Esri News
for Facilities
Fall 2012

Advice from a Rocket Scientist—How NASA LaRC Uses GIS to Manage Facilities

Langley Research Center (LaRC) is one of about a dozen National Aeronautics and Space Administration (NASA) facilities located in Hampton, Virginia, at the mouth of the Chesapeake Bay. LaRC is the oldest facility, and its roots are firmly entrenched in aeronautical research. LaRC scientists strive to improve the earth by studying the atmosphere. This provides a better understanding of the conditions planes and spacecraft fly through, making it safer for both civilian and military planes, as well as quieter and more efficient. LaRC staff also work above the atmosphere, analyzing materials and structures to help spacecraft withstand the unforgiving environments they will meet in space.

From Space to Speedos—Facilities Are Important

When swimsuit manufacturer Speedo wanted to develop a new, faster swimsuit, it called on LaRC researchers. With their expertise in drag reduction, gained through years of studying aircraft aerodynamics, the researchers were able to develop better fabric—tested in a Langley wind tunnel. This fabric now comprises suits worn by champion swimmers the world over.

The wind tunnels are an obvious asset to the LaRC facility. These unique structures require special care due to their extensive horizontal

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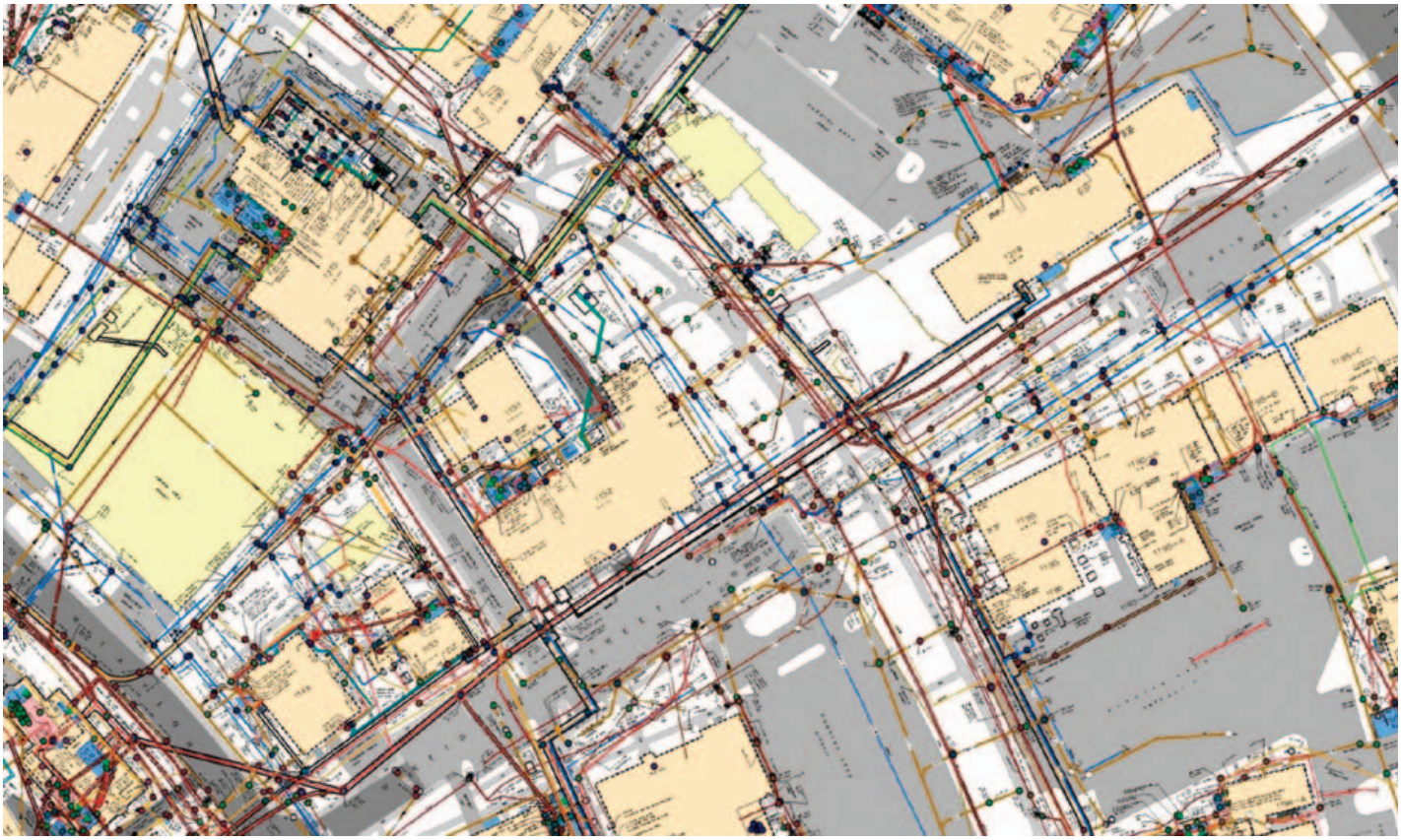

↑ The unique structures at the LaRC facility require special care in managing the infrastructure for power, cooling, and high-pressure air and other gases.

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Cornerstone

Shelli Stockton
Global Facilities Industry Manager, Esri

Collaboration is a theme that I have been thinking about for a while now. When managing facilities, collaboration is necessary. Whether we are collecting building information, finding the best solution for space usage, or planning and adequately managing physical assets, we can't work on an island.

This issue of *Esri News for Facilities* takes this theme and looks at it in a few different ways. HNTB presented an interesting paper at the Esri International User Conference (Esri UC) this past summer and has adapted this into a story on how integrating building information modeling (BIM) and lidar data with ArcGIS provided a better way for its client to view information.

The National Aeronautics and Space Administration (NASA) always seems to be pushing the envelope, and how it manages facilities is no different. Brad Ball, the director of NASA's Langley Research Center (LaRC) GIS, shares some insights on how he has successfully introduced GIS and brings to the table an interesting idea to carry collaboration even farther outside the walls of NASA to other agencies.

Public and private partnerships are also very important. Nonprofit organization CyArk discusses how GIS is helping preserve historic sites through capturing engineering accurate data to the point that these sites, if harmed, can be rebuilt.

Collaboration is what our facilities community is all about. If you think about it, this is a very green idea too—we all benefit from buildings that are better run and use fewer resources.

Advice from a Rocket Scientist—How NASA LaRC Uses GIS to Manage Facilities

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infrastructure, including power, cooling, and high-pressure air and other gases, to stay operational. Understanding and maintaining this unique environment led LaRC to find a better way to manage its data and provide decision support tools to use at the facility. The facility team looked at GIS and was drawn to the technology's ability to manage, view, and analyze data in a holistic manner.

Today, the LaRC facility contains 800 acres of housing and 280 facilities with an estimated replacement value of approximately $3.5 billion. Facilities management at LaRC includes managing approximately 6,000 rooms that contain close to four million square feet of building data. All the information needed to run this massive organization is managed by the LaRC operations directorate's GIS team. The team utilizes a vast information technology structure, and ArcGIS is an important part of that solution.

Simple Concepts Manage Complex Infrastructure

"LaRC GIS staff members try to apply two simple concepts anytime we engage in an effort," explained William "Brad" Ball, GIS team leader at LaRC.

The first concept is to pursue the most stringent requirements. For example, when addressing geodetic control, measurements should be to a few millimeters. Utility and facility locations are to be measured to a few centimeters, and aerial imagery should provide two-inch resolution

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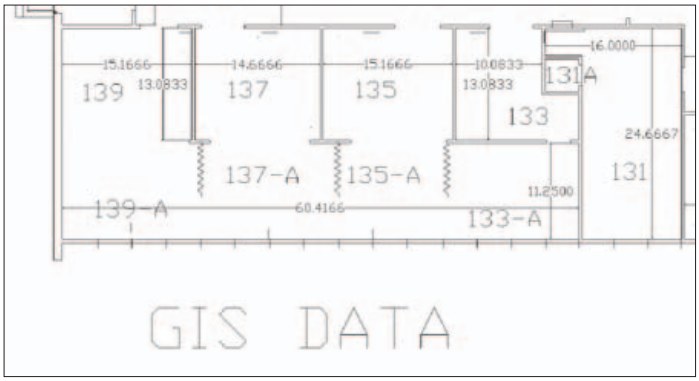

↑ Building data, such as as-built data and laser scans, can be aligned with georeferenced building data to solve inaccuracies in collected data.

