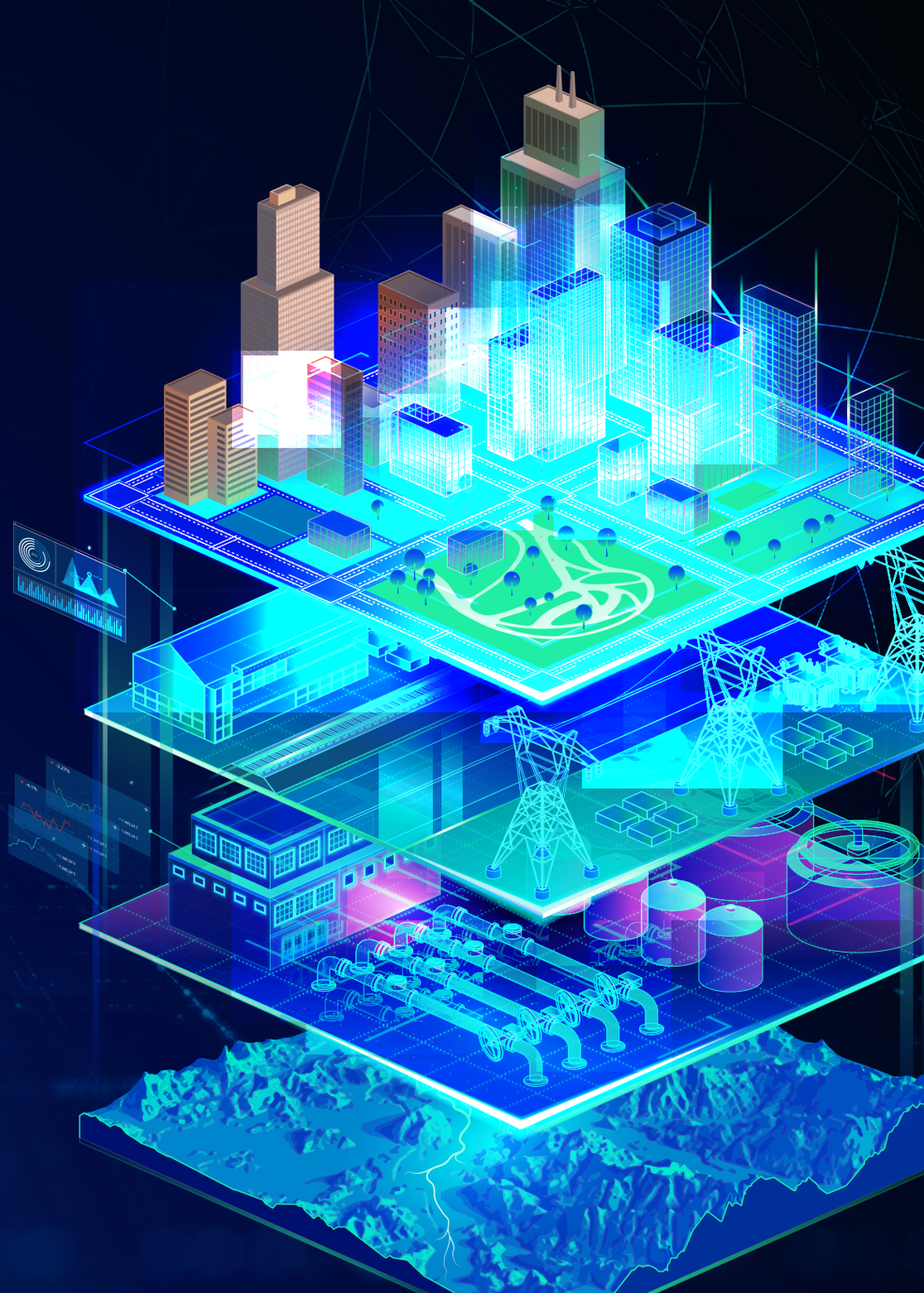
ArcGIS: The Foundation for Digital Twins

Creating the Sustainable Infrastructure of the Future



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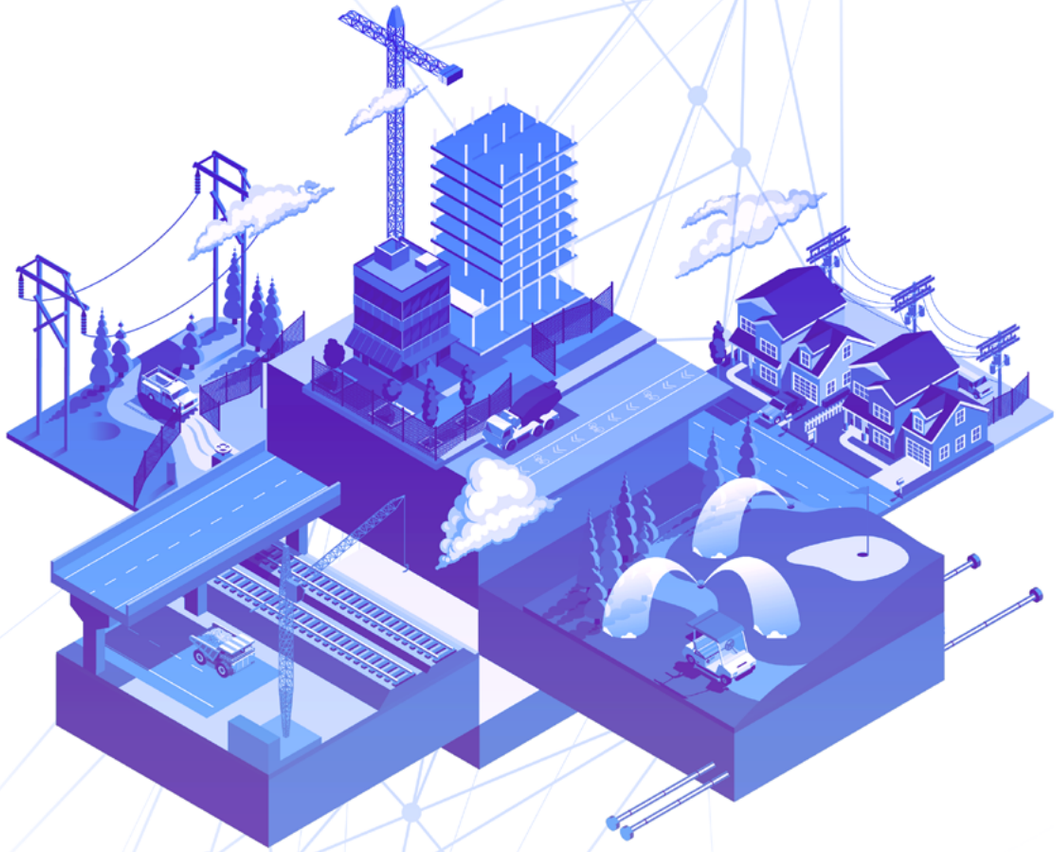


Digital twins are virtual representations of the real world including physical objects, processes, relationships, and behaviors.

