally transform this workflow with tools that could provide a more engaging and immersive experience for clients.

“Urban planning and design is a complex process that involves considerable effort in data collection, analysis, and visualisation, which is used to support decision-making,” said Le An, senior urban planner and designer at Gensler’s Washington, DC, office.

Many people in the industry already think of GIS as a technology that helps planners and designers understand such things as the topography, hydrology, demographics, and government regulations of an area—which inform project design. So Gensler’s city and urban design team wanted to explore the possibilities of using GIS technology to create plans, visualise scenarios, and support collaboration and decision-making.

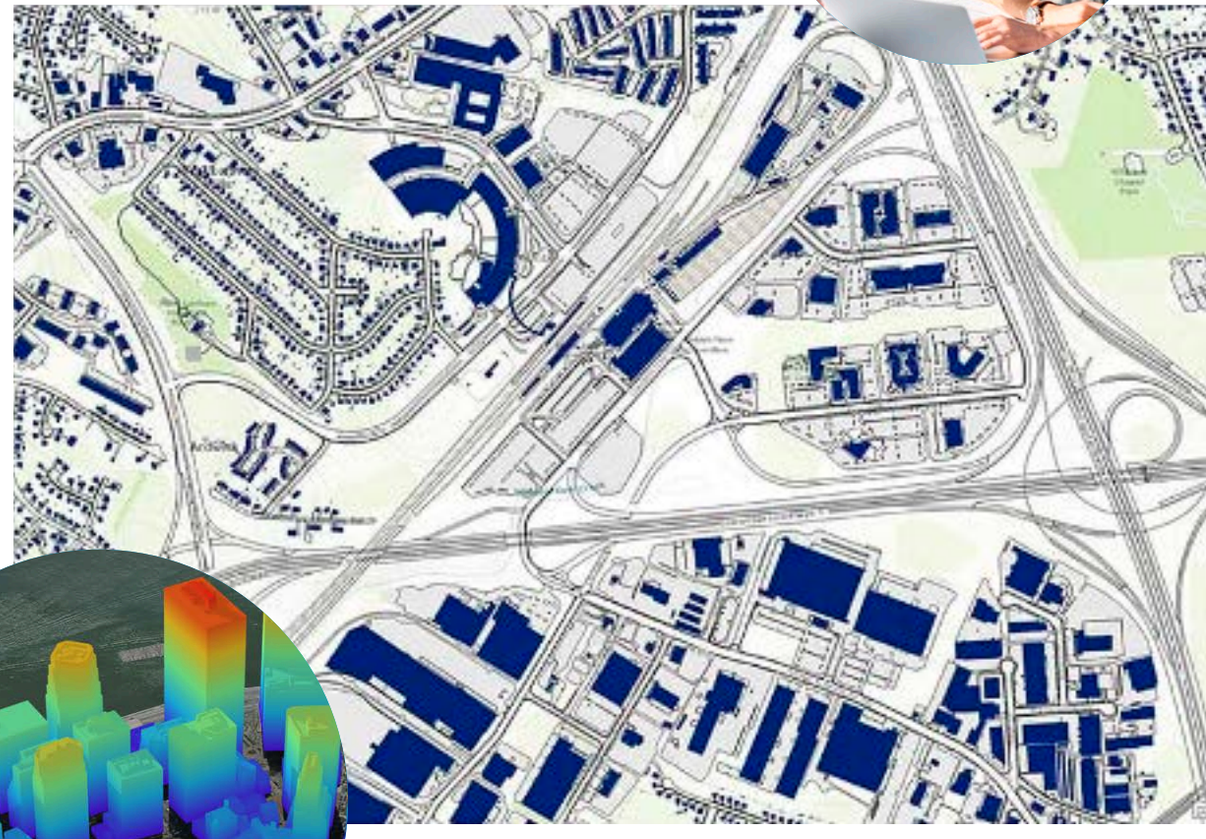
Looking at the capabilities of 3D GIS, the team thought it could help simplify the design and construction process required for a planned community.

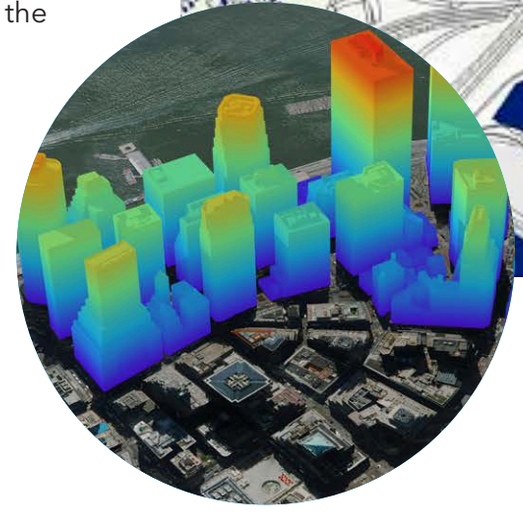
"We use both speculative site study and real-world urban design projects to develop and test our development framework," said An. "This enables us to integrate real-world GIS data, quickly create plans and models for multiple scenarios, evaluate the metrics, and perform spatial analytics of potential impacts."

