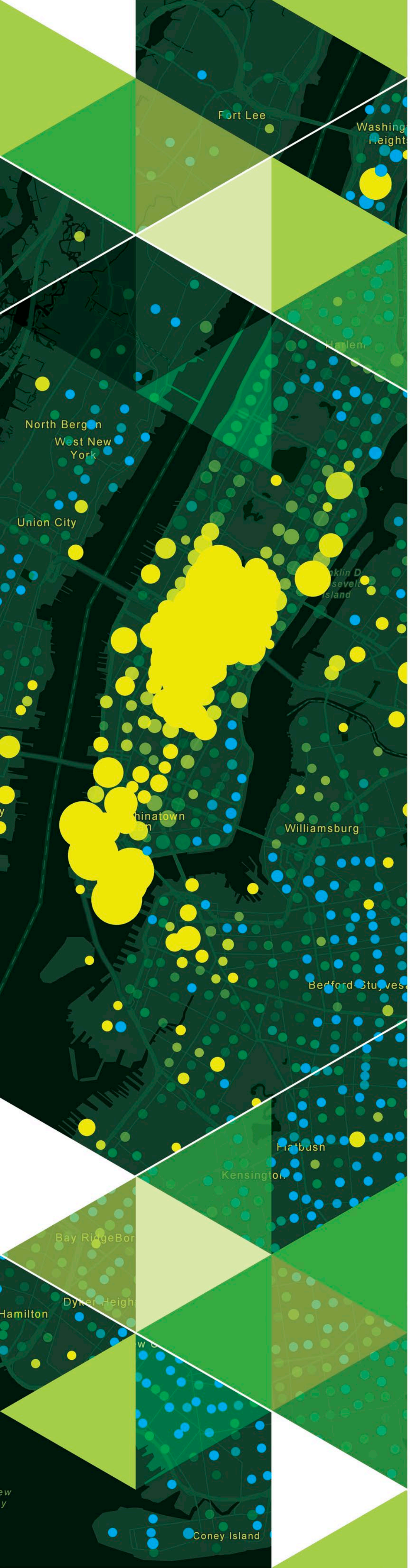

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GIS and BIM Integration: Common Myths and Practical Outcomes

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GIS and BIM Integration: Common Myths and Practical Outcomes

Executive Summary

Data and workflow integration across GIS and BIM help to realize greater efficiency, sustainability, and livability of cities, workplaces, and campuses.

The increased portability of geospatial data and intelligent digital models puts above- and below-ground infrastructure into context to improve safety and speed construction and maintenance. New technologies, such as Augmented Reality, offer the opportunity to use GIS and BIM information to achieve better understanding and faster validation from the office to the field.

Combined, BIM and GIS lead to smarter outcomes for communities and more efficient projects for AEC services providers.

In the 1980's and 90's, CAD and GIS technology emerged as competitive alternatives for professionals who needed to work with spatial information that was mostly processed using the prevailing media of the time, paper. In that era, the sophistication of software and capacity of hardware limited the scope of what could be done with computer-assisted technology for drafting and for map analysis. CAD and GIS appeared to be overlapping versions of computerized tools for working with geometry and data to produce paper documentation.

Driving toward fully digitalized workflows

As software and hardware have improved performance and become more sophisticated, we have witnessed the specialization of every technology around us, including CAD and GIS, driving toward fully digitalized workflows. CAD technology initially focused on automating manual drafting tasks. Building Information Modeling (BIM), a process to achieve efficiency during design and construction, has gradually pushed design tools away from drawing creation and toward intelligent digital models of real-world assets.

The models created in modern BIM design processes are sophisticated enough to simulate construction to find defects early in design and to generate highly accurate estimates of budget compliance throughout dynamically changing projects.