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and comparable accuracy. A similar attention to detail is also adhered to when interior building measurements are taken.

The second concept Ball expects his staff to engage in is data integration. "I want all possible data uses brought together," said Ball. "Then, I want to publicize the data as widely as possible, where security concerns allow, of course."

These approaches allow the LaRC facility team to use and reuse data. The data is made even more available by providing access to it on the web. Using an integrated process like this allows team members to view all the data and flag any potential problems quickly.

"Sharing data gives us the benefit of many eyes with different perspectives looking at it and quality checking," said Ball. "This means we are using our limited resources as efficiently as possible."

The result: the LaRC GIS website supports approximately five million hits a year.

From As-built Comes Better Building Management

More than a decade ago, the LaRC team realized that there was tremendous value associated with integrating building interior data and GIS. At that time, the team was supporting the organization with spatial data management and decision support tools. As the team began pursuing using facilities data, the owner of the data would not allow the GIS process to do anything but publish the data exactly as it existed in as-built drawings.

To address the challenges, Ball's team developed a process that consumes the building spatial data directly from the drawings, then translates, scales, and rotates the data to align with the georeferenced building outline. Using this process, Ball's team could use the data. To date, approximately 20 layers of information have been consumed, including fire system components, automated external defibrillators, handicap accessible features, and electrical panels.

Again using Ball's integration concept, data is tied into LaRC's space utilization, real property, and master plan processes. Database tools are used to address day-to-day processes such as figuring out statistics describing the use of buildings, move management, demolition coordination, and organization change projection tools.

Space Optimization and Beyond

"The most recent and possibly revolutionary twist to our implementation approach has been our Space Utilization Optimization tool," Ball said.

This tool not only automates optimization of any available space in a facility but also allows users to manually drag and drop and fine-tune data including which organizations or personnel should inhabit a space. The automated optimization operates under a series of constraints and metrics that Ball's team set up. Metrics can include any commodity that can be modeled such as energy efficiency, carbon footprint, safety, or

↓ The NASA LaRC facility contains 800 acres of housing and 280 facilities with an estimated replacement value of approximately $3.5 billion.

security concerns. The constraints include rules such as minimum and maximum areas for various types of employees. In the system, managers require their own offices.

Current metrics in the LaRC administrative model deal with synergy within and between organizations, move costs, and lighting costs. Optimization can be applied to address both tactical, or short-term, needs and strategic, or long-term, goals. The LaRC team has found that an optimization run can generally improve the modeled cost of metrics by a factor of two, meaning the new configuration will be twice as efficient as the original.

Seeing the Buildings through the Spatial Trees

LaRC staff employs a unique user interface to support presenting and interacting with the optimization tools. The interface consists of spatial tree diagramming, which was developed so the user can see all bases, facilities, buildings, rooms, or personnel across a wide geographic area. Since there are millions and millions of square feet, the interface uses an abstract representation of any space in question.

Because ArcGIS is used as the underlying functionality, the visualization or symbolization can be based on any data available. For example, instead of square footage, a user can easily change the information displayed to represent operational cost, or perhaps the commodity rendered. Any rooms larger than 1,000 square feet can be shaded in red, or heating costs per space can be thematically displayed to find outliers that may require attention.

This abstraction makes it easier for staff members to process quickly. For detailed information, including realistic renderings, the interface also links to maps and building layouts. The user simply clicks on the feature in the image in question, and the actual floor plan is opened.

NASA is patenting this technology to be used outside its walls. "We developed a process to automatically consume any building-level vector data that exists and link it with any attribute data that is available," said Ball. Currently, LaRC is using this technology to prototype more efficient use of facilities for partners, including the US Navy.

Creating Alliances

"Much can be accomplished in the area of facilities management with meager resources; LaRC GIS is living proof," said Ball. "All it takes is a few technologically savvy and motivated individuals to start the effort."

Ball also pointed out that much can be addressed by partnering, especially within and between government entities. LaRC GIS has kicked off and partnered on numerous initiatives across many government entities over the years.

"It is much easier if top-down management support exists, even if there is nothing else other than a prototype," said Ball.

However, in some instances, the LaRC GIS team has resorted to the "build it and they will come" philosophy in an effort to overcome legacy processes.

"In our instance, alignment with principal users, such as Space Utilization, Real Property, and Master Plan, contributed to our success," said Ball. "Now integration with other functions, such as maintenance, communications, safety, and security, are starting to be better understood."

Extending a Helping Hand

This fall, the LaRC GIS team delivered a briefing on its building interior data management and decision support capability, including the Space Utilization Optimization tool. The briefing was presented to the 7th Annual International Facilities Management Association (IFMA), hosted by the Federal Facilities Council (FFC) Public Policy Forum in Washington, DC.

IFMA is the international association for facility management professionals and supports almost 23,000 members in 78 countries that together manage more than 37 billion square feet of property. The association meets regularly around the world and certifies facility managers through accredited programs.

This IFMA briefing was by invitation only. Approximately 150 attendees came to listen to congressmen and executives from organizations including the GSA Office of Federal High-Performance Green Buildings, the Public Buildings Sub-Committee of House Transportation and Infrastructure Committee, the High Performance Buildings Congressional Caucus, and the National Capital Planning Commission (District of Columbia Southwest).

"We hope this is a first step to additional outside partnering initiatives," said Brad Ball, GIS team leader at LaRC. "By working together, we can advance the use of GIS for managing facilities more effectively. It's a winning situation for everyone involved."

For more information, contact Brad Ball at William.b.ball@nasa.gov.

Use It or Lose It

Where GIS is first placed can also be critical. "My experience has been that linking the GIS to organizations that routinely use the data versus organizations that perform oversight or process functions, such as IT groups, has generally produced superior results," said Ball.

Additionally, use of interns is a very affordable approach to facilitate initial development as well as major changes to any program, including GIS.

"Finally, I suggest building FM [facilities management] on top of core technologies like GIS and a robust RDBMS as opposed to pursuit of third-party products," said Ball. "This simplifies customization to align with your organization's workflow."

For more information on how GIS can help facilities managers, visit esri.com/fm.

Preserving the Past for Future Generations

Modern 3D Technology Creates an Enduring Record of Fragile Historic Monuments

"Our goal is to preserve these sites and spread information about them throughout the world. Using GIS and 3D imaging technology, we are able to aid in archaeology and conservation by extending an image to include animation and visualization and investigate these sites and structures in new ways."

Tom Greaves, Executive Director of CyArk

In 2002, Ben Kacyra founded California-based nonprofit CyArk (archive.cyark.org) to apply accurate, portable laser-scanning technology to preserve the world's cultural heritage sites. This data is analyzed and made available for visualization in ArcGIS.

Kacyra originally developed the scanning technology for documenting nuclear power plants, oil refineries, and other industrial and civil engineering structures. CyArk's methods are fast and accurate. Pulsed lasers generate 3D point clouds, which render surfaces at an accuracy within millimeters. Combined with high-resolution photography and traditional surveying techniques, the data points make it possible to create highly detailed media—architectural drawings, photo-textured animations, 3D fly-throughs—that digitally preserve knowledge about heritage sites and help protect the information against natural disaster, war, and neglect while also making the sites accessible to the world. Among the sites already digitally preserved are the Mayan temples in Mexico, the Leaning Tower of Pisa, and Mount Rushmore.

↓ Scott Lee of CyArk captures the front facades of Mission Dolores in 3D with a Leica C10 time-of-flight scanner.

"Our goal is to preserve these sites and spread information about them throughout the world," said Tom Greaves, executive director of CyArk. "Using GIS and 3D imaging technology, we are able to aid in archaeology and conservation by extending an image to include animation and visualization and investigate these sites and structures in new ways."

GIS for Heritage Preservation

Laser scanning is only the start of the process. CyArk has taken advantage of Esri's nonprofit program and uses ArcGIS to incorporate supplementary datasets such as historic maps, photos, and up-to-date geographic data. For many projects, analysis is required for research and modeling, and this is also done in ArcGIS.

As an example, ArcGIS and terrestrial lidar were used for mapping historic structures and landscapes at ancient Merv, which is in the deserts of the central Asian nation of Turkmenistan and has been designated a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO). UNESCO promotes international cooperation among its 193 member states and 6 associate members in the fields of education, science, culture, and communication. The ability to use topographic and hydrologic analysis tools in combination with detailed lidar data created new information to better aid conservation.