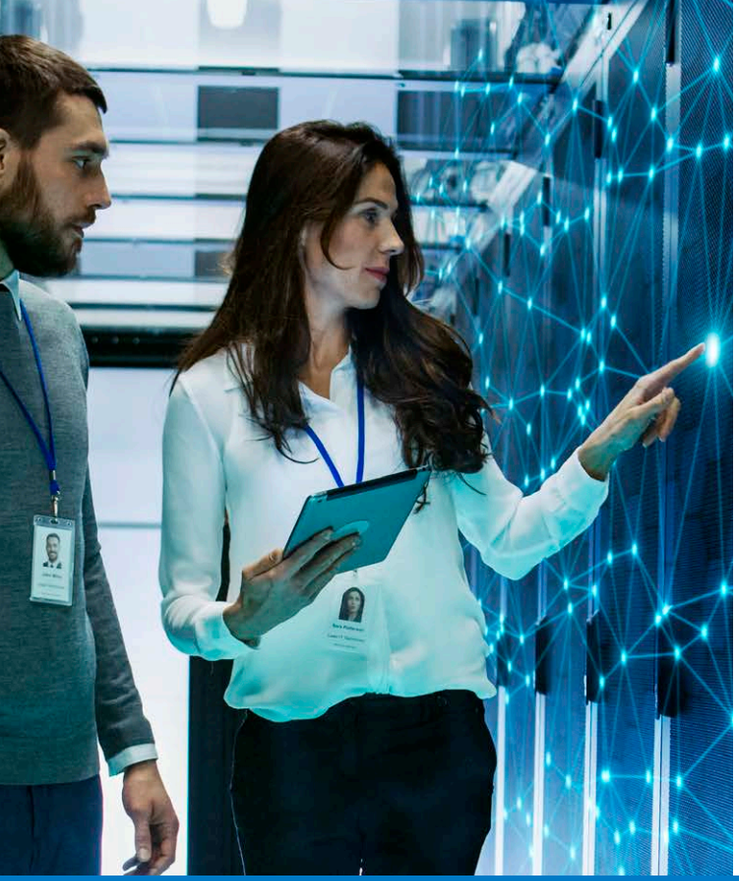
Using 3D GIS, teams have a comprehensive view and detailed information about a proposed design, as every element in the 3D web application is clickable. When client feedback includes new information or requests, 3D GIS makes design iterations and visualisations easier to create.

"Thanks to the rapid development of 3D and interactive GIS technology, urban planners can now adopt a more integrative and dynamic approach to manage and moderate planning and design tasks [that] better serve the communities where they are constructing these projects," said An.

Approved 3D GIS models and related plans can move seamlessly from urban designers to architects. This allows the design to be further developed in the BIM environment.







Security in GIS

Esri's ArcGIS, the market-leading GIS technology, allows organisations to leverage geospatial capabilities with the assurance of a robust, effective security framework. Esri continually advances the security of ArcGIS in the cloud, on mobile and desktop devices, and across the enterprise.

SECTION 5 |

IT MANAGEMENT

Today's infrastructure and the IT systems that support it are under constant threat from cyberattacks. The administration and maintenance of IT infrastructure is critical to the safety and security of all other infrastructure assets and services. As a secure and scalable technology, GIS connects maps, apps, data, and people in ways that benefit organisations:

- Empowering staff across the organisation to access, create, and securely share maps and key information
- Allowing flexibility with capabilities offered through multiple implementation patterns and approaches
- Extending the reach of geospatial tools across the enterprise
- Maintaining privacy, security, cloud capabilities, and scalability even when spikes in usage occur unexpectedly

CASE STUDY

United Kingdom: Skanska UK's Use of Digital Twins Accelerates Digital Transformation

Skanska UK, one of the United Kingdom's leading contractors, is driving digital transformation of the construction sector by leveraging its expertise alongside advancements in digital technologies. Integrating the power of GIS with key information management processes such as building information modelling (BIM) and digital technology, Skanska UK is deploying Esri's ArcGIS technology and BIM outputs to develop a smart, collaborative, agnostic geospatial twin that, in return, is transforming project delivery and delivering economic, social, and environmental value.

Access to data of the right quality and at the right time, in a format that is trusted by all parties, is increasingly recognised as a critical enabler of digital transformation across the construction sector. The challenge is to avoid data silos, enhance cross-organisational collaboration, and transform the customer experience, while also playing a central role in the shift toward a low-carbon economy. And all of this must be accomplished while maintaining a high level of ethics and worker safety.

Skanska UK has always taken great pride in integrating construction intelligence with innovative technologies. A leader in the GIS space, Skanska UK believes that adoption of geospatial technologies is vital in accelerating decision-making while underpinning collaboration and process improvements, even more notable in an industry often seen as resistant to change.

Integration with BIM aims to improve cross-disciplinary collaboration throughout the entire project cycle: planning, design, preconstruction, and construction—plus handover and operations. Each stage has its own challenges. Skanska UK is implementing a holistic digital strategy, using digital twins to improve decision-making by providing accessible and trusted information to all project stakeholders.

The entire ArcGIS Enterprise stack is used, including dynamic apps that support digital twin visualisation through 3D virtual representation of both built and natural environments. This geospatial approach allows different types of data and systems to be connected and accessed via a single view, throughout the project life cycle. The system fully supports information and collaboration, internally and externally, across multiple organisations.

At the outset of any project, construction design management (CDM) hazards are captured within ArcGIS Online, enabling various stakeholders to collaborate over the identified hazards. The design team can note a CDM hazard, which is then reviewed by the designer and contractor before being handed over to the operation and maintenance teams. ArcGIS Enterprise is used to consume numerous data formats and make the information accessible across teams. ArcGIS StoryMaps℠ is used to communicate plans with local communities.

Time and money are saved by the team's ability to iteratively model changes, test how components or systems function, and troubleshoot malfunctions in a virtual world. The integrated system also saves considerable time spent during projects. Capturing hazards within the 3D GIS portal helps improve health, safety, and equality.

Sustainable Development Goals

While all 17 SDGs are important, a few are earning greater focus from infrastructure organisations.

