SmartMarket Report

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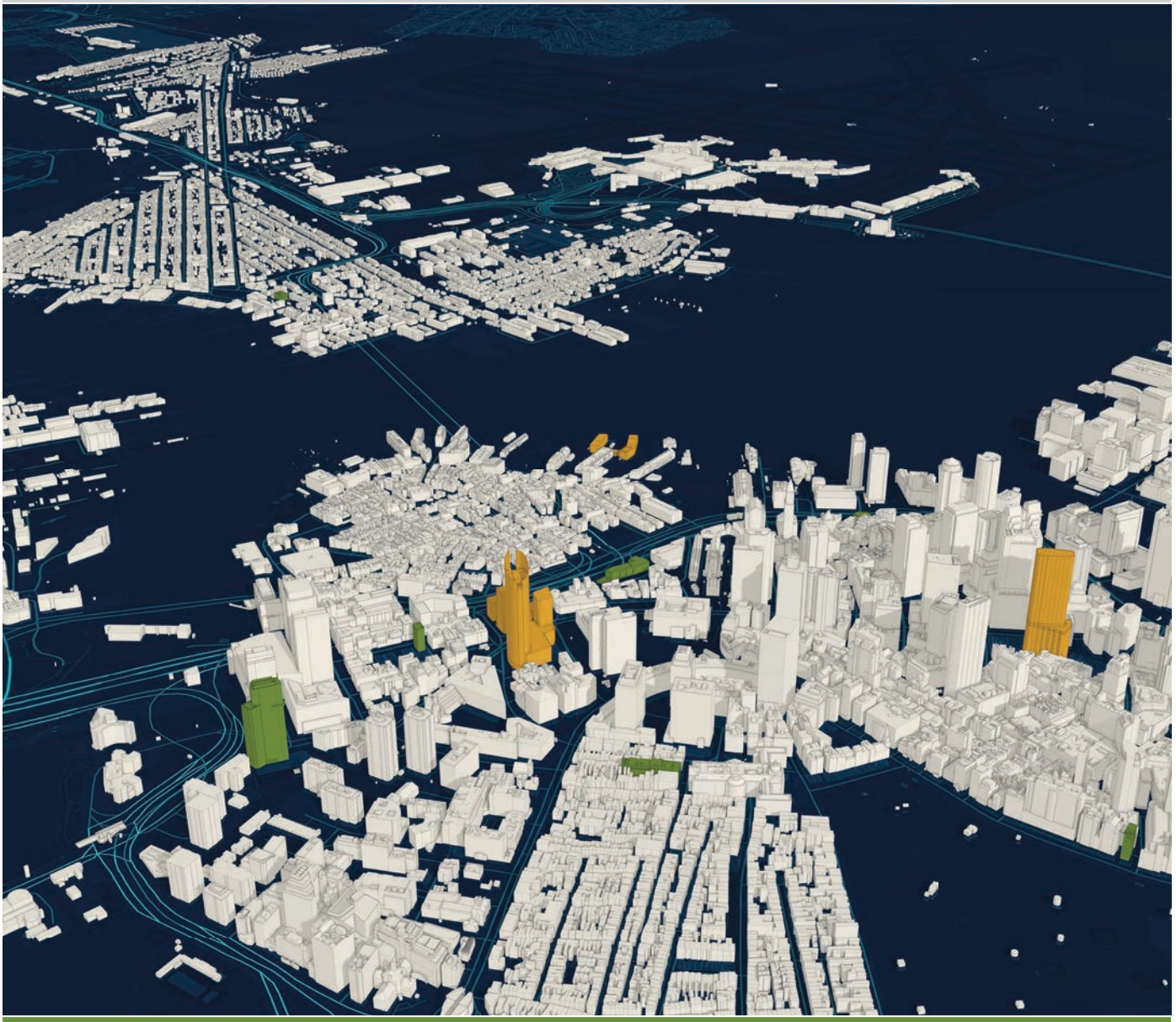

The Business Value of GIS for Design and Construction

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SmartMarket Report

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DODGE DATA & ANALYTICS

About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of commercial construction project data, market forecasting & analytics services and workflow integration solutions for the construction industry. Building product manufacturers, architects, engineers, contractors, and service providers leverage Dodge to identify and pursue unseen growth opportunities that help them grow their business. On a local, regional or national level, Dodge empowers its customers to better understand their markets, uncover key relationships, size growth opportunities, and pursue specific sales opportunities with success. The company's construction project information is the most comprehensive and verified in the industry. Dodge is leveraging its more than 125-year-old legacy of continuous innovation to help the industry meet the building challenges of the future.

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Introduction

Our physical world is a rich three-dimensional experience. While architectural and engineering design tools have been dramatically advancing to more effectively engage with 3D, geospatial (GIS) information has also been evolving from 2D maps into detailed surface,subsurface and land use datasets and visualizations. Now these exciting advancements are joining forces to provide fully informed 3D contextual environments.

Esri and Autodesk have partnered with Dodge Data & Analytics on this study to understand exactly how the design and construction industry is currently using GIS and its benefits to their projects and companies in order to help the industry better understand its potential.

The study reveals that the inherent value of GIS is well understood by architects, engineers and contractors. Those who use it report achieving many important benefits, and most of those who do not have a favorable view of its positive potential.

As examined in this report, GIS offers designers and contractors a wide range of ways to employ its data and tools. Some of the most common ways it is currently being deployed include for project planning and permitting/ urban planning, to classify land use, buildings, highways and infrastructure, for site data collection, for digital handover of project information, to monitor issues like RFIs and punch lists and to support information sharing and collaboration. However, there are many other uses that are still emerging, including being able to use demographic surveys to inform design, to use it to support decision-making on projects, and to improve safety and monitor the location and usage of materials and equipment onsite. All of these offer the potential to improve the final project, increase productivity and address stakeholder concerns.

Those using GIS data report a wide variety of benefits, from improved project processes and outcomes, to risk reduction and improved sustainability of their projects, to internal and market-related business benefits. Among those most widely considered to be important by the respondents are:

- **Improved productivity**
- **Improved client satisfaction**
- **Ability to offer more services**
- **Reduced conflicts, field coordination problems and changes during construction**
- **Increased ability to manage project complexity**

One of the hallmarks of data, though, is that it is most powerful when widely shared across the project team, and that is true for GIS as well. Designers and contractors alike both see particular value in the entire design team using GIS data, and designers also see a high degree of importance in owner engagement in GIS tools and activities.

However, as is common when attempting to incorporate new data into existing processes, there are certain challenges the industry must address to increase its use across project teams. The top challenge and driver for increased use is improving interoperability with other tools so that it can seamlessly be part of designer and contractor workflows. The industry also has been investing in training to help address the challenge of finding qualified staff to manage GIS.

The benefits that GIS brings will help encourage the industry to address the challenges, and the study as a whole reinforces the enormous potential for GIS to become a critical tool in design and construction.

We thank Esri and Autodesk for supporting Dodge in providing this critical analysis to the industry.

Stephen A. Jones
Senior Director
Industry Insights Research
Dodge Data & Analytics

Stephen A. Jones leads DD&A's Industry Insights Research division. He is active in numerous industry organizations and frequently speaks at industry events around the world. Before DD&A, Jones was vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he was principal and a Board of Directors member with Burt Hill, a major A/E firm (now merged with Stantec).