At Merv, CyArk worked with its partner, the University College London's Institute of Archaeology, to document multiple earthen architecture (adobe) structures and the immediately surrounding landscape. In the 1950s, a large earthen canal was carved through the desert to feed the cotton fields of the former Union of Soviet Socialist Republics (USSR). The vast dirt canal allowed huge volumes of water to seep into the surrounding landscape and has drastically raised the water table of the area. As a result, each year's rains are no longer quickly absorbed by the soil, causing pooling and water basins near the wall foundations of adobe structures that have stood anywhere from 700 to 2,300 years. These ancient monuments have therefore begun suffering catastrophic collapse in the last few decades as the bases of walls have eroded. The laser scan data was used to record the structures in their current state as well as the surrounding landscape. A detailed contour map of the terrain was then created at approximately 10-centimeter intervals. The contour data was brought into ArcGIS, and a digital elevation model (DEM) was created. From the DEM, powerful hydrologic analysis tools in ArcGIS were used to map water flow and identify problems around some of the threatened structures. With this information about the natural drainage paths and basins causing dangerous pooling, site archaeologists can improve water drainage away from the structures, helping mitigate erosion and collapse.

Defining a UNESCO Site

CyArk, along with other organizations, has been hard at work preserving the California Mission Trail—El Camino Real ("the Royal Road")—with digital technology. This 600-mile historic route stretches from San Diego to north of Sonoma and maps out the Spanish colonization of California. The route contains many historic buildings including missions, presidios, and pueblos. This is an important project, as it is helping lay the groundwork and initial research required for nominating the route as a UNESCO World Heritage Route. While parts of the historic route have been preserved in their original state, there are many segments that have been upgraded and are now part of the California modern-day highway system, including US Route 101 and State Route 82. There have been many changes since the route began in 1769. Understanding the original contextual landscape that lies underneath today's urban landscape will take a lot of effort and funding. CyArk has received almost 10 percent of the seed funding for this vast undertaking, which will digitally preserve the route and its 21 missions, 4 presidios, 3 pueblos, and numerous other buildings.

↑ This 1823 map of El Camino Real highlights the coastline (black), the trail (red), key waterways, and structures (yellow dots).

The first mission the CyArk team members tackled is close to them—Mission Dolores of San Francisco. Dolores was founded June 29, 1776, and is reported to be the oldest intact building in San Francisco, as well as the oldest original intact mission along the route. The mission also lies adjacent to the San Andreas Fault, making it a fragile yet invaluable resource. The mission cemetery contains the remains of many significant members of San Francisco and California history including thousands of Native Americans.

Scanning the Past

In mid-July, CyArk's Scott Lee and Alexander Rienhold began the digital preservation process to document Mission Dolores. Fieldwork was conducted using two terrestrial scanners, the Leica C10 and the smaller FARO Focus3D. The first day began with scanning the exterior of the building and the cemetery. At the end of the first day, CyArk had captured over 75 scans with the two scanners, including panoramic images to provide color information to create photo-realistic 3D data.

The mission interior was scanned on the second day, including the loft and attic. Jaime Pursuit, development manager with CyArk, joined Lee and Rienhold in the field to meet with some prominent visitors, lead a tour, and introduce the technology being employed. One of the documentation team's most interesting discoveries was the original

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wood beams in the attic (from 1776), which were tied together with leather straps that still had animal hair on them.

"As a trained archaeologist, this was a delightful surprise and evidence of this mission's authenticity," said Rienhold.

At the end of the day, the FARO scanner was lowered from the attic into a two-foot gap between the current altar and the original adobe wall. The original adobe is covered in Native American murals, protected by the detached modern wall. The gap was narrow, limiting access, but the team managed to capture parts of these original works. Although three days of fieldwork were planned, the two scanners worked flawlessly and with speed and precision, and the team completed the work by the end of the second day.

Mapping the Mission Route

CyArk staff members went back to an original map from 1823, which was provided by the Santa Barbara Trust for Historic Preservation, and used that to locate the route and the sites themselves. The map was registered to modern-day maps using ArcGIS. "Combining this very old information from 1823 meant that they didn't quite match up great with the newer maps, but our intention is to create some visualizations for the public to understand how El Camino Real looked in the past," said Greaves.

Views of each century will be re-created so people can see the change of the mission route throughout the years. The Royal Road is not necessarily recognizable in certain parts—where once an orange grove and sloping hills defined the view, now it is paved, and passersby see only the gas stations competing on either side.

These views of the road will also be combined with photo-realistic 3D models derived from the laser scan data and digital photos. "Combining these technologies and being able to navigate from one site to the other is something that we could barely do even two years ago," said Greaves. "Now we are able to create materials from this data that will be compelling for students, researchers, and the general public. Now you can visit more sites virtually than you could ever hope to otherwise."

Other applications only made possible by the combination of engineering-grade information and georeferenced data include seismic refits, which are especially helpful for the missions. El Camino Real follows the San Andreas Fault, which created a natural valley in California. "It's not a question of if—it's when—an earthquake happens," said Greaves. "We'll be able to understand how these structures were built. There are many possibilities for engineers and architects to take advantage of this rich dataset."

For more information on how lidar can be used with ArcGIS for 3D mapping, visit esri.com/lidar.

↑ The FARO Scanner inside the Attic

↑ ArcGIS displays a polyline representing the western coastline as defined by the 1823 map. It has been overlaid for comparison with modern satellite imagery.

↑ Earthquake damage to Mission San Juan Bautista is seen here as a number of small, hairline cracks.

Bringing GIS and Cityworks *Inside* to Help Meet Sustainability Goals

Sustainability is generally understood as the measurement, management, and reduction of energy consumption and carbon emissions/carbon footprints to reduce both environmental impact and operating costs. Influences driving recent attention in sustainability range across governmental regulation, environmental concerns such as global climate change, and the ever-increasing costs to care for facilities.

Cityworks, software from Esri partner Azteca, based in Sandy, Utah, is a customer care, service request, and work order management system that is used in public works and utility departments around the United States. The software helps city staff manage any feature in a geodatabase: water, wastewater, storm water, streets, signs, traffic signals, parks, and facilities, for example. Using a geodatabase gets rid of redundant data and helps staff manage work more effectively.

While Cityworks (and ArcGIS, for that matter) is most often associated with managing infrastructure and other assets outside, this is only part of the story. Buildings, floors, and rooms also have geography that can be mapped and analyzed. Beyond design and construction, ongoing maintenance is more efficient and effective when facility asset data is managed in a GIS. Cityworks users have long recognized the inherent benefits of GIS, using the GIS database as the asset repository to manage outside infrastructure; many now leverage the same technology to inventory and manage assets indoors.

Why Cityworks for Inside

Buildings have huge environmental footprints. In 2010, facilities directly accounted for nearly 40 percent of primary energy use, 12 percent of water use, and 60 percent of all nonindustrial waste. And the processes used to produce and deliver energy to facilities for heating, cooling, ventilation, computers, and appliances accounted for 40 percent of US greenhouse gas emissions. Thus, the need to better understand and manage the performance of publicly owned buildings and facilities has approached center stage.

Sustainability use cases include the following:

- Operations and maintenance—From changing a series of light bulbs in a library to refinishing the floor of a fire station, preventive maintenance ensures the appropriate performance of publicly owned assets while extending the useful life of the facility over time.
- Energy management—Visualizing and tracking energy usage within a building allows operators to discover and optimize usage by location and time of day within a building.
- Building thermal efficiency—Assessing energy "leakiness" with GIS helps facilities maintenance personnel locate and remedy costly environmental issues.
- Space usage—Operational costs are reduced when existing space is utilized more efficiently, which often lowers capital cost by mitigating the need to build or acquire additional facilities. GIS helps facilities managers visualize and organize space usage through the distribution of personnel, assets, and storage of materials.
- Solar potential—The ability to determine the solar potential of an individual rooftop is an inherently geographic problem. Both public and private entities are utilizing GIS to identify buildings with the potential for the best return on solar investment.
- Climate action plan—A GIS-based, campus-wide greenhouse gas inventory, including landscape irrigation requirements, tree canopy analysis, estimated storm water runoff, and the effect of solar reflectivity, allows the informed development of a range of possible sustainability measurement and action steps including identification of on-site renewable energy sources.

Better Stewards of the Built Environment

Facility sustainability is directly related to ongoing care and maintenance. GIS is a natural fit in managing spatially related assets and understanding their relationship across a variety of business functions. Reduction of energy and water usage, efficient and effective waste disposal, and preventive maintenance all reduce the carbon footprint of a building.