Likewise, GIS (geographic information system) has also differentiated and become deeper in capability. GIS can now handle billions of events from live sensors, serve visualizations from petabytes of 3D and imagery data to a browser or mobile phone, and perform complex predictive analysis scaled over multiple dispersed processing nodes in the cloud. The map, which started out as a paper analytical tool has been transformed into a dashboard for synthesizing complex analysis in a human-interpretable form.

To realize the full potential of integrated workflows between BIM and GIS, critical to domains such as Smart Cities and Digitalized Engineering, we need to examine how these two worlds can advance beyond legacy industry competition and toward complete digitalized workflows that will allow us to disengage from centuries-old paper processes.

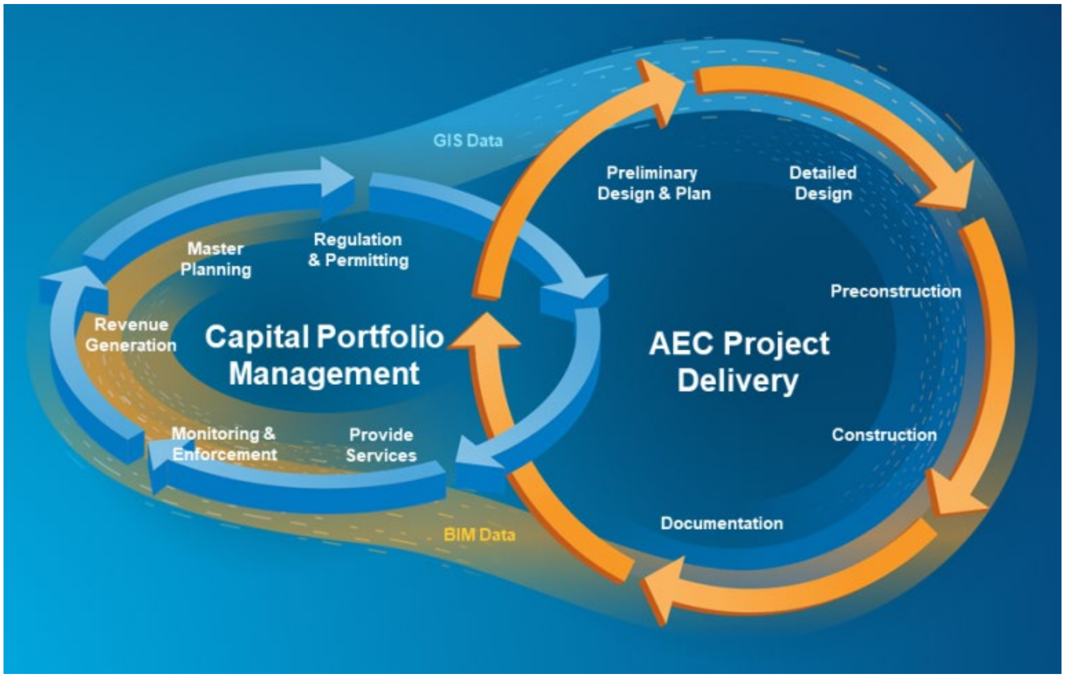

Figure 1: The purpose of BIM-GIS integration is to enable the workflows for building assets and for managing them. There are not discrete, well defined hand-offs between these two workflows.

Myth: BIM is for…

In the GIS community, one of the more common definitions of BIM is based upon outside-in understanding of the BIM world. GIS users frequently pigeonhole BIM as simply for facilities management, visualization, 3D modeling, or that it is only for buildings. Unfortunately, none of these truly represent what BIM is primarily used for, though it may extend or enable some of these capabilities or functions.

Essentially, BIM is a process for saving time and money and achieving high confidence outcomes during the design and construction process. The 3D model generated during BIM design processes is a byproduct of the need to coordinate a design, capture an as-is structure to assess demolition costs, or to provide a legal or contractual record of a change to a physical asset. Visualization can be part of the process in that it helps humans understand the dynamics, characteristics, and aesthetics of a proposed design.