Donna Laquidara-Carr, Ph.D., LEED AP
Industry Insights
Research Director
Dodge Data & Analytics

Donna Laquidara-Carr currently provides editorial direction, analysis and content to DD&A's *SmartMarket Reports*. Prior to this position, she worked for nearly 20 years with DD&A's Dodge division, where she gained detailed insight into the construction industry.

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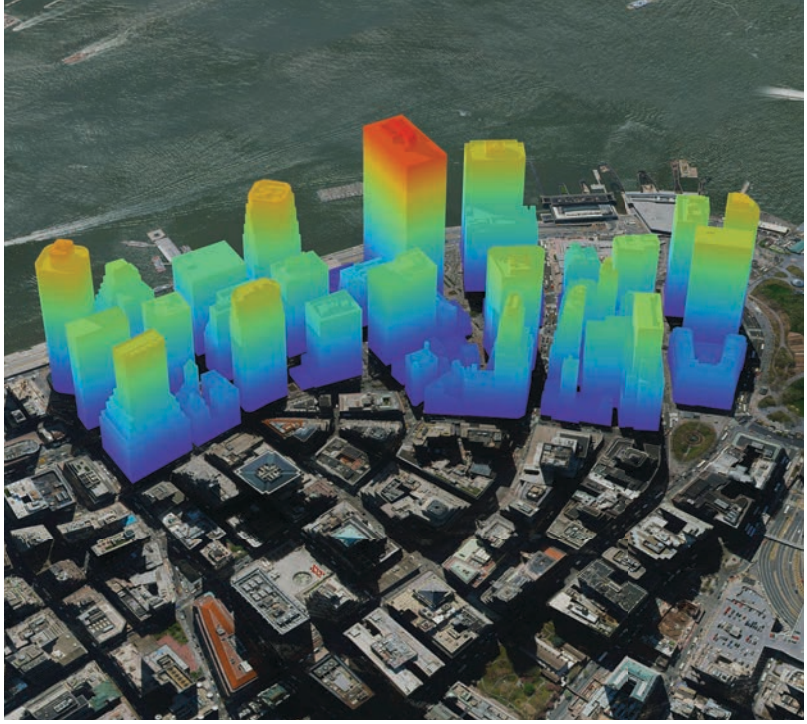


Front Cover:
Image of Digital Twin created by the City of Boston to help make planning decisions. For more information, see https://www.esri.com/about/newsroom/blog/3d-gis-boston-digital-twin/.

This Page Left:
3D GIS images used to support planning in New York City.

This Page Right:
Countywide signage and delineation survey using GIS in Pennington County, South Dakota.

Executive Summary

GIS is adding value to projects and to the companies who use it.

Companies with experience with GIS are using it to improve processes, outcomes and their businesses, but the industry is just beginning to scratch the surface of the potential that the robust data and tools can provide.

Use of GIS

The survey focused on designers and contractors who use GIS in their planning/design/construction processes. Among those respondents, GIS is used for a wide range of activities with varying frequency.

FREQUENT GIS ACTIVITIES

The chart at right shows the top ways in which these designers and contractors are using GIS on the majority of their projects. However, these are only a small sample of all the ways that they report using GIS.

- **Designers also report employing demographic, socioeconomic, commercial and cultural surveys, collecting field data and using GIS for program management, status tracking and decision support.**
- **Contractors also use it to enhance safety and security, monitor construction progress onsite and issues like RFIs and punchlists, and to monitor equipment location and usage.**

Frequency of these activities can be expected to grow as companies increase their use of GIS and the benefits become more widely understood and expected.

Investments Made to Support GIS Use and Their ROI

The top three types of investments made by designers and contractors to support their use of GIS are:

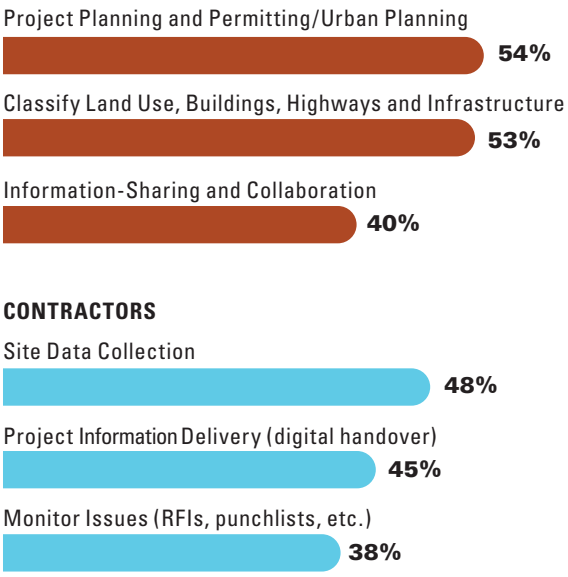
- **Software That Supports Its Use**
- **Training**
- **Developing Internal Collaborative GIS-Based Workflows**

These investments suggest that many of those using GIS are still early in their journey toward taking full advantage of its features. Given that early level of engagement, it is encouraging that 50% already feel like they are seeing a positive ROI on their GIS investments, and only 6% report that their current ROI so far is negative. Over two thirds of those who are experiencing a positive ROI also report a return of 10% or more, which can help fuel further growth in its implementation.

Most Frequently Used GIS Activities

(Percentage Using Them on More Than 50% of Projects)

Dodge Data & Analytics, 2020



Benefits of Using GIS

The high returns on investment that many are experiencing from their use of GIS are driven by a broad range of benefits. Nearly all (88% or more) of the GIS users report that they have experienced five categories of benefits from its use:

- **Project process and outcome benefits**
- **Risk reduction benefits**
- **Sustainability benefits**
- **Internal business benefits**
- **Market-related business benefits**

The top benefits within each category are listed in the chart at right. Over half of the GIS users identify reduced conflicts, field coordination problems and changes during construction, improved ability to manage project complexity, better ability to consider the environmental and social impact of design, improved productivity, improved client satisfaction and being able to offer more services. All of these frequently cited benefits are surely having a major positive impact on GIS users' projects and businesses.

Top Areas to Improve Use of GIS and Top Drivers for Increased Use

The findings of the study show a correlation between the challenges that GIS users face and the top drivers for increasing their use of GIS on their projects.