SECTION 6 |

SUSTAINABILITY

More organisations are using environmental, social, and governance (ESG) criteria to align their work with the United Nations (UN) Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development. A geographic approach will be imperative to creating sustainable networks for energy, transportation, water, and telecommunications:

- With a geographic approach, decision-makers can manage the two pillars of sustainability:
  - Reducing negative outcomes in the communities where they operate, including harmful emissions, loss of biodiversity, and other threats to the environment like water pollution
  - Becoming more resilient against rising risks from increasingly frequent natural and human-caused events that incur damage
- GIS technology enables leaders to visualise impending weather events and likely impacts on people, facilities, assets, partners, and supply lines, and then minimise threats to employees, partners, and communities.

6 CLEAN WATER AND SANITATION

Ensure availability and sustainable management of water and sanitation for all.

With the world population forecasted to reach 9.6 billion by 2050, better management of water and sanitation will be needed to sustain human well-being while preserving ecosystem resilience. Currently, an estimated 2 billion people do not have access to sanitation, and at least 880 million lack access to a safe water supply.

CASE STUDY

Netherlands: Vitens Safeguards Drinking Water

Vitens is the Netherlands' largest drinking water company, overseeing a vast network of pumps, treatment systems, reservoirs, and pipe systems. To ensure a reliable supply of clean drinking water and safeguard the supply, Vitens carefully tracks water levels in the reservoirs against water consumption. Sensors collect information from 11 billion data points. AVEVA PI System aggregates the data. By integrating the systems with ArcGIS, the data becomes visible on an interactive map, enabling new insights.

This integration allowed Vitens to configure two applications. An automatic meter reading (AMR) dashboard displays water consumption from industrial clients in real time. It also reveals whether water meters are working correctly, with every meter appearing as a dot on the map. A red dot indicates that the meter has not been sending data, suggesting a battery issue. Several red dots suggests a network outage. From the dashboard, a user can explore underlying data to confirm assumptions.

The interactive map that shows historical data, real-time data, and predictive data keeps Vitens in control. It helps analyse the data, discover relationships, and identify the root cause of a problem.

To anticipate and prevent potential water shortages, Vitens uses the Resttijden Reservoirs dashboard in ArcGIS Online. AVEVA PI System predicts the remaining water supply, in terms of reservoir inflow and outflow. ArcGIS Online visualises the predictive data on the map.

The predictive capabilities of AVEVA PI System, in combination with the map view in ArcGIS Online, supports Vitens in preparing for extended periods of warm weather.

Vitens is also experimenting with a digital twin of the water system that integrates AVEVA PI System with ArcGIS. The digital twin provides insight into the status of the water system. The twin allows for data that is much richer and more detailed.

7 AFFORDABLE AND CLEAN ENERGY

Ensure access to affordable, reliable, sustainable, and modern energy for all.

To determine and meet energy demand, considering each location in terms of its geographic conditions, infrastructure design, and energy resources should be an imperative. While utilities in many regions struggle to adopt more renewables, one-fifth of the global population still lacks access to electricity.

CASE STUDY

Austria: aspern Seestadt, Vienna's Smart City Test Bed

Vienna is a city in a bind. Austria's capital is one of the EU's largest and fastest-growing cities. It often occupies the top spot on *The Economist*'s annual rankings of the world's most livable cities.

But a city can only remain livable if there are enough places for people to live. Vienna's leadership has used the challenge of creating more housing as an opportunity to envision a new pattern of neighborhood planning and placemaking throughout Vienna.

The result is aspern Seestadt, a city within a city built on a reclaimed brownfield that was formerly an airfield. GIS technology helps planners implement clean energy and low-emission strategies. It also aids in long-range planning and implementation.

Wien 3420 AG was created in 2003 as a public-private partnership with the City of Vienna and two additional shareholders. The agency coordinates all inputs related to aspern Seestadt, a task aided by GIS.

In the early days of planning and construction, Wien 3420 used GIS primarily to print updated maps. GIS has since become a powerful integrated tool for the project's planners and architects. The agency uses GIS to create unfolding visual documentation of the plan. People involved with the project can take parts of the map relevant to their duties and integrate them into workflows for planning, constructing, operating, and marketing the development.

Over time, the map has been augmented by dashboards that show aspern Seestadt's progress. These help all project stakeholders understand whether the project is meeting its goals.

As aspern Seestadt has progressed, GIS technology has advanced along with it. A geospatial digital twin, built using ArcGIS Urban, documents the present and the past, while also helping Wien 3420 understand the future. For example, the twin guides planners in making data-driven decisions that help them apply evolving climate change standards.

Stricter energy efficiency standards were recently applied to the next phase of development. The digital twin provides visual communication of the change and quantifies efficiency gains.

Today, aspern Seestadt is a thriving community spread over 800 acres. When it is completed in 2030, it will be home to over 25,000 people and 20,000 workplaces.

Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation.

Inadequate or failing infrastructure carries significant consequences for a region's prosperity, productivity, and growth. In recent decades, increasingly intense and numerous natural disasters have caused billions of Euros of damage to essential infrastructure. The challenge, met with the help of holistic analysis, is to ensure that new or repaired infrastructure will be resilient and sustainable.

CASE STUDY

Germany: Bavaria Gains Insights into Roadways with Predictive Maintenance

With Bavaria's centralised location in the European Union, the German state is a crossroads for reaching several towns in Germany; it's also a common stop for travellers on their way to other countries, and it's part of an important transit route for goods transport across Europe. The state's 23,000 kilometers of roads (motorways, federal roads, and state roads) represent €40 billion in fixed assets. Due to a reform initiated by the federal government, the responsibility for motorways (including planning, building, and operating) was transferred from states like Bavaria to the newly founded Autobahn GmbH at the beginning of 2021.

One of the most important routes in Bavaria is the motorway Bundesautobahn 70 (A 70). The heavy car volume and the high percentage of truck transport take a toll on road conditions. The Bavarian State Ministry of Housing, Building, and Transport launched a pilot project to make road maintenance on the A 70 motorway more efficient by predicting when and where it will be needed.