Geographic information system technology creates digital twins of social, natural, and built environments and uniquely integrates many types of digital models.

Introduction

Industry and government organizations are facing challenges in every area of their business. They work hard to adapt to and leverage digital technology. Yet they often face today's challenges with yesterday's methods. In the struggle to remain relevant and thrive, organizations are looking to update to modern advanced information technology (IT) and operational technology (OT) solutions. To achieve these transformation objectives, these organizations need to reinvent the way they do business and change many legacy operating models and processes. To effect the desired change, organizations need scalable solutions that not only meet today's challenges but also align to their strategic future vision. ArcGIS® technology is the foundation for digital twins, providing solutions to achieve these organizations' vision and their transformation objectives.

Digital twins are abstracting and modeling everything. They offer a means to improve business processes, reduce risk, optimize operational efficiencies, and enhance decision-making with automation to predict future outcomes. Digital twins provide greater context to meet business challenges by creating relationships and streamlining workflows. Digital twins are used to observe and monitor current performance, represent accurate historical views, and predict future states. A digital twin of a fixed asset or real-world system benefits directly from the integration with geographic information system (GIS) technology. GIS adds spatial context around the asset, connecting the information model to other models and its surroundings. GIS creates digital twins of natural and built environments, and it can also be used to integrate many different digital representations of the real world.

In the last several years, the convergence of geospatial technology, building information modeling, and interactive 3D has redefined the value of and possibilities for digital twins and how they may be used to model, manage, and simulate single facilities, entire cities, and even large natural systems.

Esri's ArcGIS software provides out-of-the-box solutions that enable the creation, visualization, and analysis of digital twins. Easy-to-use applications streamline workflows, and maps and apps can be embedded in websites to provide access to essential information to improve understanding and business decision-making.

Contents

What Is a Digital Twin?

Digital twins are virtual representations of the real world including physical objects, processes, relationships, and behaviors. A digital twin in a geographic context represents real-world assets or natural systems along with information models, data, reports, analyses, and behaviors in spatial context to the natural and built world. Digital twins may be used to represent the current, past, or even future state of assets. Digital twins mirror what exists in the real world today, but also can forecast what may exist in the future.

The concept of a digital twin originated in the product manufacturing industry. Precise digital models of complex objects, such as airplanes or cars, were captured in a database for purposes of reporting, analyzing, and eventually simulating and testing an object's performance. The original digital twin concept helped move asset data from strictly being used for finance and cost accounting to being used for performance and operational analyses that could then be iterated back into the financial perspective of the asset's manufacture and sales.

In the last several years, the convergence of GIS technology, the Internet of Things (IoT), and—most recently—building information modeling (BIM) has created interactive 3D visualizations, which are redefining the digital twin as well as the value it brings to organizations. A digital twin is not a single product or solution—it is a complex network of technologies and systems. It must work in harmony to achieve the desired transformational outcomes and return on investment that organizations desire. As digital twin adoption increases, the possibilities and applications of digital twins continues to evolve and create value in almost every industry and organization.

The evolution of GIS technology and the deployment of IoT sensors have resulted in unprecedented amounts of data, which can now be processed, analyzed, and visualized in innovative ways. As IoT and GIS adoption increases and their applications mature, the future is becoming increasingly intelligent and automated. GIS and IoT technologies are connecting systems and data in new ways, enabling the transformation of many organizational workflows. The innovation and integration of these technologies are creating a modern digital nervous system and enabling real-time integrated digital twins.

Creating a Sustainable Future

At a global scale, organizations are looking to modernize their infrastructure to create a more sustainable future. Organizations must repair what is crumbling and ensure that it's sustainable for the needs of today and resilient for the needs of tomorrow. This means protecting our energy, water, transportation, and telecommunications networks from many threats. It also means incorporating more renewable and sustainable energy sources and using collaborative ways of working with commerce, government, and communities.

Diverse industries are facing many new challenges:

- Energy utilities are looking to modernize their aging grids while also adapting to the changes imposed by large-scale Distributed Energy Resources (DERs).
- Transportation industries are striving to offset high carbon emissions through electrification and renewable energy.
- Water industries are introducing intelligent networks to understand and preserve the supply and quality of the world's water resources.
- Telecommunication organizations are rapidly evolving to meet the demands of modern society, which is now as dependent on the communication infrastructure as it is on electricity and water.
- This integration and collaboration between organizations has redefined the importance of architecture, engineering, and construction (AEC) organizations and the role they play as they become an essential conduit to connect all these other organizations together through innovative and agile deployments of technology.

To reach this level of collaboration and resilience, organizations must be agile and able to adjust, accommodate, and meet changing business needs head-on. A massive amount of new construction in the coming decades will be driven by the ongoing march of urbanization, decarbonization, and digitization. Organizations need a strategy deployed with a geographic approach that can help energy, transportation, water, and telecommunications networks with creating and connecting the infrastructure for a sustainable future.