TOP AREAS TO IMPROVE GIS

GIS users generally agree that the top challenges they experience in their use of GIS are:

- **The lack of interoperability with other tools**
- **The challenge of finding qualified staff to manage GIS**
- **Data quality issues**

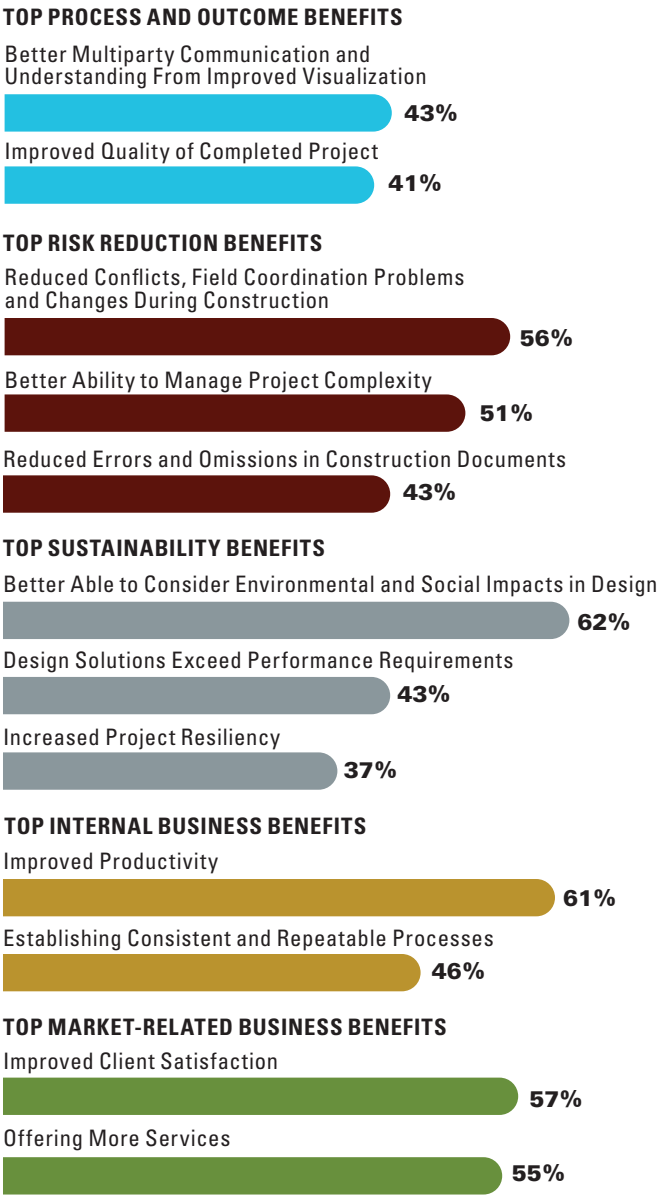
TOP DRIVERS FOR INCREASED USE

By far, the top driver that will increase implementation of GIS among those already using it is improving interoperability between GIS and other design and construction technologies, selected as one of the top three drivers by 54%. This is an area the industry has already begun to address, and as interoperability improves, wider use of GIS data on projects is likely.

The second biggest driver for wider use of GIS among those already using it is more accurate and reliable GIS information, selected in the top three by 36%. It is closely followed by more training for internal staff and owner requirements.

Top Benefits of Using GIS (Selected Among the Top Three Most Important in Each Category by GIS Users)

Dodge Data & Analytics, 2020



Team Engagement With GIS

Similar to other types of project data, GIS data is most valuable when it is used by the entire project team, rather than in isolation. GIS users rated the frequency with which they see other team members engage with GIS on the projects where they use it, and the value of those types of engagements, regardless of their frequency. Fortunately, for the most part, the frequency and value of the team engagements align.

The charts at right show how designers (top chart) and contractors (bottom chart) rank the value of GIS activities by other team members, clearly showing that for designers and contractors alike, the most valuable engagement is designers bringing GIS into their design. A key difference is that designers assign greater value to owner engagement with GIS than do contractors.

Notably, GIS users were only allowed to select one option when selecting the most valuable way that other team members engage with GIS. So even though contractor activities are selected by the lowest percentage of designers and owner activities by the lowest percentage of contractors, that does not mean that they do not perceive value in these engagements. Instead it emphasizes how important GIS engagement by other designers and owners is for designers, and GIS engagement by designers and other contractors is for contractors.

Nonusers

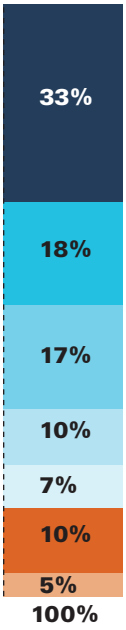
Designers and contractors with no GIS experience were also included in the study, and their responses suggest that they are positioned to drive greater adoption of GIS throughout the industry.

- **Most are familiar with GIS and view it positively.**
- **Top drivers for designers to adopt GIS would be improved project quality, improved productivity and improved client satisfaction. Fortunately, these are frequently reported benefits by GIS users.**
- **Contractors also consider improved productivity a top driver, as well as improving their compliance with the construction budget.**
- **Nonusers greatly underestimate the degree to which their competitors are using GIS, which should create competitive drivers for them to adopt it.**

Team Engagements of Greatest Value to Designers

(Single Top Choice of Greatest Value)

Dodge Data & Analytics, 2020



MOST VALUABLE ENGAGEMENT BY DESIGNERS

- At least some of the other design firms/consultants on the design team use GIS for their work.

MOST VALUABLE ENGAGEMENT BY OWNERS

- The owner provides access to the pertinent GIS data and GIS system.
- The owner expects the design team to use GIS and is aware of its use.
- The owner expects the project delivery team to provide updates back to the GIS as part of the final deliverable once project is completed.
- The owner expects the design team to provide updates back to the GIS as part of a collaborative process during design.

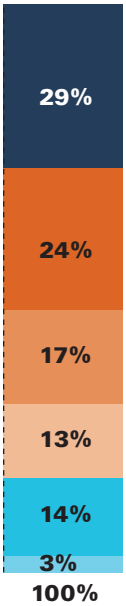
MOST VALUABLE ENGAGEMENT BY CONTRACTORS

- The main contractor takes advantage of GIS created during the design process.
- The main contractor uses GIS tools for its own processes.

Team Engagements of Greatest Value to Contractors

(Single Top Choice of Greatest Value)

Dodge Data & Analytics, 2020



MOST VALUABLE ENGAGEMENT BY DESIGNERS

- The design team has used GIS in its design.

MOST VALUABLE ENGAGEMENT BY CONTRACTORS

- The main contractor (GC/CM/Design-Build) takes advantage of the GIS in the design documents.
- The main contractor (GC/CM/Design-Build) uses GIS for its own processes.
- At least some of the other companies on the construction team (e.g., trades, fabricators, installers, etc.) use GIS for their work.

MOST VALUABLE ENGAGEMENT BY OWNERS

- The owner expects the project team to use GIS in the construction process and is aware of its use.
- The owner asks for GIS in the final deliverable after completion of the project.

Data: Introduction

The *Business Value of GIS for Design and Construction SmartMarket Report* is the latest in a series of SmartMarket studies published by Dodge Data & Analytics for over a decade on the ways in which data and technology are transforming the construction industry.

Per Esri's website, a geographic information system (GIS) is a framework for gathering, managing, and analyzing data. Rooted in the science of geography, GIS integrates many types of data. It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes.[1]

This report largely focuses on the responses of designers and contractors with GIS experience. It establishes benchmarks for the ways in which they use GIS, looking not only at the general level of familiarity with the various types of data and their use, but also the share of projects on which GIS is employed. The findings clearly demonstrate that the industry already sees the value of employing GIS, but that implementation of many types of data and tools is still relatively early across much of the industry.