The ministry used a deep learning program trained to notice and process indicators of road conditions. Working with a team of data scientists, the ministry provided data on road conditions from different measurement campaigns and traffic history. The A 70 motorway was divided into 4,800 segments, each 100 meters long. A GIS program provided a way to visualise the data and perform preprocessing functions. Using the data, a deep learning model was developed that could detect when road sections would need repairs, analysing features such as pavement thickness and road conditions.

The pilot project has proved that these approaches are capable of realistically forecasting changing road conditions. With the application of AI and deep learning, several road condition variables can be meaningfully connected, and thus interdependencies of different parameters can be included in the forecast.

With AI and location intelligence, the task of combing through reams of data, which would've taken analysts hundreds of hours to pore over, can now be done swiftly and automatically as part of ongoing workflows.

Make cities and human settlements inclusive, safe, resilient, and sustainable.

By 2030, almost 75 percent of the world's population will live in cities. The total area of cities is just 2 percent of the earth's land cover, but cities are responsible for up to 80 percent of overall energy use and 75 percent of carbon emissions. The numbers make it clear that businesses—together with governments, nongovernmental organisations (NGOs), and residents—must work to make cities more sustainable, safer, and more equitable.

CASE STUDY

Ireland: Fibrus Streamlines Broadband Expansion

Since its founding in 2019, Fibrus has looked for ways to make workflows more efficient. When Fibrus won the Project Stratum contract to deliver full fibre broadband to 85,000 rural homes and businesses in Northern Ireland, the digital transformation had to be expedited. Without delay, the company needed to establish more efficient, integrated digital processes for collecting, viewing, and sharing information, which would enable it to scale up its operations rapidly and achieve ambitious project milestones.

Using Esri's ArcGIS system, Fibrus built a suite of integrated solutions to streamline processes throughout the entire life cycle of planning, building, and maintaining fibre networks.

During the planning phase, all network designs, created by different partners, are now integrated into ArcGIS Pro and then standardised so that the information is displayed in a consistent way. Poles, for example, always appear in one colour when planned and in another colour when built, so there is no confusion for people working across multiple projects. All the data is made available to

employees, contractors, and subcontractors in contract-specific web apps that are accessed via a site created using ArcGIS Hub℠.

During the construction phase, over 1,000 field operatives, employed by different companies, use a variety of ArcGIS Field Maps solutions on mobile devices as part of their day-to-day jobs to view plans on digital maps, collect survey data, record cable and pole installations, share information in real time, and flag any issues.

If the location of a pole needs to be adjusted, the change is visible instantly and the designer is notified automatically. To aid the management of ongoing operations and maintenance, Fibrus used ArcGIS Dashboards to create a series of dashboards. Managers can view dashboards to see, at a glance, the progress against project milestones. Any maintenance issues—such as cables that have been accidentally cut or poles that have been damaged in storms—are highlighted in ArcGIS, making it easier for Fibrus to plan maintenance visits and implement rapid repairs.

The company estimated the shift to the new system saved £5 million by improving data accuracy and eliminating time-intensive tasks. The estimated time savings were 500 worker hours per week. The new ArcGIS technology-based processes have completely eliminated the use of paper maps and forms.

Take urgent action to combat climate change and its impacts.

As the average surface temperature is projected to increase 3 degrees Celsius, people will continue to see changing weather patterns, more extreme weather events, and higher sea levels. Governments and businesses are using GIS to analyse weather data, model climate change impacts, and design location-specific mitigation plans.

CASE STUDY

Sweden: Uppsala Creates a Detailed Digital Twin to Enhance Sustainability

Sweden, like many other countries, struggles with a housing shortage and lack of affordability. This isn't the first time the country has faced such a crisis. In the 1960s, the Swedish Parliament passed the Million Dwellings Program, which created a million new homes between 1965 and 1974 to accommodate the wave of baby boomers reaching adulthood. A similarly urgent movement to add housing is now underway.

Uppsala is Sweden's fastest-growing city. Part of the city's attraction is its reputation as a research center and its ambitious sustainability policy.

To handle growth, city planners in Uppsala are creating a new southeastern city district.

Early in the planning process, the planning team struggled with the amount of tabular data regarding project requirements. The number and size of spreadsheets grew, and having data in that format made it difficult to engage and collaborate with the multiple city departments involved. It was also difficult to share and conceptualise a physical representation of the complex district plan.

Planners developed a planning digital twin of the area that depicted what the project would look like and how it would fit into the larger geographic context of the city. The 3D model is built on top of a digital elevation model captured with lidar scanners to show the real topography as well as buildings and trees.

Uppsala planners are concentrating on a sustainable urban model that adds to residents' quality of life, doesn't subtract from biodiversity or degrade the environment, and cuts carbon emissions. A detailed zoning plan and a 3D model built with ArcGIS Urban help the planners visualise and present plans for the new city district.

The model provides a way to see the whole of the project. Planners use it to test approaches and reconfigure plans to meet two ambitious goals: to be fossil-fuel free by 2030, and to be climate positive by 2050. It provides the means to inform residents and gather feedback. The planning digital twin gives the city and its residents the means to make informed and sustainable decisions.

Protect, restore, and promote sustainable use of terrestrial ecosystems; sustainably manage forests; combat desertification; and halt and reverse land degradation and halt biodiversity loss.

In the past 50 years, changes in biodiversity due to human activities have been more rapid than at any other time in human history. Every year, we lose 13 million hectares of forests–habitats for up to 80 percent of all species of land animals and subsistence providers for 1.6 billion people. A major cause of biodiversity loss, and one that calls on us to intervene, is the harvesting or destruction of natural resources.