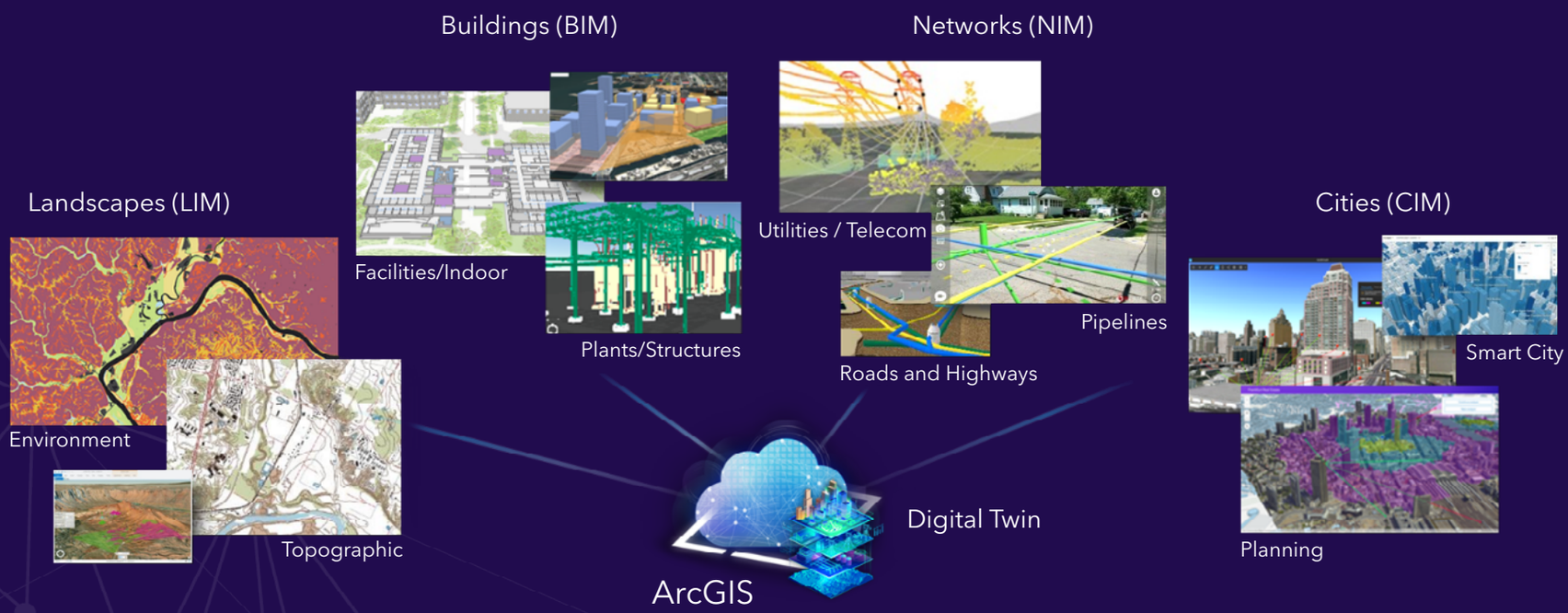
The infusion of intelligent GIS technology and the emergence of digital twins, applied with a geographic approach, make possible the integration of context awareness across all systems—built and natural.

Interconnecting GIS and Digital Twins

A modern GIS is a powerful technology for representing a holistic digital twins in spatial context . GIS allows you to abstract and model everything, bringing together many different information models.

For decades, organizations have been using GIS to create digital representations of the environment and their spatially diverse linear asset information models. But as business requirements have evolved, so have the complexities of these information models.

A modern comprehensive GIS connects these disparate information models:

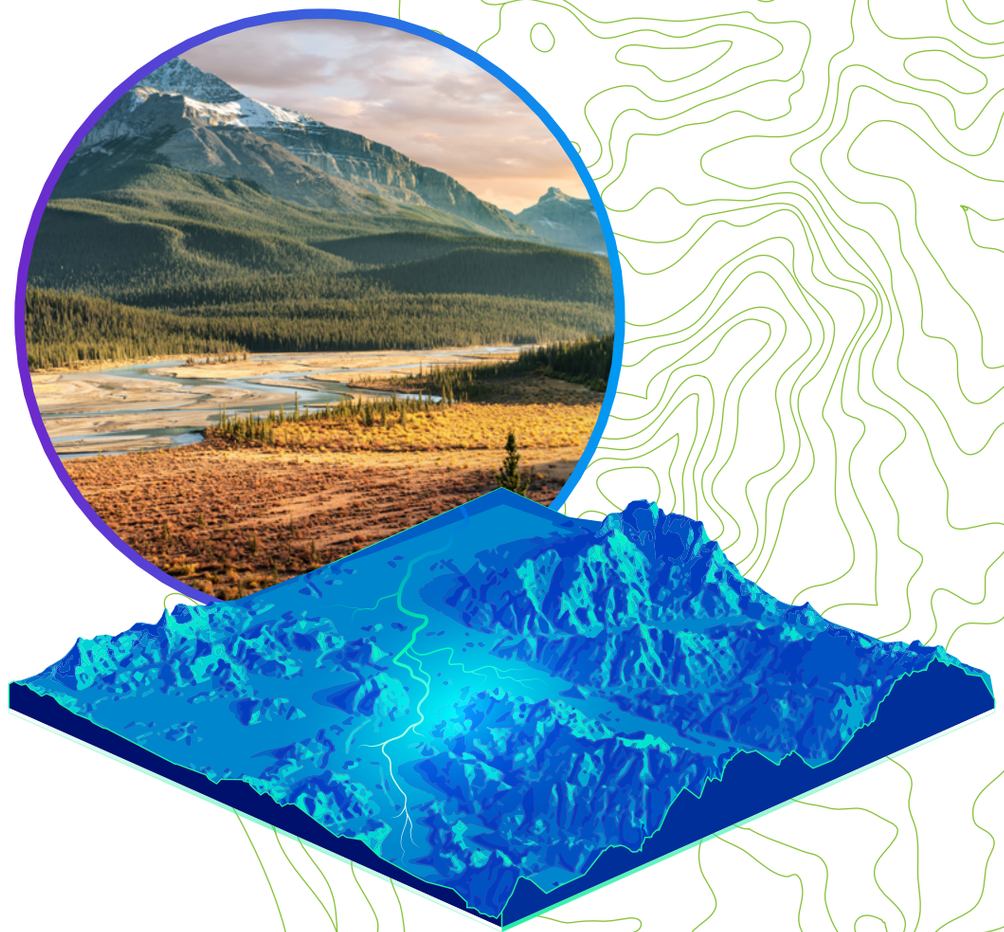


Land Base Information Model

The Land Base Information Model (LIM) consists of the environment, topology, social, and landscapes layers.