GIS users also reveal the most important benefits they experience in five categories:

- **Project process and outcomes**
- **Risk reduction**
- **Sustainability**
- **Internal business benefits**
- **Market-related business benefits**

In addition, the study explores the investments made by designers and contractors to incorporate GIS data into their projects and workflows, and their perceived return on investment for those investments. It demonstrates that half of the GIS users, due to the benefits they have received, report a positive ROI already from employing GIS.

The study also examines the challenges facing those using GIS and the drivers for increased use, both of which are dominated by interoperability issues, training and skilled staff shortages, and data quality issues.

A brief examination of the perspectives of those with no experience with GIS is also provided, including what they think of GIS, how they regard its use in the industry, the top factors preventing them from adopting it so far and the top drivers for them to begin using it.

The results demonstrate that the industry is already actively engaging with GIS, that it benefits from doing so across the project team, including the owner, and that the potential for higher engagement is strong.

About the Data
The data and analysis in this report are based on the responses to an online survey conducted in August and September 2020. The 473 respondents in the study are generally analyzed in this report in the following groups:

DESIGNERS:
These include architects, planners, civil engineers, structural engineers, other types of consulting engineers and design consultants. When there are sufficient responses and interesting differences, the analysis focuses solely on the responses from the two largest groups: the architects (which also includes a small number of planners) and the civil and structural engineers. Since the civil and structural engineer responses are analyzed together, they are referred to as civil/structural engineers throughout the report.

CONTRACTORS:
This category includes general contractors, design-builders, construction managers and specialty trade contractors. For the sake of simplicity, the term general contractor is used to represent the responses of all the prime contractors (general contractor, design-builders and construction managers), since the vast majority of those responses are from general contractors. Where there are sufficient responses and interesting differences, the analysis explores the different responses of those categorized as general contractors and the specialty trade contractors.

In addition, in the beginning of the survey, all respondents were asked whether they had experience with use of GIS data as part of their design and construction processes. Their answers determined the questions they were asked, so those with and without GIS experience are analyzed separately in the data.

1. Esri, What is GIS?: https://www.esri.com/en-us/what-is-gis/overview

Data: Use of GIS

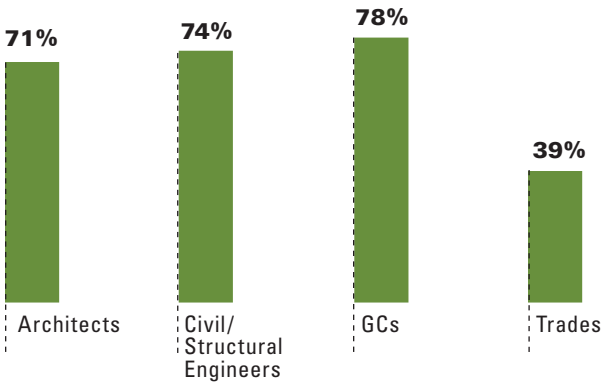
Experience Using GIS

Design and construction projects are the ideal candidates to benefit from the use of GIS data. Architects, civil/structural engineers and contractors were asked whether they had experience with using GIS in the planning, design or construction process. To make sure the use of GIS was clear, designers were provided with specific examples such as environmental surveys, location analysis, site selection or demographics using GIS software and/or data. Contractors were asked about examples such as field data collection, material logistics, status monitoring or reality capture visualization using GIS software and/or data.

- **Roughly the same share of architects, civil/structural engineers and GCs report using GIS for their planning, design and/or construction processes.**
- **However, only 39% of specialty trade contractors report having GIS experience.**
- **81% of large contractors (revenues of $100M or more annually) use GIS, compared with 52% of small contractors (revenues of less than $10M). While this reveals wide usage by large contractors, it also shows small contractors are finding GIS useful.**

Experience With GIS for Planning/Design/Construction Process
(By Type of Company)

Dodge Data & Analytics, 2020



How GIS Is Being Used

While use of GIS data in general is widespread, the various applications for its use are not uniformly adopted. Use varies based on the type of firm, of course, but it also varies by specific task. This section takes a close look at the degree of use of various GIS activities by company type.

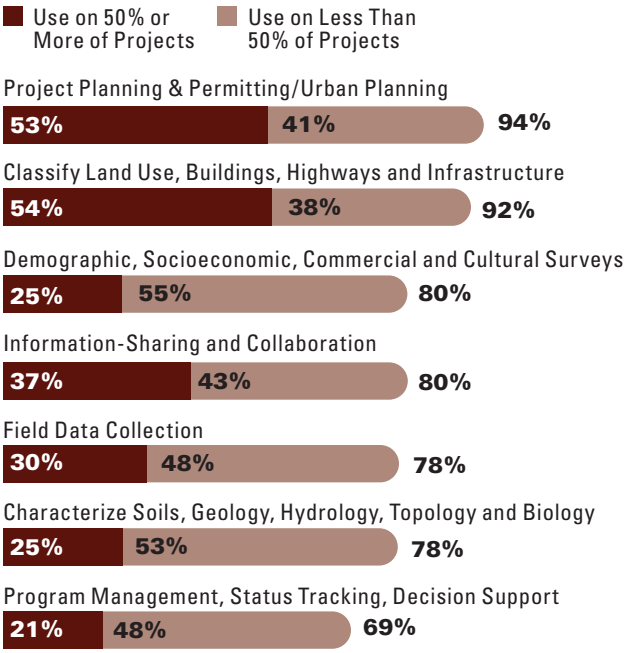
GIS Use by Architects

Architects with GIS experience were asked about their use of seven different GIS activities listed in the chart at right.

- **Nearly all of the activities listed are used by over three quarters of the architects on at least some of their projects.** This suggests that architects who use GIS have a broad awareness of the many different types of GIS data and activities available.
- **However, only two activities—project planning and permitting/urban planning and classify land use, buildings, highways and infrastructure—are used by more than half of the respondents on the majority (50% or more) of their projects.** Thus, while most of the architects are familiar with the other types of data and activities, they are not widely implementing them on their projects.
- **Most GIS-using architects (80%) have utilized the underlying data from demographic, socioeconomic, commercial or cultural surveys/studies, but only one quarter (25%) use that data on more than half of their projects.** This may suggest that the design industry has not yet fully concluded how to leverage this type of data, but that there is wide awareness of its availability to GIS users.
- **Field data collection, use of GIS to characterize soils, geology, hydrology, topology and biology and program management/status tracking/decision support also appear to be emerging functions,** with 30% or fewer currently using them on more than half of their projects.
- **Encouragingly, nearly half of the 80% of architects who use GIS for information-sharing and collaboration do so on more than half of their projects.**

Frequency of GIS Activities by Architects

Dodge Data & Analytics, 2020



GIS Use by Civil and Structural Engineers

Civil and structural engineers with GIS experience were asked about the same seven types of GIS data/activities as the architects. The percentage of civil/structural engineers using these activities on at least some of their projects is even higher than that of the architects, and the specific types of GIS data and activities with which they engage are often very different.

- **The top activity by the GIS-using civil/structural engineers is information-sharing and collaboration.** Not only are nearly all (96%) using GIS for this activity, but nearly half (48%) do so on 50% or more of their projects, compared with only 37% of architects.
- **Using GIS to classify land use, buildings, highways and infrastructure is common among both civil/structural engineers and architects, as is project planning and permitting/urban planning,** with over 90% using each of these activities on at least some projects and over half using them on 50% or more of projects.
- **Civil/structural engineers more widely report using GIS data to characterize soils, geology, hydrology, topology and biology, and doing field data collection, than do architects.** This is most evident in the overall percent who use GIS in this way, and to a lesser extent in the percentage who do so on half or more of their projects.