CASE STUDY

Sweden: E.ON Secures Electric Supply and Biodiversity

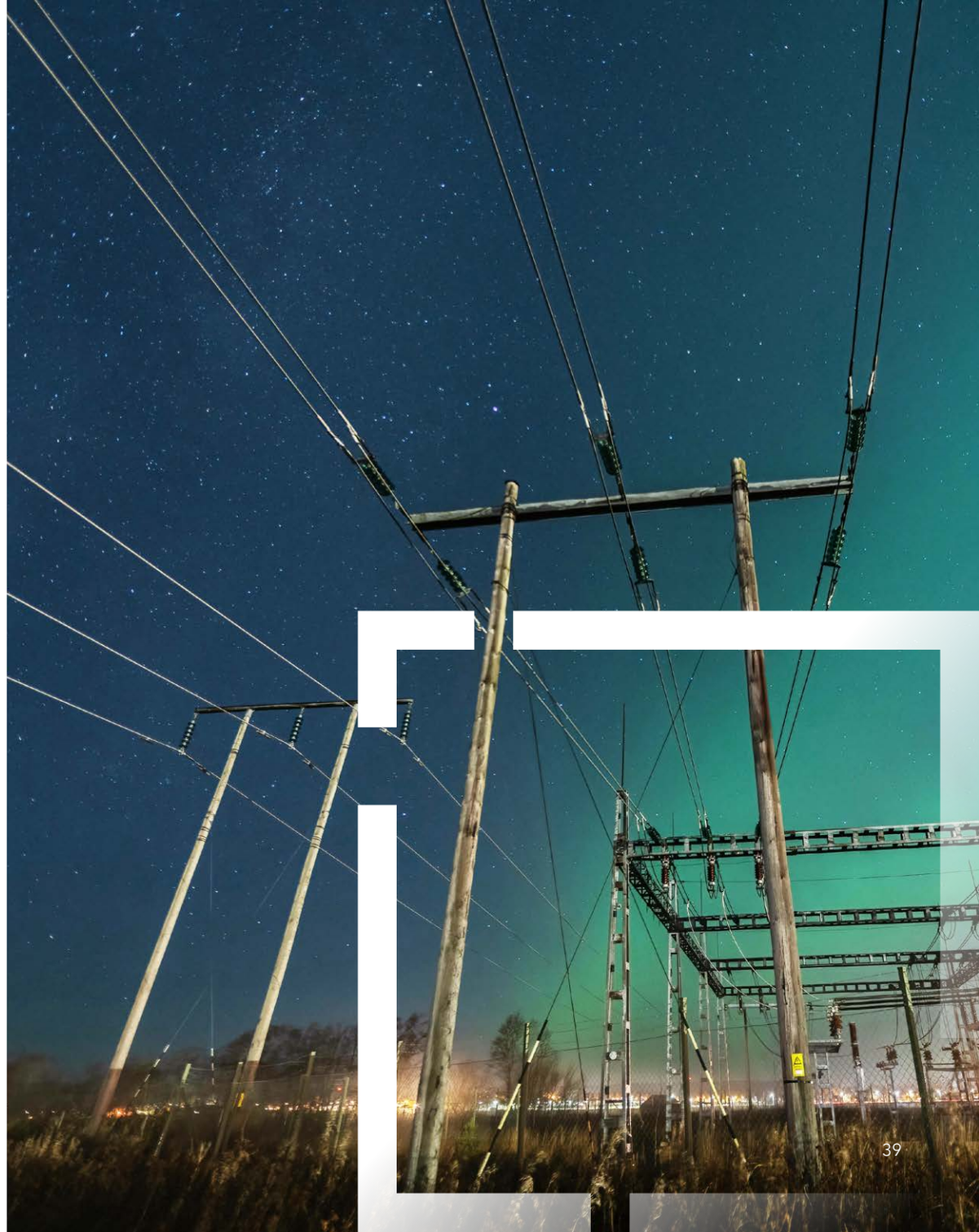
E.ON is a major supplier of electricity in Sweden and across Europe. Electricity is delivered via power lines that pass through a variety of vegetation. To maintain the stable flow of electricity, the areas near the lines must be routinely cleared. If the vegetation grows too high, it may damage the lines.

Constant maintenance work is therefore required. A major challenge of this work is that much of it occurs in remote areas that are difficult to access, and relatively few people are qualified to do this work. This further complicates the task of accessing, clearing, and repairing power lines.

In 2020, E.ON's CEO announced that within 10 years, 70,000 hectares of conduit streets (the areas around the power lines) will be cleared with special consideration for biological diversity. A project group within E.ON began the search for a new solution.

The solution was a special maintenance tool the company calls Sams. It uses satellite data, remote sensing, and machine learning to provide information about which forms of life exist near power lines. It includes not only trees, which can now be inventoried individually, but also plant and animal life as a whole.

Sams benefits from several ArcGIS products. ArcGIS Workforce helps E.ON manage the actual clearing needs. ArcGIS Survey123 allows the company to keep an inventory of flora and fauna in a manner that is both accessible and flexible. ArcGIS Enterprise Sites collects all information and makes it available to stakeholders.



SECTION 7 |

RESILIENCE

Communities must now have the capacity to mitigate risk and recover quickly. This resilience supports positive economic, social, and environmental outcomes—and it's largely dependent on infrastructure. A systems-based, geographic approach to infrastructure resilience looks at how systems act, react, and interact, using GIS to

- Focus on the network of assets in and across sectors, in addition to the resilience of the individual assets.
- Situate assets and networks in the context of their location, accounting for the unique risks and strengths of each location.
- Plan, deliver, and operate infrastructure in a way that supports continuity of service delivery.
- Prepare for and recover from all hazards and natural disaster events.