Common LIM datasets include the following:

- The ArcGIS Living Atlas of the World contains a wealth of landscape information including recent imagery and boundary data.
- Real-time data feeds such as current weather patterns and radar can be visualized and ingested in analysis.
- Important environmental factors such as soil type, vegetation, and terrain can be seamlessly incorporated into digital twin development to further enhance landscape information models.
- Demographic and social indicators such as a social vulnerability index can be incorporated and help identify vulnerable populations, inform project planning, and aid in better understanding customers.



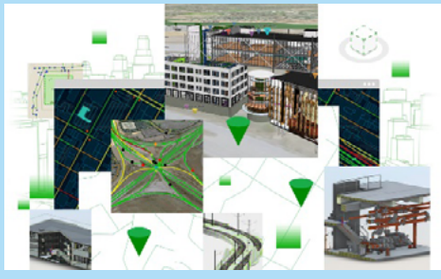
Building Information Model

A **building information model** provides an accurate and highly detailed representation of structures, plants, and facilities.

BIM and GIS work together as follows:

- BIM provides detailed information about buildings and infrastructure assets, including a 3D digital representation of their physical and functional characteristics.
- GIS provides information about assets in the context of natural and built environments and other vital factors such as demographic, socioeconomic, and environmental considerations.

Both BIM and GIS play unique and valuable roles in supporting the life cycle of building and infrastructure projects. ArcGIS GeoBIM℠ effectively integrates GIS and BIM at the workflow level, so project participants and stakeholders can capitalize on their capabilities and benefits.

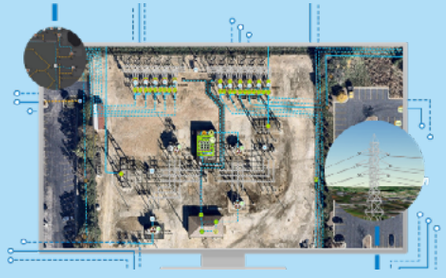


ArcGIS GeoBIM delivers an innovative, easy-to-use web-based experience for teams to explore and collaborate on building information modeling projects and issues, using data from multiple systems in a geospatial context. Architecture, engineering, and construction teams can easily work with linked data from multiple systems in configurable web apps that simplify communication and collaboration with other teams as well as stakeholders.

Network Information Model

The **Network Information Model (NIM)** manages the design and logic for networks. Typically, this type of model manages linear assets and connectivity. For utilities, this leverages ArcGIS Utility Network, which is architected to support modern network management. ArcGIS Utility Network includes the following:

- Configurability for any utility, municipality, or organization with linear assets
- The ability to model complete operational and structural networks across all domains and tiers
- Improved data quality through alignment to business and network rules
- Easy, services-based integration



ArcGIS Utility Network supports the next generation spatial information system to provide greater functionality over massive datasets at every scale of resolution. Utilities can leverage the power of ArcGIS Enterprise in its entirety to model, manage, and integrate complex modern networks.

City Information Model

City Information Model (CIM) allows for bigger-picture modeling at scale. This assists in workflows for urban planning; citizen engagement; and, most recently, smart city and smart community initiatives. Smart cities and smart communities are connected and intelligent cities that use technology to make the lives of their residents better by providing the following:

- Support for urban and community design that adapts to change
- Connection and integration with essential government services
- Improved citizen communications and engagements

ArcGIS Urban enables planners and design professionals to collaborate across teams with a web-based 3D application that supports scenario planning and impact assessment. ArcGIS Urban enables the digital transformation of city and regional planning to encourage collaboration with community stakeholders and help all groups work toward a more sustainable future.

What makes ArcGIS unique is that it integrates and connects all these different types of information models and digital twins. GIS can be the digital twin, but in some cases it is just enabling the interconnections of other digital models that create additional value to the customer by providing a more holistic view. ArcGIS allows users to go beyond using very detailed building information models of structure interiors, to see the buildings' relationships to networks and see all this in context next to the larger city views.

Digital Twin Life Cycle

GIS creates relationships and streamlines workflows across systems and information models. Everything has a location, so location becomes the common key to integrate and model the digital twin's complete life cycle. An integrated digital twin enabled through a modern GIS is not one single solution or product—rather, it is an ecosystem of capabilities and applications being bought together by GIS to support holistic and collaborative approaches. It is not one digital twin but rather many digital twins that are integrated and interconnected.

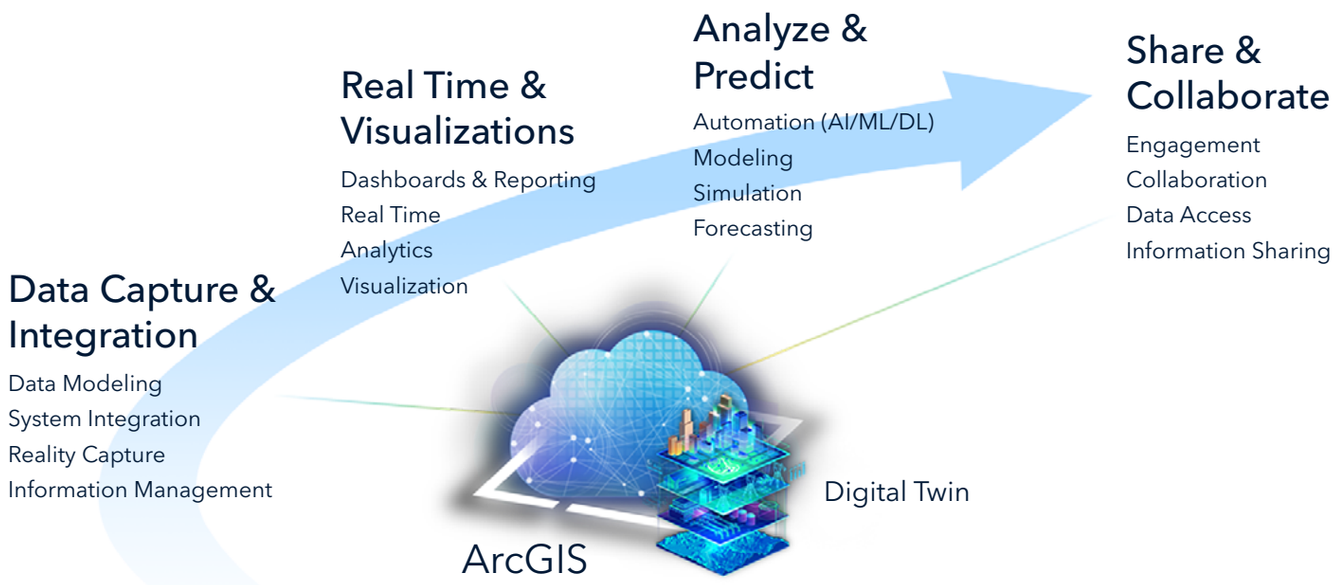
Below are the four elements for managing the information life cycle for a digital twin:

Data capture and integration is foundational to a digital twin. Organizations need comprehensive, end-to-end data management. They need to capture the data, model it, integrate it, and then manage it and its associated attributes and behaviors throughout its life cycle.

Real time and visualizations bring the data to life, taking information and creating a better understanding of what is happening now. Sensor technology enables real-time situational awareness combined with advanced visualization capabilities to virtually represent how the physical components are operating in the real world.

Analyze and predict to move decision-making beyond just understanding the current operational state. Organizations must understand the past and view predictions of the future. They need to simulate and forecast expected outcomes as well as automate the decision-making process.

Sharing and collaboration are enabled—via desktop and mobile devices—for both internal and external stakeholders. Digital twins are about collaboration—sharing information and getting it to those who need it, when they need it.

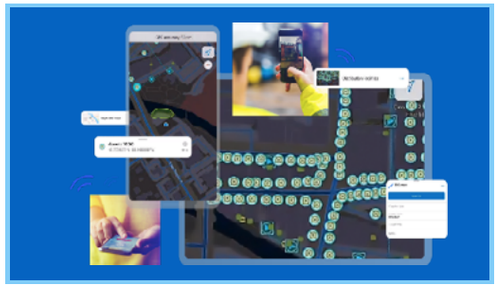


Data Capture and Integration

For many organizations, the need for data quality, information management, and system integration has long posed constraints to successfully deploying solutions to enable intelligent reporting and analytics. Traditional data-capture methods involved paper-based workflows, siloed integrations, or processes that were disconnected. This created information latency and eroded confidence in the data. Organizations need to be able to capture the transactional data from field operations and update source systems directly. In addition, they need to be able to manage and process complex, real-time, and high-volume datasets at scale from imagery and reality capture.

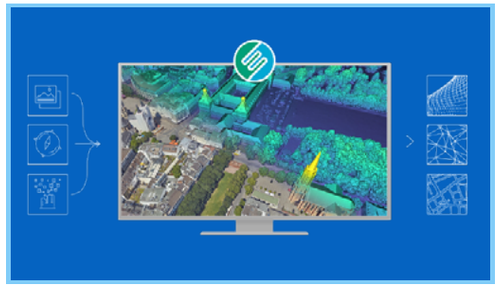
Field Operations: The mobile device has become the prime channel for communication. It is personal and always at hand, which makes it particularly useful for reporting incidents, updating records, and providing up-to-date information to end users in the field. By making it easier and more convenient for people to provide information and feedback, organizations can increase their knowledge and insight.

ArcGIS Field Maps is a premium app that is quick to deploy and allows you to manage the transactions of your digital twin in the field. Users—both online and offline—can capture data, perform inspections, take notes, and share information with the office.



ArcGIS Field Maps is an all-in-one app that uses data-driven maps to help mobile workers perform data collection and editing, find assets and information, and report their real-time locations. ArcGIS Field Maps is the go-to app, powered by field maps, that streamlines the critical workflows field personnel use every day. ArcGIS allows users to create, collect, manage, locate, and track while working in the field.

Imagery and Reality Capture: Organizations need to capture and create real-world depictions of large construction sites, cityscapes, and entire regions. Digital twins at scale enable your organization to assess infrastructure, detect change, monitor the environment, and integrate with other information models. ArcGIS offers solutions to efficiently complete your workflows for managing, processing, sharing, and extracting information from your sensor imagery. Organizations benefit from advanced features for flight planning and fleet management for drone projects. Streamline the interpretation and extraction of features from the perspective of the real world.



SURE for ArcGIS is a surface-reconstruction software that empowers you to create photorealistic models of reality. It accommodates aerial mapping projects that use data captured with large-frame nadir and oblique cameras, as well as hybrid systems with lidar sensors. Without limitation in image resolution, you can produce 3D meshes, digital surface model (DSM) orthomosaics and point clouds on common workstation hardware, and cluster environments. SURE is simple to set up and operate and is compliant with mapping industry standards.

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Florida Utility Creates Digital Twin of Electric Assets with Highly Accurate Field Operations

The Utilities Commission of New Smyrna Beach (UCNSB) has been providing residential and commercial customers with electric, water, wastewater, and reuse water services for over 50 years.

When UCNSB's transmission and distribution (T&D) assets were installed in the 1970s, the utility's as-builts were recorded in CAD software. In 2014, UCNSB converted its CAD drawings into GIS features and the organization's field teams began using the GIS maps in routine mobile work.

UCNSB acquired two Arrow Gold receivers from Eos Positioning Systems for the field teams to use with ArcGIS Collector during their routine work to capture data and create digital twins of the assets in the field. Information is updated in the field and synced with ArcGIS Online, and a data editor in the office performs a quality control check. Then the new data is merged into the production GIS database and made available to all. The turnaround time for the entire process is usually less than a day.

UCNSB has extended the use of the new system for the verification and correction of the utility's entire asset database, creating a highly accurate digital twin that reflects the true location of all transmission and distribution assets.

Read the full case study.