Today's economic pressures, government regulation, and public opinion all demand that facilities managers find sensible ways to increase efficiencies and the overall sustainability of publicly owned buildings. Extending GIS and Cityworks inside to manage the care and maintenance of assets associated with everything from a light switch in a single room to an entire community center is proven to achieve these goals. These enabling technologies provide facilities managers and executives with the appropriate tools to be better stewards of the built environment.

For more information, contact Tom Palizzi at tpalizzi@cityworks.com.

Cityworks®

Evaluating Data Readiness for Deploying Applications: Campus Place Finder Example

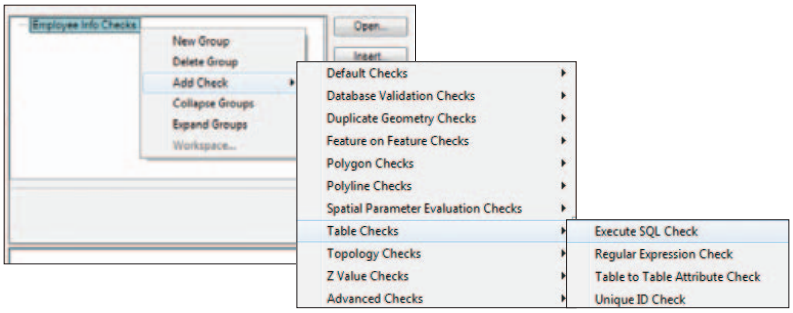
As organizations seek to improve the efficiency and effectiveness of their operations, there is often a need to leverage their GIS data in new and innovative ways. This is especially important when an organization deploys spatially enabled applications and services that provide the *where* context to a business process. Many of these applications, which may have been developed in-house or downloaded from ArcGIS Resources, enable users to leverage geographic information, visualize trends, and publish web maps to support business process improvement. For applications to provide reliable results, the underlying data must adhere to a set of new business rules that may not have been envisioned when the data was originally created.

ArcGIS Data Reviewer can help ensure that data is prepared to support the deployment of these applications. The Campus Place Finder application can illustrate this. The application requires specific attributes to be populated for building interior spaces, building floor plan lines, and employee information table. Data Reviewer checks allow users to define rules to quickly identify features and attributes that might cause the Campus Place Finder to produce erroneous results. In this article are some sample checks and demonstrations of how they can be configured in a batch job.

Create a batch job

A Data Reviewer batch job enables users to configure, organize, and store multiple Data Reviewer automated checks to be run repeatedly to validate data.

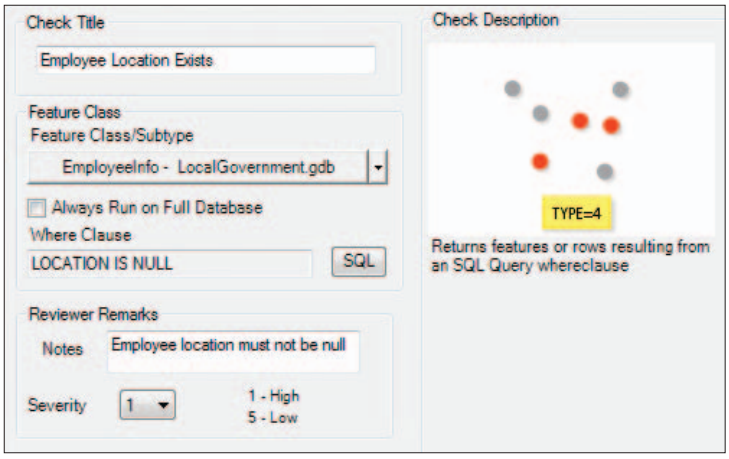
1. Start ArcMap and add the EmployeeInfo table and BuildingInteriorSpace feature class from LocalGovernment.gdb.
2. Click Reviewer Batch Job Manager on the Data Reviewer toolbar.
3. In the top window of Reviewer Batch Job Manager, right-click to create a New Group.
4. Rename the group Employee Info Checks.
5. Right-click the new group and choose Add Check > Table Checks > Execute SQL Check.



Configure an Execute SQL check

The Execute SQL check allows users to validate conditions based on a combination of attribute values. For the Campus Place Finder application to work as designed, ensure employee locations are not null.

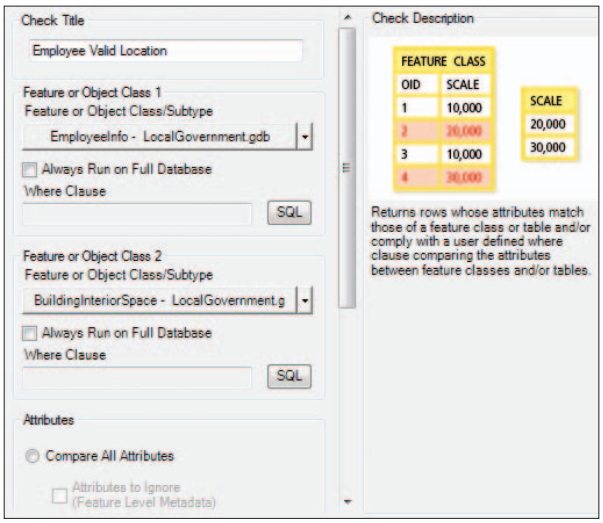
1. Add a check title: Employee Location Exists.
2. Select the feature class on which to run the check: EmployeeInfo – LocalGovernment.gdb.
3. Click SQL and create a query that describes the error condition: LOCATION IS NULL.
4. Enter reviewer remarks: Employee location must not be null.
5. Choose a severity: 1.
6. Click OK.



Add a Table to Table Attribute check to the batch job

The Table to Table Attribute check allows users to compare attributes between two tables. For the Campus Place Finder application to work as designed, ensure that the employee location is valid.

1. Right-click the group, select Add Check > Table Checks, and choose Table to Table Attribute Check.
2. Add a check title: Employee Valid Location.
3. For Feature or Object Class 1, choose the table to be checked: EmployeeInfo – localgovernment.gdb.
4. For Feature or Object Class 2, choose the table against which the data will be checked: BuildingInteriorSpace – Localgovernment.gdb.
5. Choose Compare All Attributes and then click Select Attributes.
6. On the Compare Attributes dialog box, choose LOCATION for Data Source 1 Attribute. Set Operator to =. Choose SPACEID for Data Source 2 Attribute.
7. Click Add and OK.
8. Check the check box for Not – find rows that do not match.
   Note: Choosing this returns records in which employee LOCATION is not equal to a building interior space SPACEID.
9. Provide reviewer remarks: Employee must have valid location.
10. Choose a severity: 3.
11. Save the batch job by clicking Save As.
12. Exit Reviewer Batch Job Manager by clicking OK.



Execute the batch job

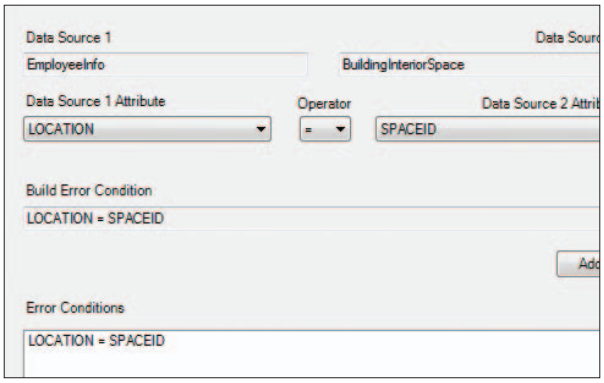
After creating a Reviewer batch job with the checks in the previous steps, execute it to identify the issues in the data.

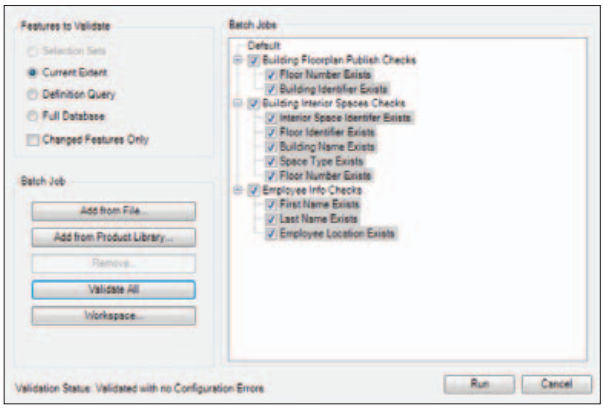
Note: Running a batch job requires being in a Reviewer session.