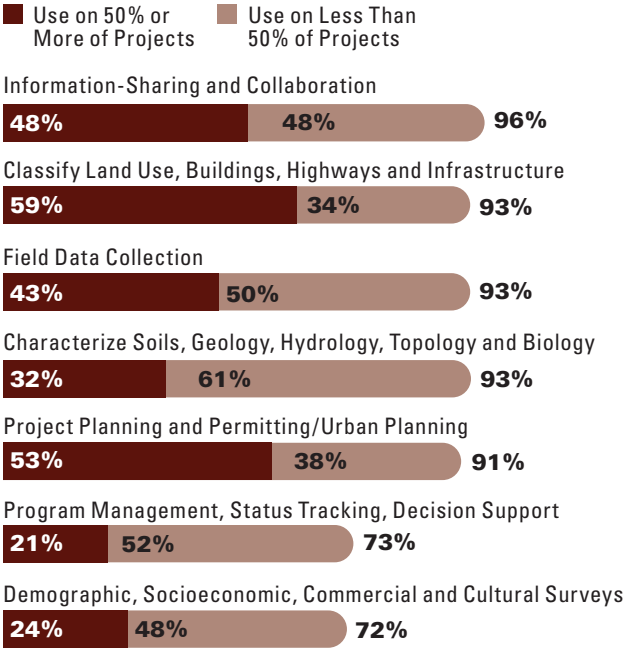
Variation by Size of Company for Architects and Civil/Structural Engineers

Two types of data/activity are used on more than half of projects more frequently by large design firms than by small ones.

- **Field data collection:** Large companies (49%) more frequently conduct field data collection than small companies (19%) on more than half of their projects.
- **Program management, status tracking, decision support:** Large firms (33%) use this type of data more frequently than small firms (11%) on more than half of their projects.

Frequency of GIS Activities by Civil/Structural Engineers

Dodge Data & Analytics, 2020



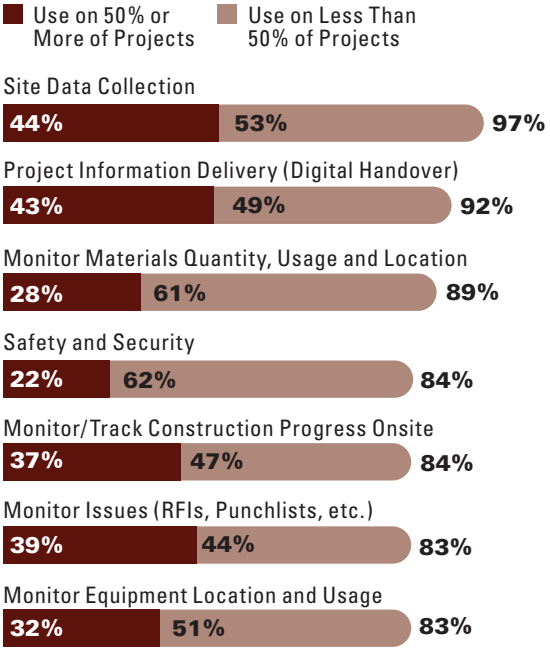
GIS Use by GCs

General contractors with GIS experience were asked about the specific GIS activities/data with which they engage. They were given a list of seven different options from the architects and civil/structural engineers that better reflects the uses that GIS offers to contracting companies.

- **Similar to the architects and civil/structural engineers, most GCs are also using most of these GIS activities/ data on at least some of their projects.**
- **However, use is less widespread among their projects than it is for the designers, less than half of the GCs using any of these activities on 50% or more of their projects.**
- **The most frequently used activities are site data collection and project information delivery (digital handover).** Not only are these used by more than 90% of the respondents on at least some projects, but they are used by over 40% on over half of their projects.
- **The biggest gap between the overall percentage using them for at least some projects and the share using them on the majority of projects are those who use GIS to monitor materials quantity, usage and location, and those who use it to improve safety and security.** As with the architects, this may suggest that the industry is still finding ways to utilize GIS for these tasks.
- **On the other hand, a relatively large share of those using GIS to monitor/track construction progress onsite and to monitor issues such as RFIs and punchlists are doing so on 50% or more of their projects.**

Frequency of GIS Activities by GCs

Dodge Data & Analytics, 2020



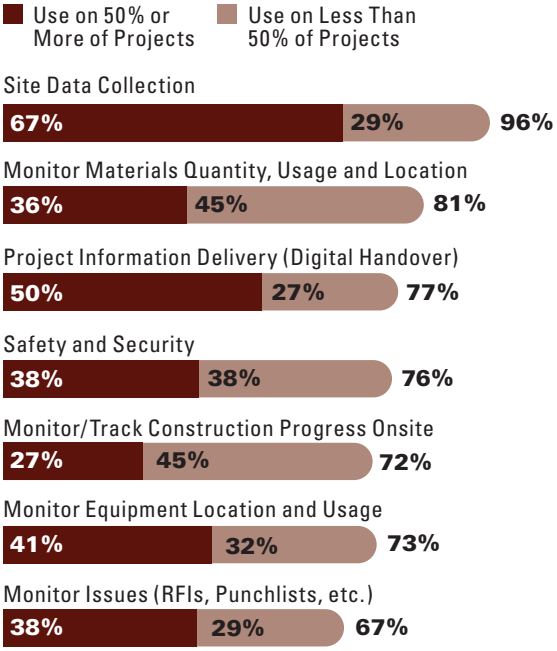
GIS Use by Specialty Trade Contractors

Specialty trade contractors with GIS experience were asked about their use of the same list of seven GIS activities/data as the general contractors. Generally, the percentage of trade contractors using these on at least some of their projects is lower, but for several, the trade contractors report more intensive use, with higher percentages reporting that they use them on 50% or more of their projects.

- **Site data collection is the top GIS activity for both trade contractors and GCs, used by nearly all on at least some of their projects.** However, over two thirds (67%) of trade contractors use GIS for site data collection on 50% or more of their projects, compared with under half (44%) of GCs.
- **Other activities for which trades report a much higher intensity of use are project information delivery, safety and security, and monitoring equipment location and usage.** Trade contractors are more immediately responsible for equipment and workers than are general contractors for much of the work done onsite, so it makes sense that the trade contractors who have invested in the use of GIS would do so more intensively for these activities.
- **On the other hand, GCs report more intensive use of GIS for monitoring and tracking construction progress onsite,** which reflects their wider responsibility for the project as a whole.

Frequency of GIS Activities by Specialty Trade Contractors

Dodge Data & Analytics, 2020



Interview: Thought Leader

Donna Huey, Senior Vice President and Director of Client Technologies, Atkins North America

With 30 years of experience in technology strategy and consulting services, Donna Huey co-founded Atkins North America's commercial IT business and later launched the region's first formal technology R&D program.

How are you currently using GIS?