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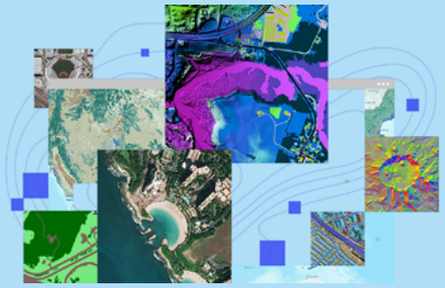
Creating the Digital Twin of Grenada from Imagery Data

The island nation of Grenada recognized the need to create data products for urban planning, economic development, emergency management, and natural-disaster preparation that will support future decision-making. Using topographic lidar and 20-centimeter-resolution imagery for the whole country, the government of Grenada was able to create a digital twin at scale. This 3D representation of Grenada includes accurate depictions of roads, building features, power lines, streams, vegetation, and more.

This digital twin was used to create maps such as a susceptibility map to test how infrastructure would be affected by a landslide. To do this, staff used ArcGIS Image for ArcGIS Online to develop GIS data from imagery provided by the governments of Grenada and the United Kingdom.

Three-dimensional geospatial digital twins are a powerful tool for aiding natural-disaster resilience. These are the foundation for flood and storm-surge modeling, and Grenada now can see exactly which buildings and infrastructure would be impacted in different scenarios.

Watch the presentation.



ArcGIS Image for ArcGIS Online is a complete offering for hosting, analyzing, and streaming imagery and raster collections. Save on infrastructure costs and maintenance using a secure, scalable, and performant cloud environment that quickly integrates imagery into all your workflows.

Real Time and Visualizations

Our world is transforming and rapidly becoming digital. Today, we are on the cusp of an Internet of Things (IoT)-driven technological revolution affecting most, if not all, industries. With billions of connected sensors deployed on assets and networks and in products around the world, companies are collecting and processing data at greater frequency and velocity. The challenge that continues to plague many organizations is not knowing how to make effective decisions from this data. Organizations are facing many new challenges and looking to technology to improve situational awareness, create operational efficiencies, and optimize all aspects of work.

While large-scale deployments of IoT technologies have improved the availability and timeliness of data, it can be difficult to connect these sometimes discrete and unstructured datasets. All sensors, assets, and networks have one thing in common: each is located somewhere. Location provides a common reference system to create relationships. An ArcGIS technology-based digital twin enables operations managers and staff to locate and monitor assets within a rich 3D, spatially accurate environment. The digital twin can also be incorporated with work management systems to identify the locations and specifications of assets prior to visiting the site. With the data available through a web browser, digital twins enable access to the information 24/7 on the user's platform of choice, including desktop, tablet, and mobile devices. The dashboard metrics provide valuable insights that can be used to reduce maintenance issues, extend life cycles, and achieve new levels of optimization.

ArcGIS Velocity℠ provides organizations real-time and big data processing and analysis capability in ArcGIS Online. ArcGIS Velocity allows you to import, visualize, analyze, store, and use data from IoT sensors. High-velocity event data can be filtered, processed, and sent to multiple destinations, allowing you to connect virtually any type of streaming data and automatically alert personnel when specified conditions occur. You can also design analytic models to process high-volume historical data and gain insights into patterns, trends,

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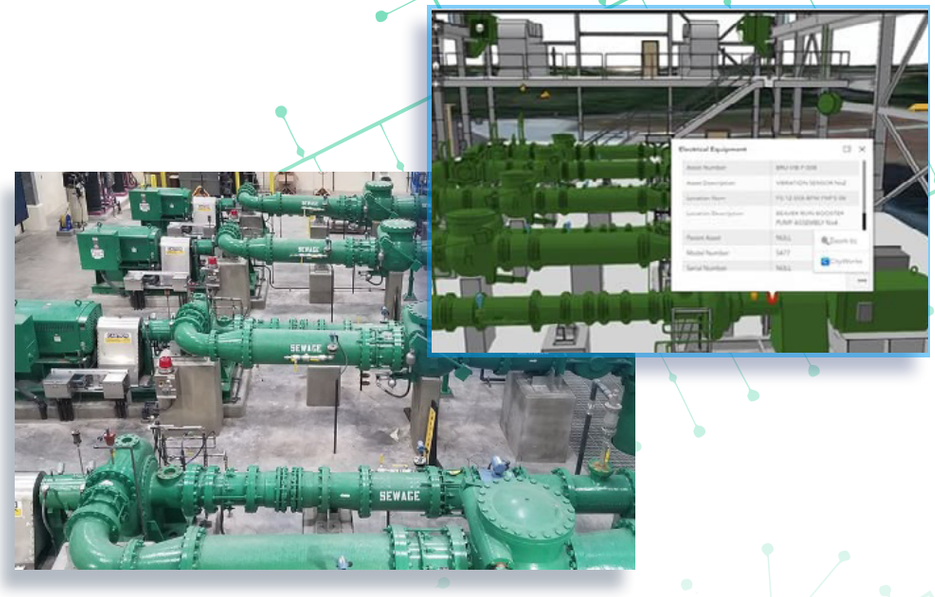
Gwinnett County Explores Digital Twins at Pump Station

Using Autodesk Revit, KCI Technologies developed a 3D building information model that is spatially accurate to within one inch and tied it to traditionally surveyed control points for a real-world location. The model was then converted to an Esri® ArcGIS 3D multipatch feature class format. In the GIS, assets and sensors were related to their functional systems and facility—achieving an easy-to-navigate 3D vertical hierarchy not present in most asset management systems. Moving from a model to the implementation of a true digital twin requires overlaying real-time data and storing it in the cloud for live and historical analysis.

To build a virtual representation of a site, information is integrated from a variety of sources, including lidar scans, subsurface utility locating, high-resolution drone imagery, and traditional surveys for ground control. The resultant point clouds, 3D surface meshes, and survey data offer a true and current as-built, often including abandoned and unknown infrastructure not present on plans.

Read the full case study.