1. Click the Reviewer Batch Validate button on the Data Reviewer toolbar.
2. Under Features to Validate, choose Current Extent.
3. Add the batch job from its saved location using Add from File.
4. Validate checks by clicking Validate All.
5. Click Run to execute the batch job.

The two checks configured above can help quickly assess whether data is ready to support the deployment of the Campus Place Finder application. They are by no means the only set of checks that could be built; however, they do provide a great starting point for using Data Reviewer. Leveraging Data Reviewer enables users to gain valuable insight into their data's overall quality and identify information gaps early, which makes the deployment of any application more successful.

Content contributed by Joan Steurer and Karen Lowery





ArcGIS 10.1 Simplifies Sharing of Geographic Information

Esri's latest release of its flagship software ArcGIS provides many new tools for facilities managers including enhanced handling of 3D data, 64-bit architecture at the server level, and more mobile applications that bring facilities mapping to anywhere in the building.

Users are already finding that ArcGIS 10.1 makes it simpler to put mapping and geospatial analytics into the hands of more people. GIS professionals can now deliver any GIS resource as a web service. These resources include, but are not limited to, maps; spatial analysis tools; and different file types containing location data, such as shapefiles, and KML, GPX, and CSV files.

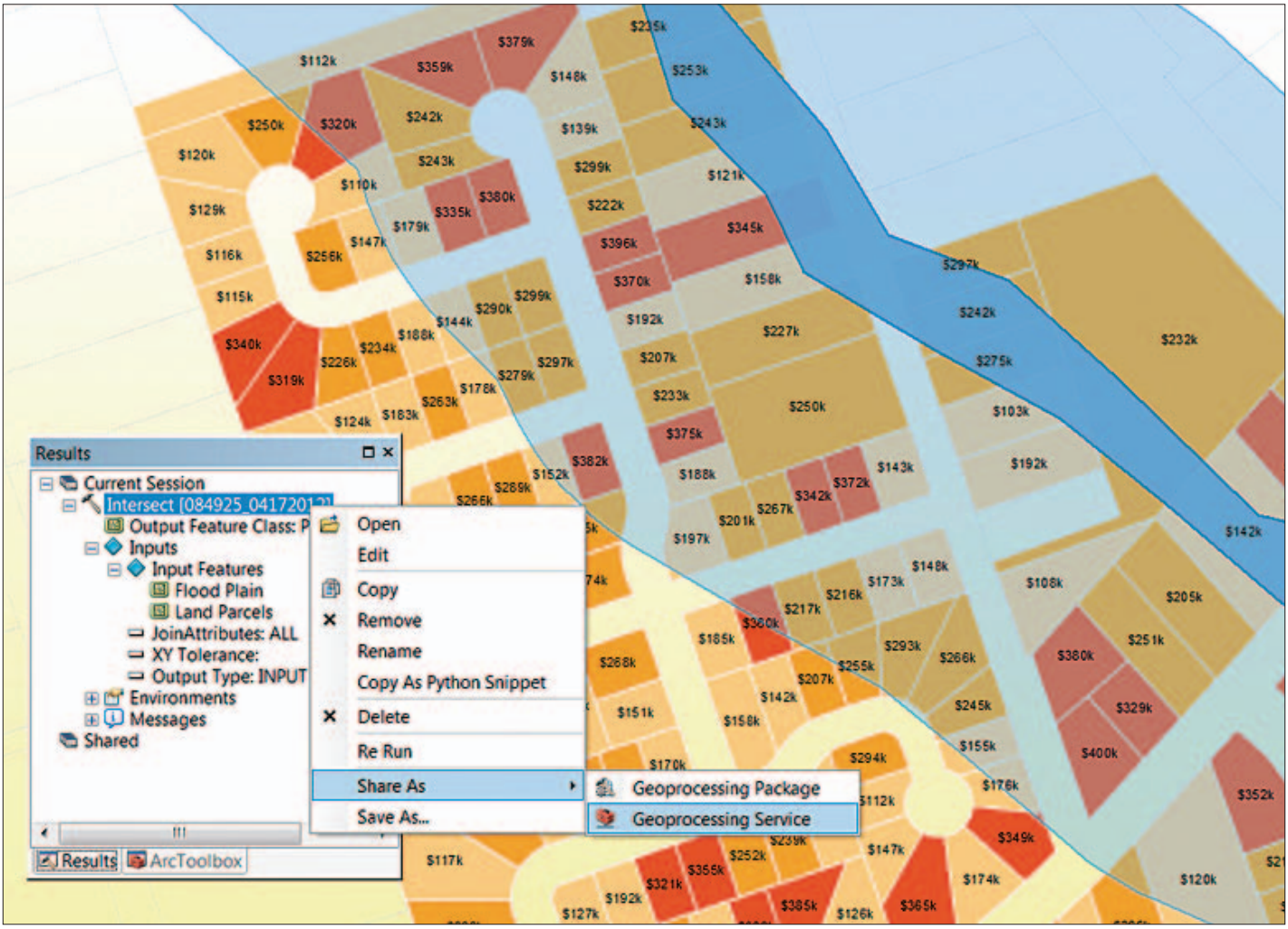
This newest release encompasses a host of improvements that will satisfy desktop, server, and mobile users, as well as provide developers with a richer, more accessible environment in which to build, test, and deploy applications and solutions.

Desktop

ArcGIS for Desktop has hundreds of new improvements at 10.1. Many of them make it easier to create and share content, while others improve a user's ability to clearly visualize the patterns and trends in complex data. A user can edit virtually any aspect or component of a map, including feature-level metadata. ArcGIS for Desktop also has dozens of new spatial analysis tools, such as spatial autocorrelation, which allows users to predict and explain things better.

Esri is advancing a new world of 3D GIS. One of the ways this is being done is through the integration of Esri CityEngine into ArcGIS 10.1. CityEngine provides users with a unique conceptual design and modeling solution for the efficient creation of 3D cities and buildings.

In addition, imagery is further integrated into the ArcGIS system. Enhanced tools for analyzing, creating, and editing mosaic datasets simplify all aspects of working with large collections of imagery and raster data



↑ Above is an example of sharing a geoprocessing service from a desktop in ArcGIS 10.1.

in ArcGIS. Imagery is easier to add to ArcGIS with the introduction of raster product support that automates the setup of functions to process traditionally complex data. The imagery also looks better, with many new ways to enhance its appearance; and automated image-to-image georeferencing enables images to be easily georeferenced to each other for better analysis.

ArcGIS 10.1 directly supports lidar. Lidar Log ASCII Standard (LAS) files can be directly viewed as point clouds, surfaces, and rasters, enabling access to a wealth of information, such as ground surface information, tree canopies, or the structure of buildings and electrical lines. Users can take advantage of combining lidar with other features to perform QC of lidar data; change classifications; and view, measure, and perform analysis. Lidar can also be served directly as image services, making lidar data accessible to large numbers of users.

At 10.1, desktops are connected to servers more than ever before. A user can author a beautiful map, a model, or analytics and simply right-click and send it over to a server. The server then caches the data, tiles it, and makes it available as either feature services or visualization services. In other words, a user doesn't have to be an administrator to create services—he or she can take whatever work is done in ArcGIS for Desktop and then deploy it immediately and share it as services. This is also true for imagery.

Server

The primary engine for geospatial infrastructure is ArcGIS for Server, which allows users to turn any location-based resource into a fast, dependable service that can be used in web, desktop, and mobile applications.

At 10.1, ArcGIS for Server is completely rearchitected, making it much easier (and quicker) to install. It is now a native 64-bit application that runs on Windows and Linux. Servers can be deployed on physical, virtualized, and cloud infrastructures or any combinations of these.

Administration tools make ArcGIS for Server more versatile and secure. ArcGIS for Server has a completely new architecture that does away with the previous server object manager/server object container model. Instead, ArcGIS for Server is deployed as a "site." A site can contain one or more GIS server machines, each running ArcGIS for Server. This new architecture makes installation much easier, but more importantly, it simplifies the process of adding and configuring new GIS servers to the site. The Manager application has been redesigned to simplify remote access and provides an improved look and feel for managing services, deploying server object extensions, and monitoring server logs. Sites can be organized into clusters, which can be configured to run dedicated subsets of services. ArcGIS for Server includes an administrative API for scripting complex or repetitive tasks, including setting e-mail alerts when a service is unavailable, querying log files, or granting permissions to services.