As Autodesk expresses it, the ‘B’ in BIM stands for ‘Building, the verb’ not ‘Building, the noun.’ Autodesk and other vendors have worked with the industry to infuse the concepts of BIM process in domains such as rail, roads and highways, utilities, and telecommunications. Any organization that manages and builds fixed physical assets has a vested interest in making sure their design and engineering contractors use BIM processes.

BIM data can potentially be used in operational workflows for asset management. This is stated, for example in the new ISO standards for BIM that have been informed by the United Kingdom's BIM mandate. Even though these new proposals are focused on use of BIM data in the full lifecycle of an asset, it's still clear that construction cost savings are a primary drive for BIM adoption.

Integrating GIS technology with BIM becomes more complex than just reading graphics and attributes from a 3D model and showing them in GIS. To really understand how information can be used across BIM and GIS, we often find that we have to redefine our concept of a building or a roadway and to understand how customers need to use a wide range of project data in geospatial context. We also find that focus on the model sometimes means we've overlooked simpler, more basic workflows that are essential to the whole story, such as using accurately collected field data on a construction site to link location and model data for inspection, inventory, and survey.

Ultimately, we'll only achieve common understanding and results if we 'cross the aisle' to work in combined teams to bring diversity to problem solving.

Myth: BIM automatically provides GIS features

One of the more difficult concepts to convey to a non-BIM user is that the BIM model that looks like an accurate bridge or building doesn't necessarily have the features that make up the definition of a building or bridge for mapping or geospatial analysis purposes.

Esri has experienced this issue first-hand with work on new experiences for inside-the-building navigation and resource management, such as ArcGIS Indoors. Developers have expected that with our work on Autodesk Revit data, we would automatically be able to extract common geometries such as rooms, spaces, floorplans, the building footprint, a building shell or even the navigation mesh for how a human would traverse the structure.

All of these geometries would be highly useful for GIS applications and for asset management workflows, yet none of these geometries is necessary to construct the building and doesn't typically exist in a Revit model.

We are examining technologies to calculate these geometries, but some offer complex research and workflow challenges. What is the watertight, shrink-wrapped shell of a building? Does it include the foundation? How about balconies? What is the footprint of a building? Does it include overhangs? Or is it only the intersection of the structure with the ground?

To guarantee that BIM models contain the features needed for GIS workflows, owner-operators will need to define specifications for that information before design and construction begin. Much like classic CAD-GIS conversion workflows in which the CAD data are validated before being converted into a GIS, the BIM process and the data that results from it need to specify and include features that would be used during lifecycle management of a structure, if that is a goal of creating the BIM data.

There are organizations around the world, typically governments and operators of controlled campuses or systems of assets, that have started to require lifecycle features and attributes to be included in BIM content. In the US, the Government Services Administration is driving new construction through BIM requirements. Agencies like the US Department of Veterans Affairs have gone to great lengths to detail out BIM elements, such as rooms and spaces, that will be useful in facility management after the building is constructed. Airports, such as Denver, Houston, and Nashville have strict control of their BIM data and the resulting documentation frequently contains highly consistent content. We expect to see more of this in the future.

Figure 2: Data shared from George HW Bush Houston International Airport (shown here in Esri's Web AppBuilder for ArcGIS) demonstrates that if BIM data are standardized, typically through drawing validation tools, then it can be consistently brought into GIS. Typically, we see construction information in BIM models before we see FM-related information.

Myth: There is a file format that can provide BIM-GIS integration

In classic enterprise integration workflows, one table or format could be mapped to another table or format to reliably enable transmission of information between different technologies.

For several reasons, this pattern is increasingly inadequate to handle the needs of 21st century information flows:

- Information stored in files is hard to stream
- Data mapping across complex domains is poor
- Data mapping implies incomplete duplication of content across systems
- Data mapping is often unidirectional
- Technology, data collection, and user workflows are changing so quickly that today's interfaces are guaranteed to be less than what tomorrow will require

In the push to true digitalization, a digital representation of an asset needs to be accessible quickly in a distributed environment that can be updated and upgraded to adjust to complex query, analysis, and inspection over time and across the lifespan of the asset.