> *"The model that was produced by KCI Technologies during this project proved that this type of information is not just for design engineers anymore. The model, as detailed and as complex as it is, can be made available in the field to frontline employees who benefit from it the most."*

- Charlie Roberts, Deputy Director
Gwinnett County Department of Water Resources

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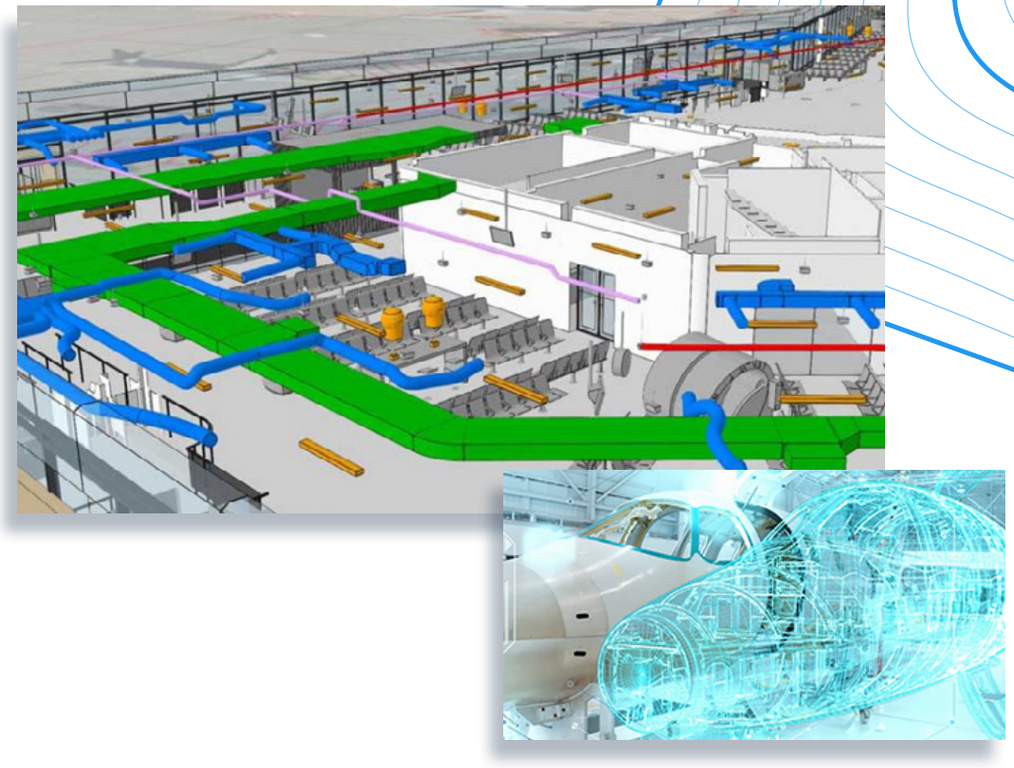
Digital Twin Helps Amsterdam Airport Schiphol Optimize Operations

Amsterdam Airport Schiphol—the world's 11th-busiest airport, the second-largest in terms of hub connectivity, and the main international airport of the Netherlands—facilitates the movement of passengers and cargo throughout the Netherlands and the rest of Europe. Schiphol implemented a digital twin known as the Common Data Environment (CDE), which organizes data from many sources—building information model data, GIS data, and data collected in real time on project changes and incidents as well as financial records, documents, and project portfolios.

CDE collects and processes data from remote sensors at the airport that are used in predictive maintenance. Within the 7,000-acre complex, the airport tracks and maintains more than 80,000 assets—both indoors and outdoors—ranging from linear networks, runways, and lighting systems to information booths and fire extinguishers.

Read the full case study.



Analyze and Predict

Access to the best information strengthens operational and strategic decision-making. Information has never been so abundant, and its ability to help organizations plan, respond, and coordinate has never been so pronounced. There is a growing and profound recognition that this insight not only improves current situational awareness but also is essential for understanding and forecasting future outcomes.

Some of the highest expectations around digital twins come from having the ability to use a high-precision digital twin to simulate, evaluate, and predict the future. In the energy industry, digital twins can be used to explore future demand of load based on population growth. In the architecture, engineering, and construction (AEC) industry, aggregated BIM information is used in the practice of virtual design and planned construction to detect possible conflicts or safety issues. At the scale of a city, planners want to be able to simulate future change, such as the shape of a new building, changes in a planned highway, or improvements to sea walls. Digital twins at all scales provide possibilities for simulations and analyses that can be used to understand and optimize current performance and forecast impacts of a potential change.

ArcGIS provides machine learning (ML) and artificial intelligence (AI) tools designed to solve complex spatial problems using **geospatial artificial intelligence (GeoAI)** to enhance the digital twin.

Below are the main patterns for GeoAI:

Object Detection

- Detection of objects from imagery/videos
- Land-cover classification

Change Detection

- Prediction
- Geospatial events and phenomena

Pattern Detection

- Statistically significant clusters and patterns

CUSTOMER STORY

Vegetation Encroachment Optimization with GeoAI

Vegetation encroachment monitoring is a critical task that needs to be performed on a regular basis to ensure the safety of both transmission and distribution networks. Utility companies operate tens of thousands of miles of power lines, yet missing a single tree growing too close to a power line can lead to massive wildfires or a power outage that affects thousands of consumers.

To minimize the risk of such events, typically an annual survey is performed on the entire grid by flying low-altitude crewed airplanes or drones equipped with lidar sensors. Using 3D feature extractions and image analyses, utilities are using this data to create 3D digital twins of their networks and the surrounding environment.

Using GIS machine learning models, analyses of power line and vegetation encroachment can now be performed at scale. This enables detailed assessment and assists in prioritizing planned inspection and maintenance work, saving thousands of work hours every year.

Using ArcGIS, accurate 3D models of the power lines and vegetation are created from lidar and imagery. Vegetation can be accurately modeled in relation to the power lines. Geospatial analysis tools detect if the vegetation is above, below, or intertwined with power lines. These models also are valuable for performing change detection following significant events.

CUSTOMER STORY

South Korean City Uses a Digital Twin to Meet Challenges

A South Korean city is using a digital twin to become a truly smart city by using its geospatial infrastructure to engage its agencies and the public to help meet challenges, both present and future.

Located on the northwest coast of South Korea and near Seoul, the nation's capital, Incheon is a major industrial center. Incheon anchors the west side of the Seoul Capital Area, the world's second-largest megaregion. As the world continues to urbanize, the region will get more crowded.