In addition to these back-office capabilities, ArcGIS for Server includes a collection of ready-to-use services, such as the geometry service (for an expanded set of geometric calculations), the search service (for creating a searchable index of an organization's GIS content), and the print service (for configuring high-quality printing in web applications).

All editions of ArcGIS for Server (Basic, Standard, and Advanced) include Spatial Data Server, a separate installation that allows feature-service-only access to geometries, attributes, symbols, and template information for vector data stored in a database or geodatabase. In addition, ArcGIS Web Adaptor, an optional setup, is included for configuring a custom URL for a site with multiple machines and integrating with an organization's web server security model.

Mobile

The world is becoming increasingly mobile, which is why Esri supports a spectrum of mobile platforms—both with open SDKs that are customizable for developers and with end-user applications that can be downloaded from application stores and marketplaces. These applications can be used to access intelligent web maps and also to share data. In this way, crowdsourced information can be exploited, with every person a sensor. This will affect how people approach science, public service, and citizen engagement. It also affects people's ability to take GIS with them wherever they are and access knowledge in context.

Developer

Esri continues to support multiple platforms and APIs for application development. The new ArcGIS Runtime SDK for WPF and Java allows developers to build applications that are fast and easy to deploy, plus they have a small footprint. In addition, Esri now has two levels of Esri Developer Network (EDN)—Standard and Advanced. EDN Standard includes ArcGIS Runtime SDK and has optional add-ons for ArcGIS Online and ArcGIS for Desktop (Basic, Standard, or Advanced). EDN Advanced also includes ArcGIS Runtime SDK, ArcGIS Online, and ArcGIS for Desktop Basic, and all ArcGIS for Desktop extensions. Developers have the option to add ArcGIS for Desktop Standard or Advanced to EDN Advanced.

Online

Underlying many of the powerful sharing capabilities in ArcGIS 10.1 is ArcGIS Online (read the article on page 14 to find out about this important technology that is helping carry ArcGIS into the future).

For more information about ArcGIS 10.1, visit esri.com/whatsnew.

A New Pattern for GIS

ArcGIS Online for Organizations Unlocks Geospatial Assets

ArcGIS Online provides facilities managers with a cost-effective, simple solution for providing comprehensive building data to those who need it.

ArcGIS Online for Organizations instantiates a different pattern of GIS that is about solving new problems, not doing the same things on a new platform. Released in June 2012, it extends the benefits of GIS to everyone in an organization. Because it is integrated with ArcGIS for Desktop and ArcGIS for Server, maps and other products created by GIS professionals can be directly accessed by other members of an organization.

ArcGIS Online is an open data platform for maps and geographic information. This subscription-based service in the cloud makes content and tools directly available to an organization through intelligent web maps and applications that can be accessed from web clients, the desktop, and mobile devices such as smartphones and tablets. Non-GIS professionals can quickly create maps from the unstructured information in spreadsheets and text files and share these maps with others on any device. Through this common infrastructure, knowledge workers, managers, and even casual users can interact with the data and use information derived from it to get work done.

An annual subscription provides a private instance of Esri's secure, multitenant cloud that's scalable and ready to use. No additional hardware or software is needed to access basemaps and other content for creating and sharing maps and applications. Any user associated with an ArcGIS Online organizational account can quickly share maps

↑ With ArcGIS Online for Organizations, administrators can apply fine-grained management and customize appearance and functionality.

by embedding them in a website or blog, through social media, or using a preconfigured web application template. The catalog of these maps and applications can be shared with specific groups, the entire organization, or the public. Note that organizations retain all rights, title, and interest to any content they publish in ArcGIS Online.

Extending ArcGIS Online

Initially, ArcGIS Online was made available through two types of free accounts: anonymous and personal use. Both account types are for personal, noncommercial use. ArcGIS Online for Organizations facilitates the pervasive use of geographic information for all types of uses.

Organizational use extends these capabilities considerably beyond making maps and mashups to creating map services and the unrestricted use of APIs, applications, and tools for commercial purposes. Registering data/services on ArcGIS Online makes them accessible from any device (browsers, mobile devices, and tablets) so anyone can use, make, and share maps. In addition to purchased subscriptions, ArcGIS Online can be deployed on premises. The two approaches, cloud and on-site, can also be blended in a hybrid solution.

With any of these scenarios, ArcGIS Online supplies fine-grained management and customization specific to an organization. It supports three roles: administrator, publisher, and user. Administrators can publish and use content, monitor service consumption, manage users, delete content and groups, determine security policy, and customize the appearance of their instance of ArcGIS Online. Publishers can publish and use content. Named users are the primary consumers of the content and can view and edit content made available by the organization.

The annual subscription plan for ArcGIS Online for Organizations is structured to be flexible. Plans begin with five named users and 2,500 service credits. A service credit entitles an organization to consume a set amount of ArcGIS Online services (e.g., storage for feature services, geocoding). Credits can be used in whatever fashion best fits organizational workflows. More users and service credits can be added to the plan at any time. Organizations that have an existing enterprise license agreement (ELA) with Esri receive an ArcGIS Online subscription with a certain number of service credits allocated and unlimited users.

New Insights

Making geospatial content accessible to anyone can create new insights and opportunities for organizations. On-demand and self-serve mapping frees GIS professionals from routine map requests and lets them spend more time creating and publishing authoritative information products. It also fosters better collaboration among teams and departments that can interact using intelligent web maps.

For more information about ArcGIS Online, visit esri.com/agol.

Find Out the Latest in Government GIS

Find out the latest in government GIS including facilities. Come to the Esri Federal GIS Conference in Washington, DC, February 25–27, 2013, for three valuable days of learning and networking. Take part in unmatched opportunities:

- Explore trends and policies driving GIS projects such as open government initiatives and cloud-based GIS.
- Gain proven strategies for managing your GIS program.
- Develop your technical skills.
- Connect with GIS users and experts.

There will be more than 100 conference sessions including technical sessions led by experts, user sessions focused on case studies and best practices, and Federal DevGo sessions just for developers. New ArcGIS for National Government sessions, showcasing Esri's comprehensive government solutions, and the Federal GIS Solutions EXPO, featuring products and services from more than 70 government solution providers, will also be available for attendees.

Last year, the agenda included the ArcGIS for Facilities and GeoDesign and Analysis for Urban Planners and Facility Managers technical workshops and a session on facilities management and community outreach.

Don't miss this year's sessions, workshops, and more.

For more information and to register, visit esri.com/fedgis.

A Technology Trifecta: Lidar, BIM, and GIS

"Historically, information regarding water quality, water quality improvements, and physical features of water were located in separate departments at MMSD."