One data model cannot encompass everything that could be integrated in BIM and GIS across highly diverse industries and customer needs, thus there is no one format that can capture the entirety of this process in a manner that could be quickly accessed and bidirectional. We expect integration technologies to continue to mature over time as BIM becomes richer in content and as the need to use BIM data in GIS context for lifecycle asset management becomes more critical to sustainable human habitation.

Myth: You can't directly use BIM content in GIS

Conversely to the discussion about finding GIS features in BIM data, we often hear that it's not reasonable or possible to directly use BIM content in GIS for reasons ranging from semantic complexity to asset density to asset scale. The discussion about BIM-GIS integration typically turns toward file formats and Extract, Transform, and Load (ETL) workflows.

In fact, we are already directly using BIM content in GIS.

Last summer, Esri introduced the ability to directly read a Revit file in ArcGIS Pro. At that time, the model could be interacted with in ArcGIS Pro as if it was composed of GIS features and then transformed to other standard GIS formats through manual effort, if desired. With ArcGIS Pro 2.3, a new layer type called a Building Scene Layer allows a user to encapsulate the semantics, geometry, and attribute detail of a Revit model in highly scalable format built for GIS experiences. The Building Scene Layer feels like a Revit model to the user while allowing interaction using standard GIS tools and practices.

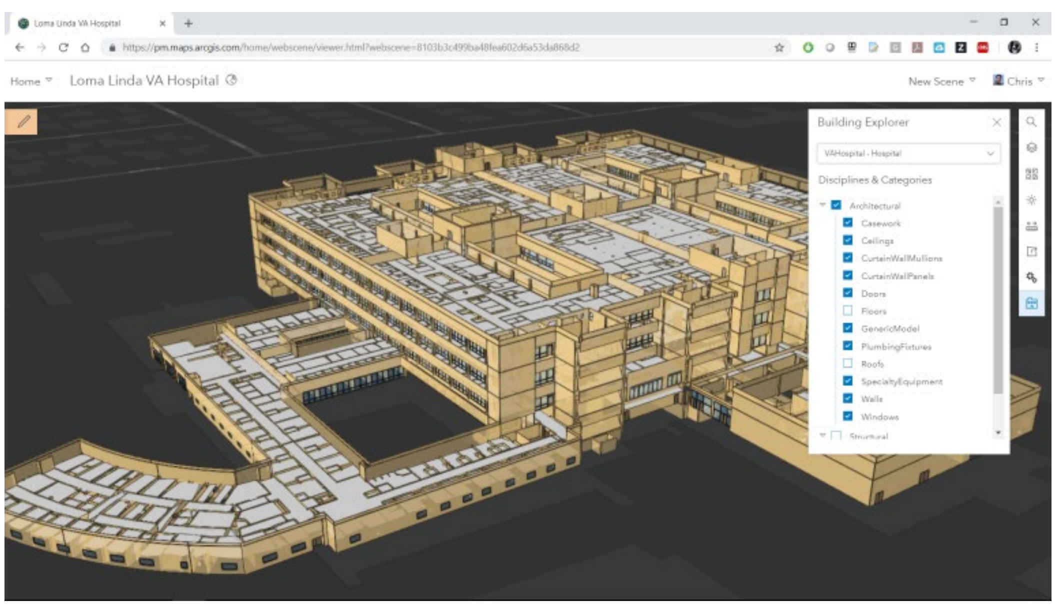

Figure 3: Thanks to the US Veterans Administration, we've been able to experiment with a hospital as a Building Scene Layer, preserving geometry, attributes, and semantics in the GIS.