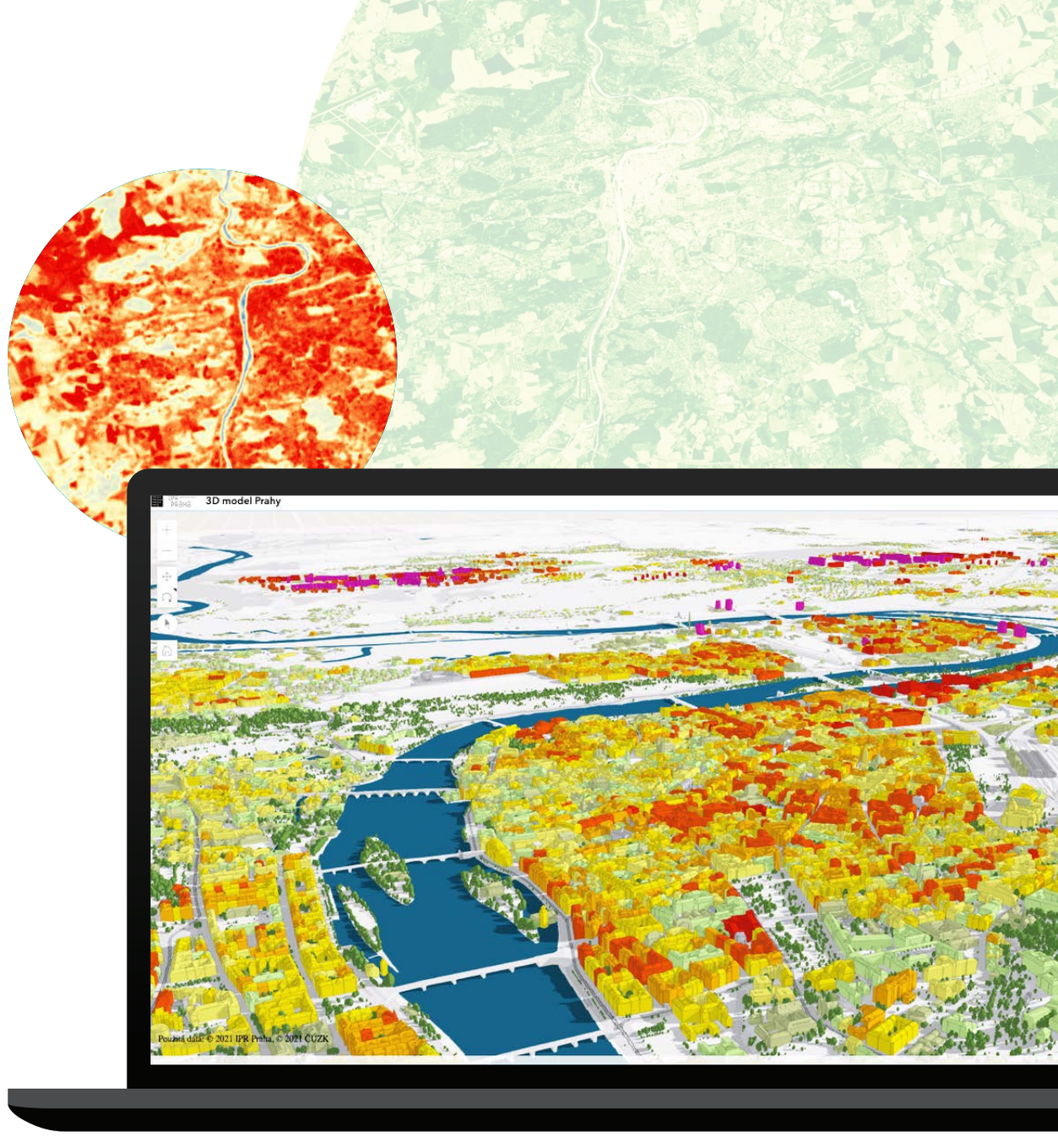
CASE STUDY

Czech Republic: Prague Planners Chart a New Future to Escape Extreme Heat

Prague is particularly vulnerable to extreme heat. Compared to other European cities, it has more paved spaces, built-up areas, and industrial infrastructure—the kind of spaces that can create heat islands. In mid-August 2022, temperature records were again broken across the Czech Republic. In some areas, the highs exceeded 35 degrees Celsius.

Prague's planners turned to GIS to analyse where the city could add resilience. GIS allows planners at the Prague Institute of Planning and Development (IPR Prague) to analyse the city both in street-level granularity and from a bird's-eye view. GIS provides a way to visualise—and therefore contextualise—extreme heat statistics. Demographics and other human population data become layers on a smart map. The layers can be set against environmental features of the city, offering a graphic representation of how the city and its populations interact.