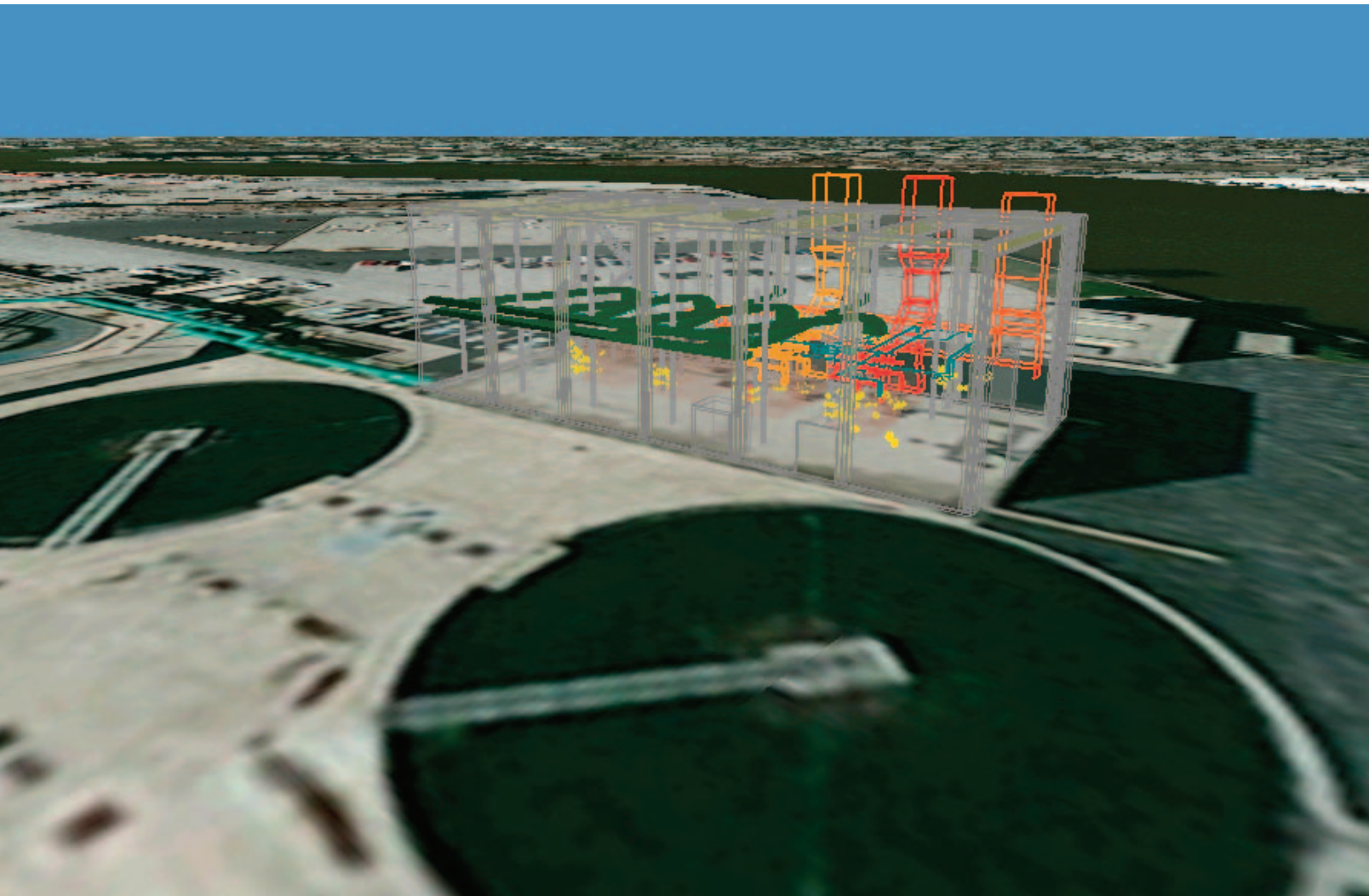
Jeff Siegel, GISP, Associate Vice President of HNTB

While Milwaukee is the twenty-sixth largest city in the United States, its regional wastewater system is among the largest, most sophisticated, and well run in the country. *Innovative* is one word to describe the successful district. In 1926, its Jones Island water reclamation plant became the first facility to produce fertilizer as the by-product of the water reclamation process, and the district continues to push the envelope by producing an organic fertilizer known as Milorgranite.

Milwaukee Metropolitan Sewerage District (MMSD) provides wastewater services for 28 municipalities housing about one million people. The district's 411-square-mile planning area includes all cities and villages except the city of South Milwaukee. Serving these municipalities requires MMSD to develop spatial inventories and applications that meet internal and external needs for planning and design. Like any large facility, many of these efforts began organically within single departments to answer a specific need for one project.

To more readily facilitate the consolidation of facilities data information, MMSD called on HNTB, a national, employee-owned infrastructure firm, to conduct a practical research project that pilots a data management approach for lidar and building information model data. The project specifically studied the practical business applications integrating 3D design and construction data from an aeration system rehabilitation project into MMSD's enterprise GIS environment.

↓ Below is an interactive viewing of the 3D geodatabase in the ArcGIS Engine application, including dynamic symbolization of features.

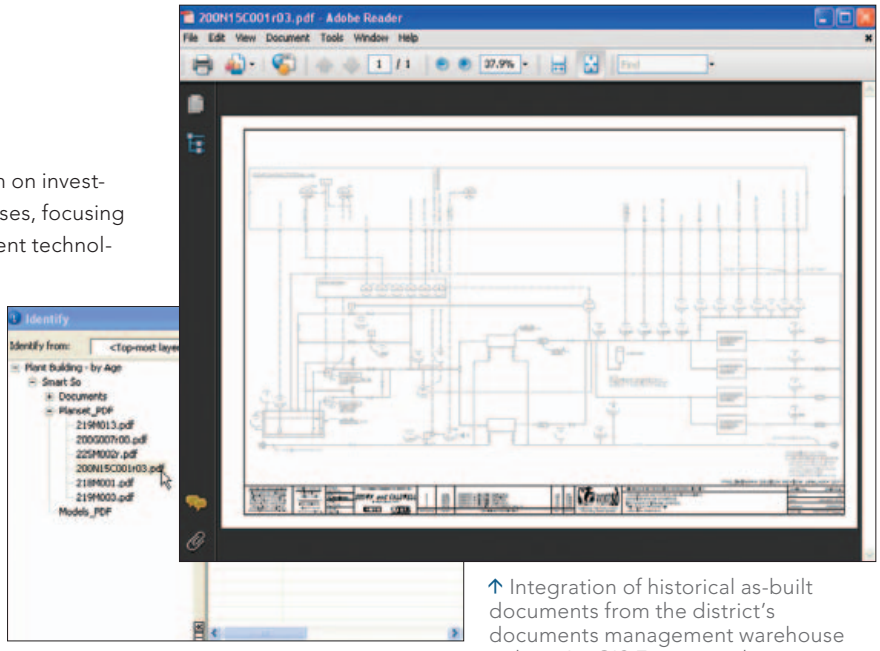


Put the Money Where the ROI Is

As part of this research and development project, return on investment (ROI) estimates were generated for distinct use cases, focusing on integrating lidar and building information management technology with GIS to greatly improve access and retrieval of as-built conditions for MMSD employees and consultants. The result of this effort was a list of 10 requirements that an application would have to meet to provide a sustainable, integrated solution:

1. View 3D model
2. No (or minimal) loss of features in translation into a geodatabase
3. Overlay aerial images
4. Overlay other GIS layers
5. Unique ID of elements within the 3D model
6. Select individual features within the 3D model
7. Relate individual features to external data, such as the district's document management and asset management systems
8. Symbolize the 3D model from attributes
9. Relate individual features to documents
10. Query related data

A number of different application development platforms and existing software solutions were considered for the project. Each software package was evaluated based on criteria defined by MMSD. Esri's ArcGIS Engine was selected as the platform that met all these requirements. ArcGIS Engine is a collection of GIS components and developer resources that can be embedded into other applications, allowing dynamic mapping and GIS capabilities in many different environments.



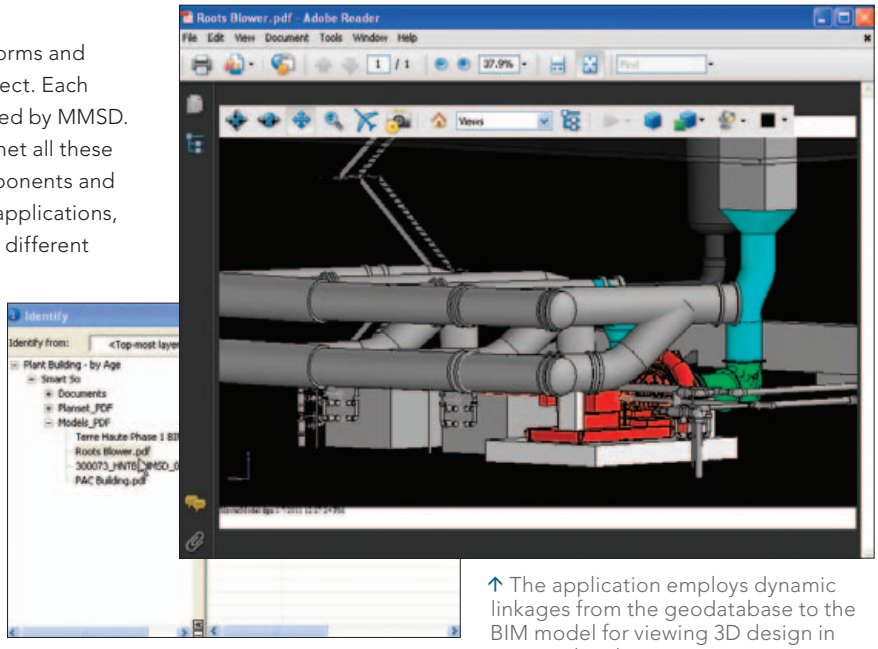
↑ Integration of historical as-built documents from the district's documents management warehouse utilizes ArcGIS Engine as the integrator.