Myth: GIS is the perfect repository for BIM information

BIM documentation is often the “legal record” for recording business decisions and compliance information for construction defect analysis and lawsuits, tax and code assessment, and as a record of a deliverable. In many cases, architects and engineers are required to stamp or certify that their work is valid and meets the requirements of their specialty and applicable laws or codes.

At some point, it’s conceivable that GIS could be a system of record for BIM models, but that could be years or decades away, anchored by legal systems that are still computerized versions of paper processes. We are looking at workflows to link assets in GIS to assets in BIM repositories so that customers can take advantage of the versioning and document management required in the BIM world alongside the ability of a map to put asset information in rich geospatial context for analysis, understanding, and communication.

Integrating information across BIM repositories and GIS will be greatly assisted by standardized information models in GIS and BIM that allow applications to reliably link information across the two domains. That doesn’t mean that there will be a single information model to capture both GIS and BIM information. There are too many differences in how the data need to be used. But we do need to be sure that we build flexible technology and standards that can accommodate the use of information across both platforms with high fidelity and conservation of information content.

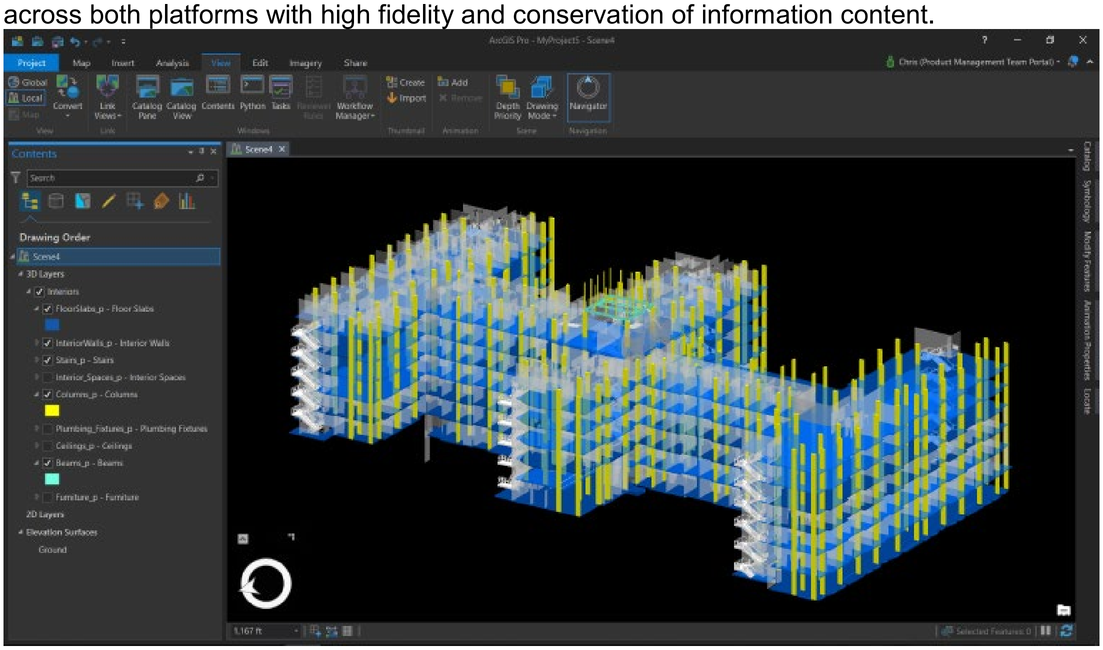

Figure 4: The University of Kentucky uses rigorous drawing validation to make sure that the right data are in the BIM data to support full lifecycle operations and maintenance.

GIS and BIM integration patterns that we adopt today need to be ‘future proof’ so that we can work together toward a more sustainable future. To capitalize on technology advancements, we need to create integrated teams and partnerships to propose solutions to complex problems that impact whole systems, not discrete, stove-piped workflows. We also need to fundamentally shift toward new technology patterns that can address integration issues with more robustness and flexibility.

Before today's era of digitalized workflows, projects began with 2D designs, moved to 3D physical mockups, and then became real-world infrastructure.