HUEY: [We have traditionally used it] for 2D site and constraints analysis, but over the past five to eight years, much more for modeling and prediction. [We do] building geospatial models where, for example, we run iterations taking in climate change models and running predictions on storm events, or looking at resiliency and the impact of climate change. We also have a subsidiary data transfer solution that offers an enterprise asset management system built around spatial data infrastructure and GIS. So, a very large piece of what we're doing today with GIS data is to address work order management, strategic asset management.

What are the main GIS benefits you have experienced?

HUEY: The biggest benefit is storytelling. Maps and GIS have always had the power of bringing [data] to life ... When we develop and deliver infrastructure, many of those projects have to go through regulatory stages that require public engagement. So we use GIS technology, visualization and mapping as a vital component of communicating with the public ... We've found that the use of maps and visualization to tell the story really drives benefits because you are able to get your message through clearer, stakeholders become more engaged, and decisions get made faster as a result.

Have you experienced any unexpected benefits?

HUEY: Interoperability ... Our architects and development modelers leverage GIS to inform design because they can now see their design in the context that the traditional 2D GIS gives. And conversely, we're able to look at the 3D BIM models inside that geospatial environment and the attribution of the models, so that we can look at everything from sequencing to modeling and analysis in that geospatial environment, which lends itself better to some of those functions.

What challenges still exist to getting the most out of GIS data in design and construction?

HUEY: I'll point back [again to] interoperability. Even though the industry has made strides [in this area], it's not perfect and [more is needed]. The other challenge is uniting the geospatial community with the design-authoring community. They still see each other in two different worlds. And even though those worlds are colliding in the space of information management, the practitioners are still a little bit siloed organizationally.

So what do you recommend to companies considering greater integration of GIS and BIM?

HUEY: My recommendation has two parts. One is to make sure when you think about the information you need to deliver your project, that you think of the whole space of information, with GIS incorporated. But the bigger piece of advice is to plan your information in advance. Too many times, we don't think about information management until we are awarded the project, and we start the job: Where are we going to store our files? How are we going to put the pieces together? We've made a conscious effort here at Atkins to [consider how to] start those [information management] conversations at the bid stage or the positioning stage of a project. Because if you don't think about it far enough in advance, then you might not get the advantages and execution... It's much more expensive after the fact to try to go back and get everything in sync. So planning in advance is really the best recommendation.

What do you think is the future for GIS in the design and construction industry?

HUEY: I've always referred to the data continuum ... If done properly, the information that you build [in the planning stage, typically with GIS] grows in value [throughout the project lifecycle into operations]. If we can get incentives aligned through the supply chain of delivery of infrastructure so that we place importance on information management as a key component of benefits outcomes in the end state, then that will be a big leap forward. ■

The Integration of BIM and GIS

To meet an ever-increasing demand for data to aid in planning, design, construction and operations, a sharper focus has been placed in recent years on integrating BIM and GIS to help unlock additional capabilities and streamline existing ones.

The combination of information-rich BIM models with the geometric context provided by GIS offers the potential for more insightful and efficient planning and design, while offering a seamless flow of information that can benefit all project team members and stakeholders throughout a project's lifecycle.

Past Challenges

For decades, however, GIS and CAD—and more recently BIM—have largely stayed in their own respective silos, both from the standpoint of technology and culture. But significant strides are being made to bridge that gap—particularly when planning and designing infrastructure projects—to more closely align professionals and the data they aggregate.

Chuck Pietra, civil infrastructure CAD manager at C&S Companies, has seen the potential for decades, particularly in the civil sector. While working on superfund remediation projects, Pietra heavily leveraged geotechnical data that was needed for investigation, remediation, mitigation and eventually building on sites. "I started with lots of GIS data because the legacy data was all GIS," he recalls. "There were some CAD drawings, but CAD was just coming on the scene as we started putting buildings on these sites. Then, BIM wedged its way into the process, and I found myself constantly looking for ways to translate from the GIS platform to CAD or BIM and back again."

Although translators were somewhat effective, they were an added step in the workflow. "That created more versions of things, more steps in the workflow, and it was not seamless," he adds.

Integrations in Design

Today, Pietra says he sees technology providers developing more integrated solutions that increase efficiency and reliability. Currently, he sees these offerings providing the most value in planning and early design. "I now can get GIS into something a lot more visual," he says. "Now, in a matter of half of a day, we've got an information-packed model in 3D that we can use to inform where the building would be best located and what direction it should face. And I can show the reasons why: Here are the existing roads, the traffic flow and the intersections. So, we can start making decisions right away."

Cory Dippold, vice president and head of special project applications at Mott MacDonald, says his firm recently took a deep dive into BIM and GIS integration while providing design services for the rehabilitation of the Lower Catskill Aqueduct, a major water source for New York City. "The thing that I found frustrating in 2018 was that we had a lot of good information about various assets over this 12-mile alignment that was wrapped up in GIS, and we also had a lot of very good information about assets in BIM," he says. "And I thought, 'This is stupid. It's all the same asset. Why do I have to pick and choose where I go for my information?'"

In working with its technology partners, Mott MacDonald was able to make some successful first steps, building an accurate 3D model with data from both platforms that helps reduce engineering costs. But Dippold says he sees many more steps in the journey ahead. Today's BIM and GIS models "feel more federated than integrated" at this stage of development.

"Ultimately, I'd like to have like a photo-realistic, 3D video game environment that convenes all the benefits that BIM has to provide," he says. "So it has contextual data—accurate data that's not only geometric, but location data and parametric information about objects in terms of static information. There is potentially dynamic information in there, things that change design intent. I'd also like to enhance the power of GIS. Not just the location stuff, but the ability of the analytics and datasets that you can run in a GIS environment to be applied into your BIM information. That's where we're headed."

A critical component in this effort is breaking down silos. Dippold admits that GIS is often "treated like the poor cousin of BIM," but his firm is working to change that cultural

divide. "GIS has a tremendous amount of value to add when it's combined in the right ways at the right times with our project delivery work," he adds. "One of the things we're trying to do now is identify the best integrations or touch points that we can develop with our GIS people. How do we expand that with that knowledge base?"

The Skanska-Costain-STRABAG Joint Venture for the HS2 Project (high-speed railway) in United Kingdom is undertaking a multi-year BIM-GIS integration effort that aims to break down barriers and pull together professionals across multiple disciplines, says George Floros, senior GIS data specialist on the project. Two years ago, the effort was limited with about 30 people using generic formats to bring GIS and BIM together. Today, more than 1,000 accounts have access to the information, bringing together seven different data types from a dozen disciplines.

Floros says the team has realized significant savings—both direct and indirect—by having one shared environment. He estimates that a 10% time-savings could be realized "because we spend lots of time during planning and early stage-design, trying to find where the latest information is." The company has also reduced the number of software licenses it needs, resulting in an annual savings of more than $325,000.

In a specific example, the project team pulls together CAD, BIM and GIS data for the extensive excavation modeling required on the project. "Having these three working together, having this database, you can export from a single place and estimate the volume of the excavation material using automated tools," he says. "This gives a result that is 85% to 95% accurate and is ten times faster (than conventional processes)."