An Expandable Enterprise System

MMSD was already a user of Esri technology, having adopted ArcGIS for Desktop software in 2003 for department-specific solutions. In 2009, MMSD consulted with HNTB to help facilitate a move into an enterprise environment using ArcGIS for Server. This was a multiphase implementation that included the development of a business data model. The data model focused on existing data inventory and application user needs at the time, including improving mapping and organizational efficiencies as well as bringing added value to MMSD business operations. In 2011, MMSD completed the project, developing several applications that addressed specific areas to map related data to the district's infrastructure resources and service areas.

"Historically, information regarding water quality, water quality improvements, and physical features of water were located in separate departments at MMSD," said Jeff Siegel, GISP, associate vice president of HNTB. "Consolidation of this information took time, money, and executive sponsorship to change priorities. Now, all staff

continued on page 18



↑ The application employs dynamic linkages from the geodatabase to the BIM model for viewing 3D design in greater detail.

 continued from page 17

can access and output this information from their desktops without the help or sponsorship of other staff. The staff has the information it needs to make better and faster decisions, which was another of our guiding objectives."

For this new study area project, among the many criteria MMSD had, access to data and documents was again selected as a high priority. "In this scenario, a 3D model was created and integrated into ArcGIS," said Siegel.

The objective was for users to again view and select features on their own. In this case, the 3D model would be displayed within an environment they are familiar with—the ArcGIS environment. Using this model, staff can access related data in external databases including documents relevant to the 3D model feature selected.

Modern Technology Studies a Historic Facility

The study area included the Jones Island water reclamation facility, one of two wastewater treatment facilities within the district's service area. Jones Island is located on the shores of Lake Michigan in the city of Milwaukee. On average, the Jones Island facility collects and treats a maximum flow of 300 million gallons of wastewater each day, returning clean, clear water to Lake Michigan.

Opened in 1925, the facility, located on a 75-acre campus, was designated a National Historic Civil Engineering Landmark by the American Society of Civil Engineers in 1974 and is also on the National Register of Historic Places.

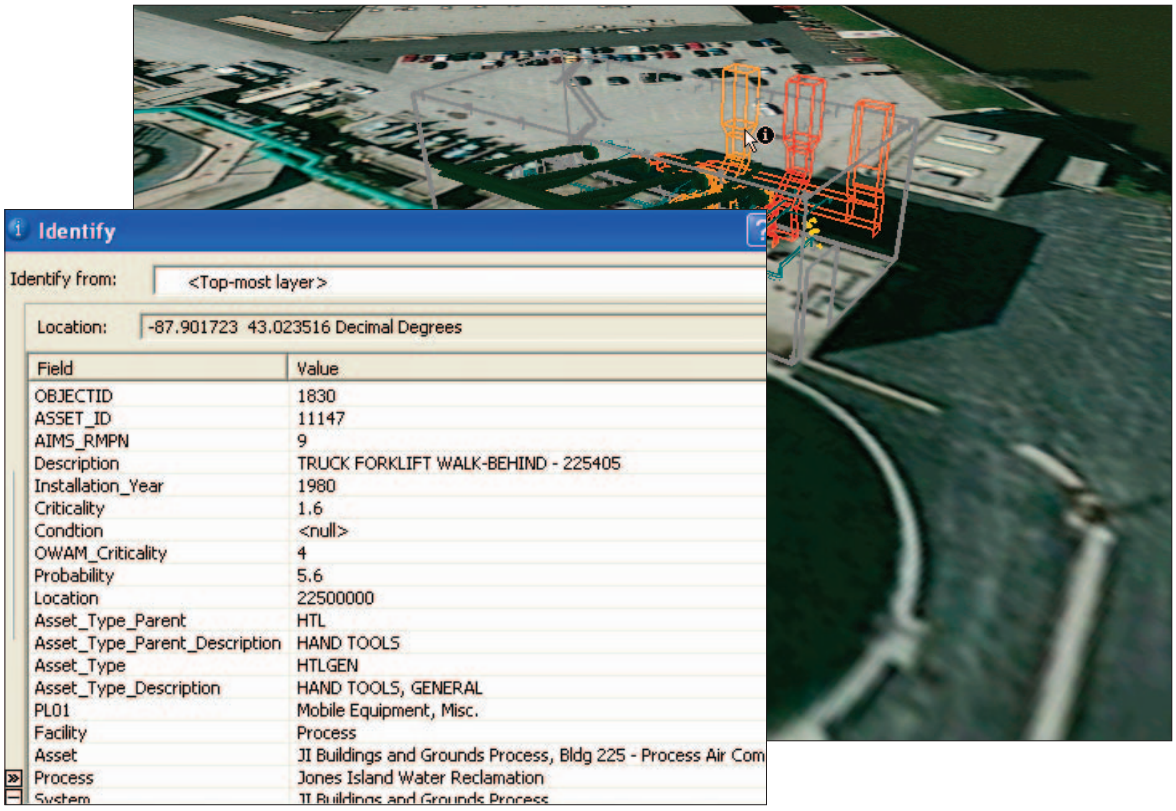
As part of the Milwaukee Metropolitan Sewerage District 2020 Facilities Plan, HNTB was tasked with developing design improvements for the Jones Island facility aeration system. The project will lead to a reduction of electrical energy usage through gains in aeration system blower and diffuser efficiencies, as well as enhancements to controlling air distribution to aeration basins and channels.

To gather accurate and precise as-built conditions of the aeration system, HNTB engineers decided to collect internal facility data to derive a building information model (BIM) from static lidar point clouds. This approach quickly brought dependable existing conditions information to the designers in an interactive 3D design environment.

"Because static lidar scanning is a direct line-of-sight method of data collection, the entire interior of a facility required enough scans for every single feature to be captured," said Siegel. "The estimated number of scans required increases based on the number of floors and the complexity of the building."

A typical static lidar scan takes about 10–15 minutes, so a crew of two has the ability to scan anywhere from four to six locations—typically a room or hallway—in just one hour. For this project, more than 100 scans were collected in one day to gather point clouds of the entire facility.

The decision to use BIM to manage the design process allowed many different disciplines to collaborate at different phases of the facility design project. BIM is defined as a process using a combination of technologies and resources to capture, manage, analyze, and display a digital representation of physical and functional characteristics of a facility.



→ Integration of asset inventory data from the district's asset management warehouse utilizes ArcGIS Engine as the integrator.

Realistic 3D Models for Everyday Use

Integrating lidar and BIM data with MMSD's enterprise GIS was thought to offer many benefits to the agency. "In our opinion, this was the most well-organized way to package up and deliver all our 3D design and construction methods to our client," said Siegel.

By extending BIM and lidar into the ArcGIS environment, the district can benefit from the data and integration points between the technologies, realizing significant operational efficiencies. Asset and facilities management is one area where improvements to maintenance management and document management systems can happen. The ability to manage data and keep a record of work orders and maintenance activity is invaluable to managers.

"GIS technology allows users to view, understand, question, interpret, and visualize data in so many ways that were difficult before," said Siegel. "Using ArcGIS, we can provide a way for our stakeholders to use the lidar and BIM technology and see and manipulate a dynamic and intelligent 3D model of a project."

Another area where the district is expected to realize efficiencies is in plant and facilities operations. "There are a number of ways a 3D geographically based representation of the facilities will help our customer," said Siegel. "From safety and training to creating documentation and just having an operational database, GIS makes it easy to manage and use the collected information and model the facility dynamically in so many ways."

Facility planning is another area where this approach can offer some real payback. Whether modeling proposed upgrades or capital improvements, the ease of sharing this information in an easily understandable format is a big win. "Since this is a historical landmark for the area, there are many complexities in maintaining the 3D model to the data management standards that MMSD expects," said Siegel. "Viewing a 3D model that is intelligent—meaning we can see more information about the facility picture we are displaying—makes it so much more efficient to answer questions, propose new scenarios, and move the projects along at a quicker pace."

Lessons Learned

The most critical factor preventing more robust integration between BIM and GIS is the native incompatibility of the two data formats. A critical data integration fracture between BIM and GIS is the importance of defining spatial coordinates of the BIM file at the beginning of the project. "The purpose of this is to allow us and our client to accurately locate a building within a site and give it a physical location context at larger scales that can be overlaid with aerial imagery and topographic and other layers from an enterprise geodatabase," said Siegel.

For more information on using GIS for facilities, visit esri.com/facilities.

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- Delivering an Accurate Surface Profile of the Nation—Larry Sugarbaker, the National Geospatial Program's senior adviser for the US Geological Survey (USGS), discusses the importance of lidar and imagery data delivery services to business and government.

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