Incheon's digital twin mirrors many of the city's functions in real time. The real-world system it duplicates is no less complicated than Incheon itself. Since the beginning of the year, the Incheon digital twin has grown to include six project areas: fire response management, traffic, urban sanitation, facilities management, urban development, and city revitalization.

Incheon's digital twin is now being used to operate a flood-prediction monitoring system. This is an important development because the digital twin doesn't just mirror the city as it is in the moment; it can be used to predict events caused by changes in conditions in the city.

Read the full case study.

Share and Collaborate

GIS and mapping are essential for supporting a smarter world. GIS is a system for managing and applying geographic information, providing the fundamental language to create understanding. GIS connects people, organizations, and communities by improving communication and collaboration.

To create value from a digital twin, the information must be shared, allowing everyone to access and understand it. ArcGIS promotes user collaboration and interaction. Engagement starts with communication—connecting people in real time, using location-aware devices. ArcGIS empowers employees, customers, and executives with the information they need. Digital twins can be shared on any device via web maps, storytelling apps, or content-sharing hubs.

A story can effect change, influence opinion, and create awareness—and maps are an integral part of storytelling. ArcGIS StoryMaps℠ can give your narrative a stronger sense of place, illustrate spatial relationships, and add visual appeal and credibility to your ideas.

ArcGIS Hub℠ is an easy-to-configure community engagement software as a service (SaaS) that organizes people, data, and tools through information-driven initiatives. Organizations can leverage their existing data and technology and work together with internal and external stakeholders to track progress, improve outcomes, and create vibrant communities.

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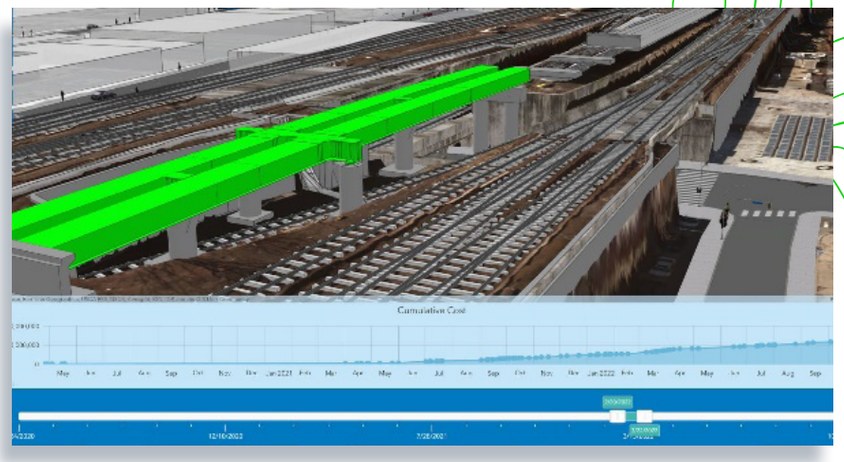
5D: The New Frontier for Digital Twins

Using GIS technology, HNTB pioneered a 5D project management strategy that integrated interactive 3D models with the additional dimensions of time and cost.

This 5D approach empowered leaders in a railroad project to track and predict how design changes might affect scheduling or construction costs and adjust their decisions accordingly. The ability of GIS to integrate different types of data and software in a cloud-native environment made it possible for anyone associated with the project to access the visualizations via a web browser.

HNTB established a web-based GIS strategy to drive the 5D project from the start, acting as a centralized, authoritative data source where information would be updated continuously and open to any team member—internal or external—who needed access. With that model in place, workers who went into the field to inspect the railroad track and take photos were able to upload such data directly into the GIS platform, making it available within a 5D view.

Read the article.



> *"A solution like this was critical because trying to convey these complex designs and this complex phase of construction is always a challenge for all the stakeholders."*

- Jeff Siegel
Director of Technology Solutions Center and Vice President of HNTB

CUSTOMER STORY

Uppsala Creates a Detailed Digital Twin to Enhance Sustainability

City planners in Uppsala, Sweden's fourth-largest city, are designing a new district with 33,000 new housing units to accommodate 50,000 new residents by 2050. Today, the municipality of Uppsala has 230,000 residents, and its population is expected to reach 350,000 by 2050—more than a 50 percent increase. Much of this expansion will occur according to Uppsala's comprehensive plan, but an area equivalent to 250 city blocks is being designed around green growth concepts.

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 3D model built with ArcGIS Urban help the planners visualize and present plans for the new city district.

The interactive 3D model gives users an impression of the future district in a way that written documents or 2D maps can't, allowing users to zoom and fly around new urban areas and get a good sense of what is coming. For city staff, the ability to quickly make changes and see the impact of alternative designs is helping to drive the adoption of new workflows and the use of new tools.

Read the full case study.

ArcGIS—The Foundation for Digital Twins

A modern GIS is a powerful tool used to represent a holistic digital twin in spatial context. Digital twins can address problems associated with understanding the historical events of an asset, monitoring current operational performance, and testing.

Any digital twin of a fixed asset or real-world system benefits directly from the inclusion of GIS data about the asset or system as well as its geographic context. Not only can GIS be used to create digital twins of natural and built environments, it also can be used to integrate many different digital representations of the real world.

GIS is the only technology that uses a simple key—location—to allow complex analysis of diverse data models and datasets. Geospatial digital twins, built with ArcGIS, can be explored on mobile devices, in a web browser, or through rich desktop applications from Esri and its partners.

GIS data also powers many simulations of real-world dynamics and behaviors. For simple analyses, such as investigating shadow impacts on a planned structure, 3D GIS provides dynamic, easy-to-use experiences in a web browser. For complex analyses, advanced geoprocessing workflows may be used to simulate changes in large utility networks and then to see those changes in a simple dashboard.

For decades, GIS has played a central role in helping customers model, analyze, and observe their assets and systems. New technologies, such as game engines and real-time data feeds, have added exciting possibilities to create richer interactive experiences for users to explore and analyze their assets and the world around them.

Esri is investing heavily in reality capture, building information modeling (BIM) integration, building systems integration, the analysis of Internet of Things (IoT) data, and related technologies and tools that will be used for creating the next great digital twins with ArcGIS.

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

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For more information, visit **esri.com/digitaltwin**.

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