Now, the architecture and engineering industries are moving beyond drawings toward 3D models with project-centric attribution as the focal point of communication during construction and design. This has led to broad worldwide shifts where structures, infrastructure, campuses, and even cities are being built and contextualized digitally first.

Smart Communities Need Data: Seeing Buildings and Infrastructure Before They're Born

As the world experiences rapid urbanization and population growth, communities have become the focal point for the flow of information between the operational and capital asset construction workflows. Communities that meet the needs of citizens using a strategy that includes consuming, analyzing, and using information about the natural and built environments in the decision-making process are termed smart communities.

Smart communities foster a data-rich environment. They make data accessible to citizen, business, and government groups while meeting privacy needs and supporting public safety. Data-rich communities work to actively or passively detect change. That change can be in noise levels, transportation needs, or utility usage. Most communities that are considered smart already use GIS. Many of these smart communities are already actively investigating BIM-GIS integration because they realize that a more streamlined flow of information between operational and construction life cycle data will allow them to more accurately plan, fund, and maintain community infrastructure assets.

AEC projects typically generate large quantities of documentation during construction and after assets are commissioned that will be useful during the life cycle of assets. This documentation is often not accessible to users through GIS dashboards and analysis tools.

Esri has been working with multiple AEC industry vendors that are experts in BIM technology. In November 2017, Esri and Autodesk announced an industry collaboration to research and build new workflows between products from each company to their common customers to achieve better integration between BIM and GIS and address many of those pain points.

Esri's work with Autodesk will include transforming the project life cycle, providing continuous context of the site and the environment around BIM projects, and detecting site change. In addition, improvements are planned for the overall process for designing and visualizing the real world in 3D and building technologies to help optimize infrastructure operation.

Figure 5: Demand for 3D capability continues to grow. Esri has addressed this demand by expanding 3D layer types, creating a web-based 3D viewer, and adding new features to the ArcGIS platform, as illustrated by this web scene of the city of Philadelphia.

What's Next for BIM and GIS

BIM and GIS together are helping lead to smarter outcomes for communities and more efficient projects for AEC services providers. This will require more than just the collaboration of software vendors. Local governments and asset management organizations will need to establish specifications for BIM information that introduce attributes early during the design process to be used later in operations and management workflows.

For major urban areas, this will mean creating multiple standards across transportation, utilities, and architecture projects that may impact many agencies. Working with Autodesk and others, Esri will have to build workflows that allow users to reliably access, update, and use standardized BIM data in spatial context throughout the life cycle of assets.

Esri is working to make it easier for GIS professionals to query, visualize, and connect timely BIM data in familiar GIS experiences. Similarly, Esri is already working on delivering better access for architects and engineers to GIS data from within industry-standard design and construction tools.

Combining geospatial information, field auditing, data capture workflows, and detailed design information helps all stakeholders achieve comprehensive awareness and understanding of the projects that will sustain and improve the world around us.

Case Studies

Three Real World Examples of merging BIM and GIS

1 DC Demonstrates the Portability of the District's Digital Twin

The National Capital Planning Commission (NCPC) provides overall planning guidance for federal land and buildings in the National Capital Region. The agency oversees long-range planning for future development and monitors capital investment by federal agencies.

As new buildings and development projects come along, NCPC evaluates them while working with established planning constraints and laws. Among these laws and policies is the Height of Buildings Act—a law that dates back to 1910 when Congress established the city's horizontal look and layout.

The local District government also governs the look of the city and recently updated its zoning laws which hadn't been rewritten since 1958. Zoning laws impact the city landscape and skyline. To explore the impacts of zoning on the city skyline and layout, NCPC staff created an interactive 3D application and model to serve as the foundation of a digital twin for the city. Planners can use the 3D app to study how updated DC zoning codes might impact views.