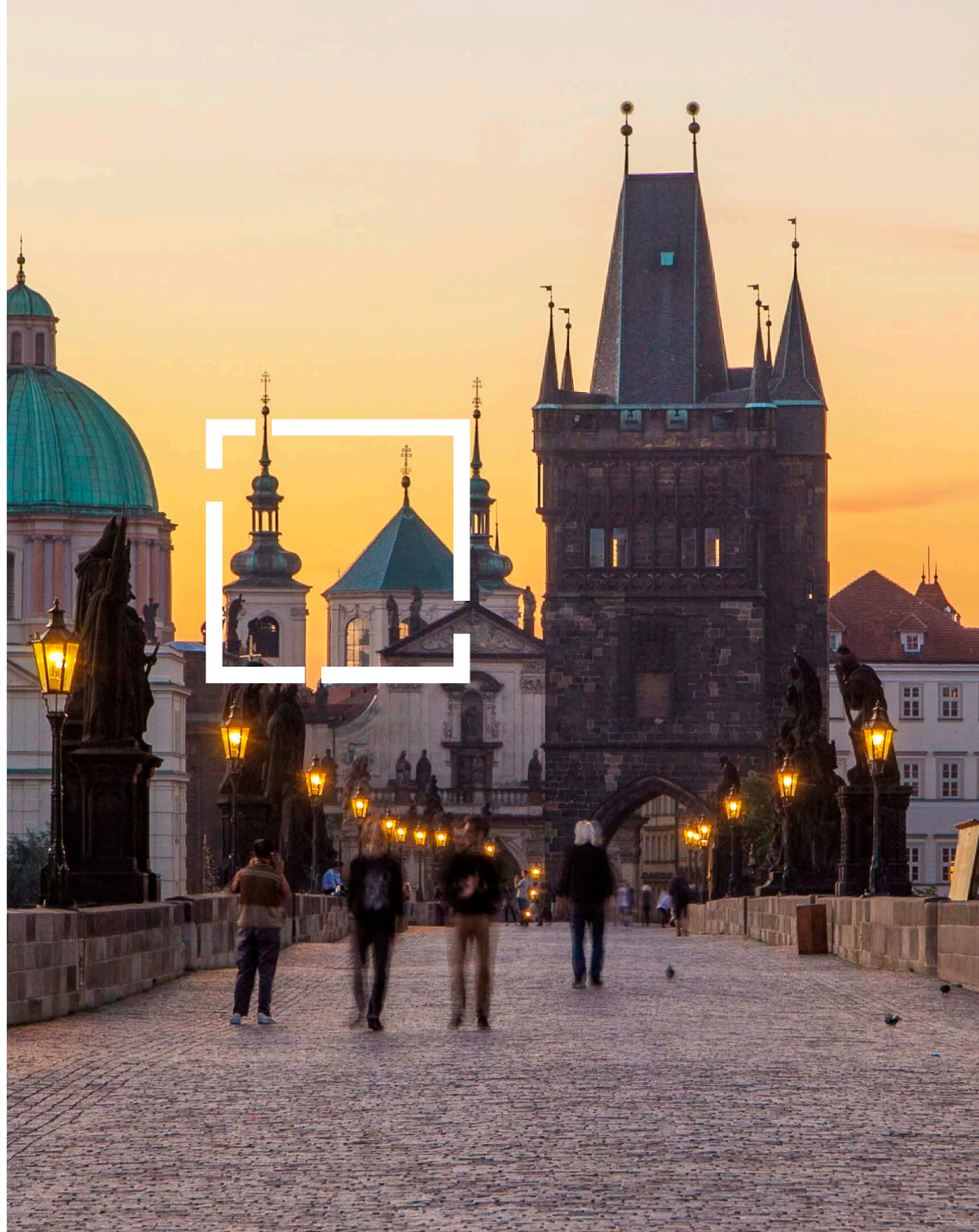
Prague is also one of the fastest-growing cities in Europe. For the redevelopment of Florenc, a neighborhood with deep historical ties to the city, combatting extreme heat was a priority.



The city is committed to preserving Florenc's historic character, but any development had to fit within Prague's commitment to climate change resiliency. Florenc is also one of the city's largest brownfields, a contaminated remnant of the area's industrial past. It's also where the city's modern rail transportation infrastructure comes together, creating a barrier to community cohesion.

In keeping with IPR Prague's interest in how Florenc will fare in an era of climate change, the design team integrated sustainable energy sources and microclimate research into its design. The digital twin helped the planners and designers strike the right balance with new development that addresses climate pressures while improving the lives of residents.

In Prague, an awareness of extreme heat at the microclimate level led to creating parks in the places where they would best cool the city. GIS was used to construct intricate 3D models of the city's microclimates to analyse the likely effects of mitigation strategies before the city makes any large investment of time and money.



CASE STUDY

United Kingdom: Real-Time Location Sits at the Center of London's Traffic Management

Twice in less than 15 years, Londoners have seen dramatic shifts in the way they interact with streets and transit. The first time was in 2012, when the Olympic Games temporarily brought 600,000 new riders to London's buses and trains. The second was in 2020, when the COVID-19 pandemic emptied streets, buses, and rail cars.

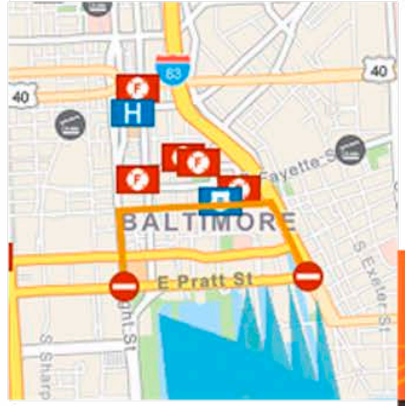
During the Olympics, Transport for London (TfL) had to move people around to the many venues while also maintaining mobility for residents and businesses. In response to the pandemic, TfL had to reconsider how mobility can enhance public safety.

In both instances, TfL planners looked for real-time understanding of traffic patterns, demand levels, and incidents by using situational awareness from a geographic information system. In 2014, TfL reinforced its GIS and began delivering GIS as a service to other key enterprise systems.

The data and layers captured in TfL's GIS describe locations and things, including up-to-date details about roadways, rails, paths, and all the physical assets the agency maintains. Sharing this capacity as a service means that other systems can ingest and build on authoritative data and visualise, query, and analyse it for specific purposes.