BIM and GIS integration on the HS2 project in London

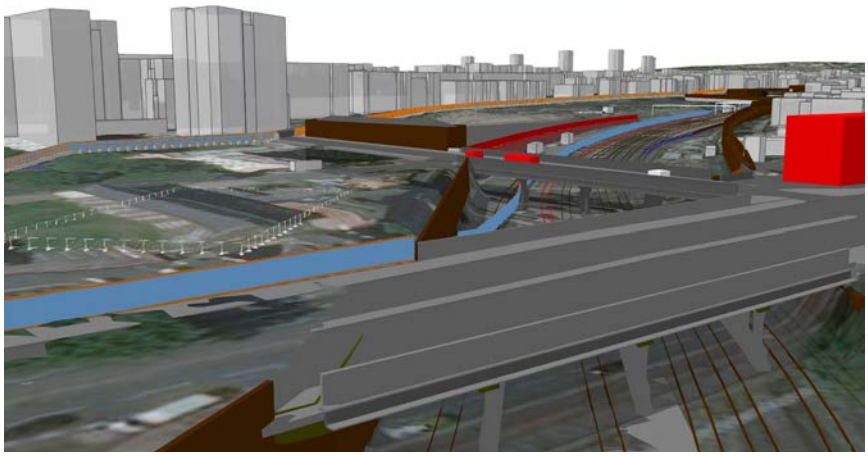


Image Courtesy of Skanska-Costain-STRABAG Joint Venture

Value for Owners

The value of BIM-GIS integration for owners is also emerging. Dippold says, traditionally, engineers have struggled to fully grasp the long-term implications of major infrastructure projects. "To understand whether the client's investment is ever going to achieve its goals would be tricky were it not for something like GIS, where we could begin to measure things like household incomes or surface porosity or the effects on wetlands or pedestrian safety or even the impact to the opioid crisis. You can make datasets for virtually anything. And we can start looking at this, not only over the duration of the job, but decades to come. That helps clients understand how those types of investments will reshape entire cities, and then use that to the benefit of future planning."

Still, early adopters continue searching for optimal ways to provide datasets that will help clients with asset management. Although promising work is happening on the front-end of projects, he says BIM-GIS integration for operations and maintenance is "not really there yet."

But with clients starting to pursue concepts like smart cities and digital twins, Pietra sees demand growing for asset management solutions. "Building owners and facility managers are under more pressure than ever to be responsive to everything from public safety to pandemics," he says. "They want to know: How can I use the model? How can I get this information to work for me and make decisions faster?"

Although GIS and BIM practitioners are still climbing the adoption curve, Pietra sees the opportunity to evolve GIS into being a tool that goes well beyond mapping as a welcome development.

"The GIS community has never been as excited as it is now," Pietra says. ■

Benefits of GIS on Project Processes and Outcomes

Benefits of Using GIS Tools and Data

Use of GIS provides a variety of benefits to design and construction professionals. This section of the report looks at five different types of benefits:

- **Benefits to Project Processes and Outcomes**
- **Risk Reduction Benefits**
- **Sustainability Benefits**
- **Internal Business Benefits**
- **Market-Related Business Benefits**

Benefits of Using GIS on Project Processes and Outcomes

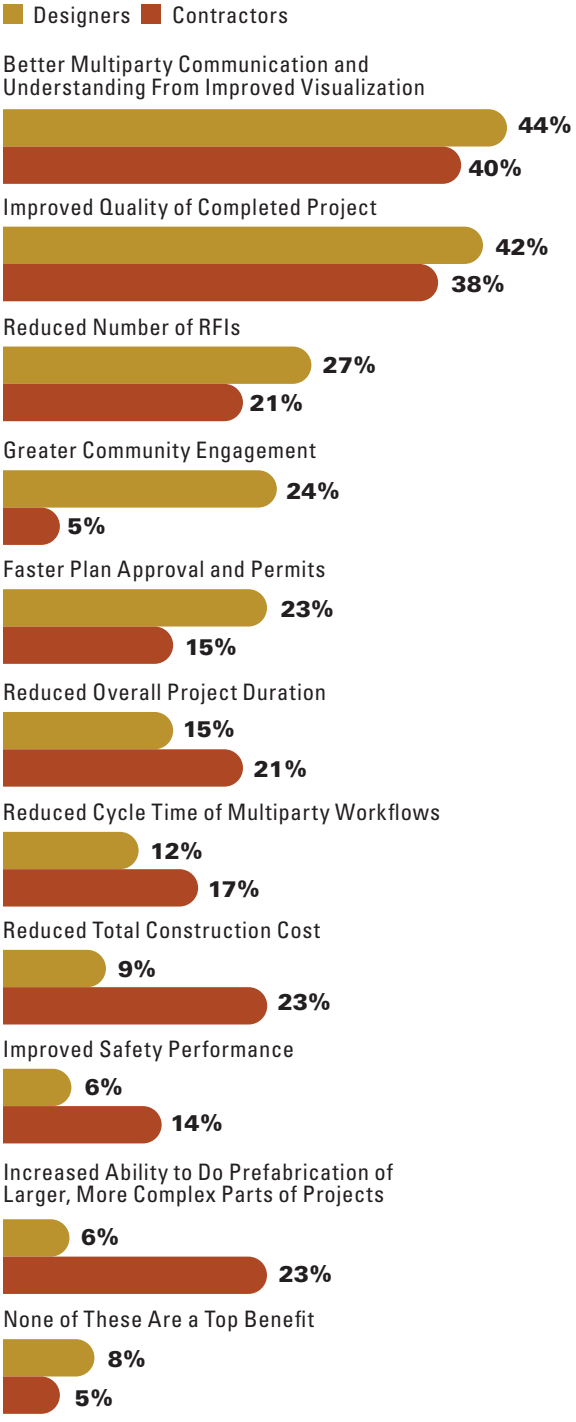
Respondents were asked to select the top three most important benefits from a list of 10 options, which included six improved processes and four improved outcomes. They were also provided with the option that they do not consider any of the 10 choices an important benefit derived by using GIS. Notably, only 8% of designers and 5% of contractors agree with that view, demonstrating that the vast majority of industry players using GIS see process and project outcome benefits from its use.

PROCESS IMPROVEMENTS

Many of the other financial and risk reduction benefits experienced when using GIS are due to the process improvements that GIS provides. Therefore, it is not surprising that when the survey respondents were asked to select the top three most important to their company from a list of 10 potential outcome and process benefits, **the top benefit selected by 43% of all respondents is a process benefit: better multiparty communication and understanding from improved visualization.** It is also the top benefit for both designers and contractors. This finding corresponds with numerous other studies conducted by Dodge Data & Analytics that demonstrate that the ability to collaborate effectively is directly correlated with greater project success.

Top Improved Processes and Outcomes Due to GIS Capabilities (Selected in Top Three by Designers and Contractors)

Dodge Data & Analytics, 2020



Benefits of GIS on Project Processes and Outcomes CONTINUED

Five other process-related benefits were included among the 10 total options in the survey. These are generally more widely cited by architects than contractors as being among their top three most important benefits, even though many of them are important to a substantial percentage of contractors as well.