NCPC planners created a number of real-time visualization workflows to see and analyze the impact of policy decisions. The digital twin allows NCPC to test different scenarios based on different inputs in real time, giving them a sense of what types of policies they might create to preserve the character of the city.

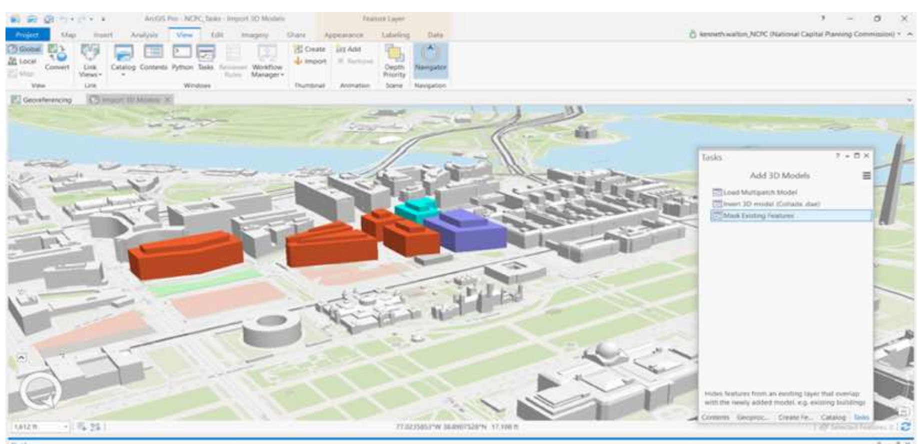

Figure 6: An accurate 3D base model provides the foundation to explore planning scenarios.

NCPC planners piloted an early proof-of-concept augmented reality (AR) application that joins the digital and virtual worlds. By projecting a detailed digital model in real-world context, AR gives planners a chance to experience a development before it is built. Using this AR experience, a user can walk around and view the scene through their device to see how the model looks from different vantage points.

2 HS2 Inserts Modern Infrastructure Under an Ancient City

In the greater London area, a joint venture of Skanska, Costain, and STRABAG is designing a high-speed rail line in a unique way. The partners are responsible for the urban segment of this project that involves threading a new tunnel into a complex urban environment. The effort involves diverting major utilities, precise tunnel work to avoid existing infrastructure, and demolition work. To achieve these tricky maneuvers and minimize disruption, the team is combining 3D GIS of the terrain and built environment with 3D BIM to provide team members a comprehensive, interactive, 3D view of new infrastructure in its geographic context.

GIS helps stakeholders see the project modeled with interrelationships such as terrain and structures around the rail line, including underground utilities. BIM provides a detailed 3D view of the structure being built. With the combined tools, planners can see a 3D model in context before they break ground—which can prevent rework and cost overruns.

For this project, 3D modeling technologies are also the digital sandbox that allows planners to stand in a location and see a proposed construction from any angle, within the environment it will inhabit. This allows designers and stakeholders to see the internal and external context of buildings during the concept stage.

In a 2017 report, the UK Get It Right Initiative that is dedicated to driving errors out of construction found that the industry lost £21 billion—or 21 percent of its annual revenue—to late design changes, ineffective communication, and poor coordination.

The pairing of GIS and BIM technologies helps the joint venture to see relationships between the built environment and planned structures. With that vision, they can plan for contingencies and avoid surprises during construction.

3 Ohio State Integrates GIS and BIM and Expands Access Campus wide

The Ohio State University (OSU) spans 16,000 acres and 1,283 buildings across six regional campuses. This infrastructure rivals that of a small city. To keep track of maintenance and help direct the more than 60,000 students to where they need to be, OSU has created detailed GIS and BIM models of its campuses and buildings. Work is ongoing to capture all buildings in BIM, with 500 completed so far.

OSU's Facilities Information and Technology Services (FITS) department recently undertook an effort to integrate buildings and geospatial data to prevent isolated or redundant implementations. It now provides a single point of truth within an integrated platform that brings together its utilities, construction, space management, facility maintenance, and other operations.