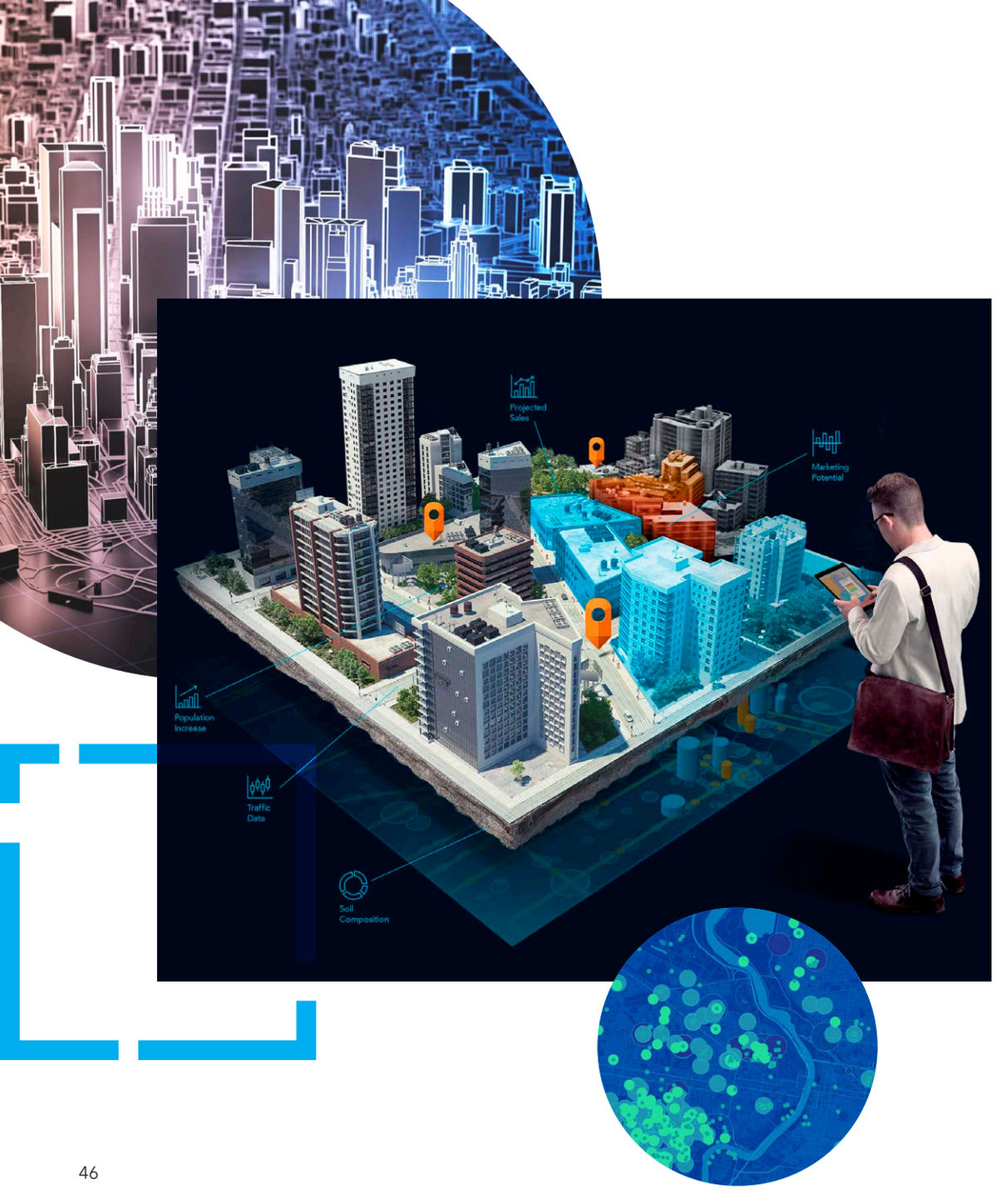
All inputs are combined in TfL's Traffic Information Management System (TIMS) to monitor and manage traffic by using a GIS database of live and planned traffic disruptions in London, including congestion, traffic incidents, repair work, and special events. TIMS allows media agencies and other stakeholders to view disruptions in real time (updated every five minutes) and see information about planned activity likely to impact traffic—providing a shared situational awareness.

Maps provide a powerful, visual understanding of mobility capacity as well as a strong platform to plan, prioritise, and improve roadwork projects. The Olympics effort was deemed a success, with 90 percent of journeys completed on time despite a record number of riders. During the ongoing pandemic, TfL's system has allowed the agency to support London's goals for active, sustainable transportation while creating more space for fewer people.



CONCLUSION

Around the globe, an infrastructure overhaul is underway to make way for clean energy and a modern information-based economy. But we can't just rebuild our roads, redouble our broadband networks, and rebury our water mains in the ways we always have.



What we must do is create a new generation of transit, connectivity, and water networks that are sustainable, easier to manage, and resilient against climate risks.

In the short term, that means prioritising where to repair and where to build anew. Long term, it means ensuring that critical assets can sustain a growing and migrating global population amid climate change while expanding networks to serve more people.

Approaching the situation geographically means using data to understand where people and objects are in relation to each other as well as in relation to built and natural systems. With GIS maps and analysis, far more insight can be gleaned from data, providing the holistic view that is long overdue.

As Esri president Jack Dangermond noted, “Today, a lack of understanding of our reality is one of the greatest risks that our society is facing. Our future depends on creating and applying that understanding.”

Esri, the global market leader in GIS software, offers the most powerful mapping and spatial analytics technology available.

Esri, the global market leader in GIS software, offers the most powerful mapping and spatial analytics technology available. Since 1969, Esri has helped customers unlock the full potential of data to improve operational and business results. Today, Esri software is deployed in more than 350,000 organizations including the world's largest cities, most national governments, 75 percent of Fortune 500 companies, and more than 7,000 colleges and universities. Esri engineers the most advanced solutions for digital transformation, the Internet of Things (IoT), and location analytics to inform the most authoritative maps in the world.

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