The shared GIS Maps interface provides answers to questions about buildings and available transportation options. Related information includes each asset's location, condition, and general specifications, such as its square footage and the materials used in its construction. Links to leases, CAD drawings, and other documents are also available.

OSU's design and construction and real estate departments make extensive use of GIS Maps. The real estate department tracks all university parcels, easements, and leases. Non-GIS staff develop map documents for real estate transactions. To support planning efforts, the GIS analyst creates maps for meetings of the board of trustees.

This data is now being leveraged to create purpose-built applications to address specific operations. FITS created a Shut Off Valve application that includes data from both BIM and GIS along with sensors to monitor water, steam and fuel pipelines. The app helps maintenance crews monitor these critical networks and to find the right shut-off valve should a failure occur.

OSU envisioned a system to give all operations staff access to all the data they need to do their jobs. Pulling data from previously siloed systems exposed data gaps that it has begun to collect.

OSU is well on its way to creating an intelligent 3D model or digital twin of the existing facility, which greatly enhances the support for facilities management, maintenance, and safety.

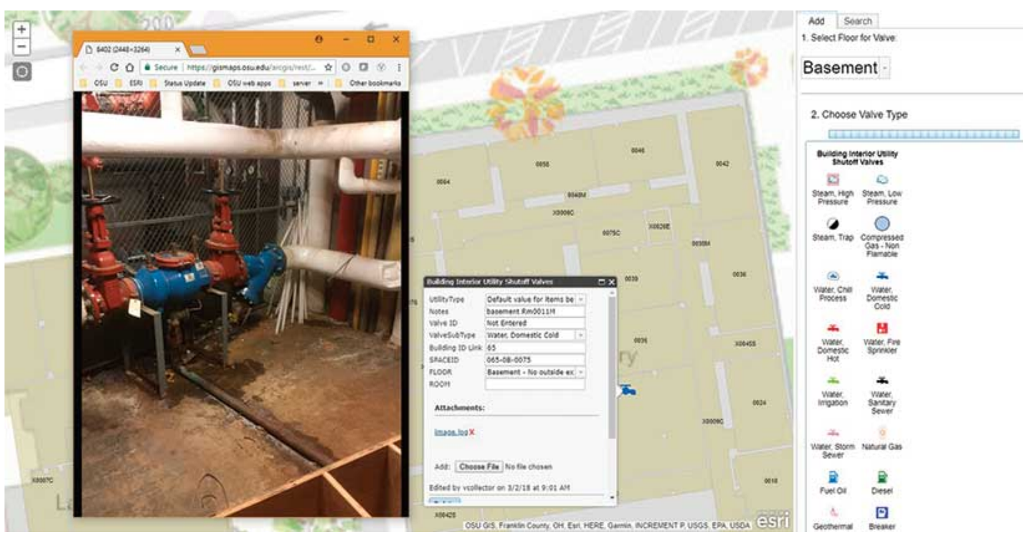

Figure 7: Asset management apps include the Shut Off Valve application, which collects and updates the location of shutoff valves both inside and outside many OSU buildings and includes pictures of the valves to assist in locating them.

About the Authors

Chris Andrews is an experienced product manager and technology leader who thrives on solving problems, establishing high performance teams, and connecting people and businesses in positive collaborations. Chris started off as the senior product manager for 3D across the ArcGIS platform at Esri. Five years later, Chris now leads a team of product managers with responsibility for ArcGIS Hub, ArcGIS Excalibur, 3D, ArcGIS Urban, AEC/CAD/BIM offerings, ArcGIS Business Analyst, and more. Chris has focused on strategic innovation, defining and driving to production new products at top-tier software companies. He strives to positively impact millions of users through better experience and by connecting data and technology to solve problems. He is active on social media and provides mentoring on 3D, product management, and technical career growth.

Esri, the global market leader in geographic information system (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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