- **Reduced RFIs are selected in the top three by a slightly higher percentage of designers (27%) than contractors (21%).** That difference is not statistically significant, and reducing RFIs still ranks among the top benefits for contractors as well.
- **More designers select greater community engagement and faster plan approval and permits than do contractors.** This makes sense because designers are often more directly engaged in obtaining approvals and in engaging community support, especially on public projects, than are contractors, who are often brought onto the project after plan approvals and initial permitting have been completed.
- **More contractors than designers select two process benefits: reduced cycle time of multiparty workflows and increased ability to do prefabrication of larger, more complex parts of projects.** The ability to do prefabrication, in fact, ranks third highest among contractors. This finding is not surprising given the results of other Dodge Data & Analytics studies, which demonstrate that prefabrication provides contractors with improved ability to manage labor and productivity, frequently saves them time and money, improves safety and reduces waste.

OUTCOMES

One of the most important of the 10 process and outcome benefits, selected in the top three by the second highest percentage of all respondents (41%), is the use of GIS to improve the quality of the completed project. It is very close in importance to the top benefit—improving multiparty communication and understanding—and ranks second for designers and contractors alike. It is also likely that there is a direct causal relationship between these two benefits: improved quality can be the direct result of better communication and understanding, because better communication improves the project team's ability to deliver a project that fully meets the needs of the owner and delivers the design intent.

Many of the other outcome benefits are more frequently included among the top three by contractors than they are by designers.

- **Reduced total construction cost is the third most frequently identified benefit among contractors, selected in the top three by 23% (tied with the increased ability to do prefabrication of larger, more complex parts of projects), but only by 9% of designers.**
- **The other benefit selected by over 20% of contractors is reduced overall project duration, and again, designers less frequently select this among their top three.**
- **Due to contractors' responsibility for it, improved project safety performance is selected by more than twice the percentage of contractors than designers,** but only 14% of contractors select it among their top three, which may suggest that this is an emerging benefit related to the use for GIS data.

Risk Reduction Benefits From Use of GIS

Respondents were asked to select the top three most important ways that using GIS helps them to reduce risk from a list of six options. They also had the option to say that none of the choices is an important benefit of GIS. Since there are no significant differences in the responses of designers and contractors, the chart at right represents all the GIS users who participated in the study.

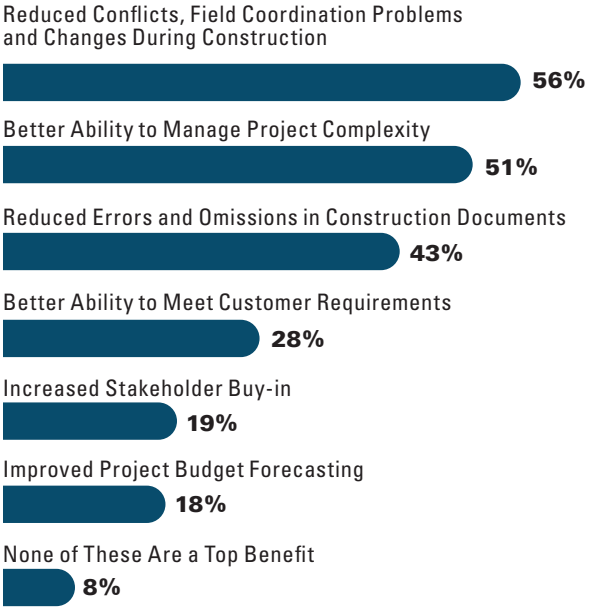
The findings reveal that using GIS plays a key role in helping to reduce risk on projects, with three major benefits frequently selected by respondents as the most important.

- **Nearly all (92%) respondents find that their use of GIS generates at least one of these risk-reducing benefits.**
- **The top risk-reducing benefit is reducing conflicts, field coordination problems and changes during construction.** This is cited by over half of all participants, even the designers. This benefit is linked to the top process improvement of better multiparty understanding (see page 16), since that leads to reduced conflicts and coordination issues.
- **Better ability to manage project complexity is also a top benefit, selected by over half of respondents.** With complex projects, reducing uncertainty is critical to project success. The data provided by GIS tools can help reduce that uncertainty.
- **The third most important way GIS tools help minimize and manage risk is reducing errors and omissions in construction documents.** Again, this relates to GIS providing more accurate information to designers that can help improve the construction documents.

The other four benefits are less widely chosen among all GIS users as being among their most important benefits, but still selected by enough to suggest that they contribute to risk reduction on projects. Over one quarter feel that GIS provides them with a better ability to meet customer requirements, and nearly one fifth credit GIS with helping them to increase stakeholder buy-in and improve project budget forecasting.

Top Risk Reduction Benefits Due to GIS Capabilities (According to All GIS Users)

Dodge Data & Analytics, 2020



Sustainability Benefits From Use of GIS

Designers were asked to select the top three most important ways that using GIS helps them to improve sustainability from a list of six benefits, or indicate that none of the options qualify as a top benefit.

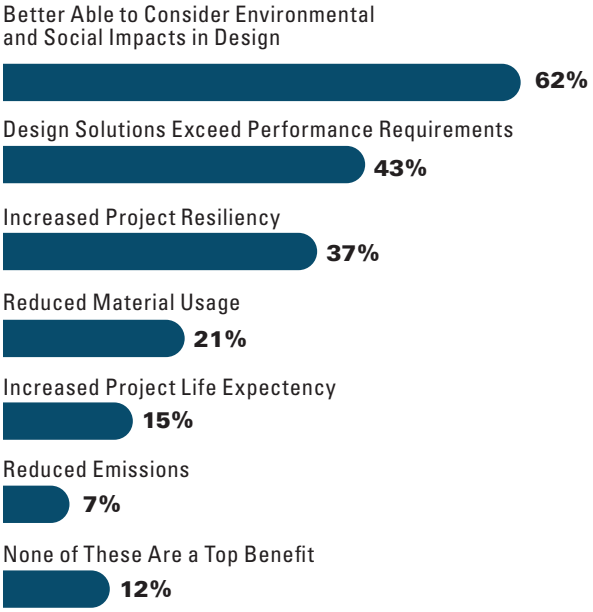
Most designers (88%) consider at least one of the options provided to be an important sustainability benefit of GIS. However, there is a clear priority in their responses on the ability that GIS gives them to address sustainability in a more holistic fashion than the ability to achieve very specific benefits.

- **By far, the highest percentage (62%) select the improved ability to consider environmental and social impacts in design as one of the most important benefits of using GIS tools to improve sustainability.** The design sector has often been a leader in sustainability, and they have long used tools that predict the building performance and its impact on the environment (e.g., lighting studies, wind studies, airflow studies, etc.). However, GIS allows access to underlying social data that can help designers specifically consider how their building fits into the social fabric into which it is being placed, providing a new level of sustainability.
- **A relatively high percentage (43%) also regard the ability of GIS to help their design solutions exceed performance requirements to be one of the top benefits of sustainability.** Again, since the data that GIS provides goes beyond just addressing building performance impacts on the environment, access to that data can offer new opportunities for designers who seek to make a more extensive positive impact with their buildings.
- **Increased project resiliency is the third most important benefit selected by designers.** As the frequency and impact of natural disasters continues to grow, resiliency has become a major concern for owners, architects and engineers, so it is not surprising that the ability of GIS data to increase project resiliency is selected as one of its most important sustainability benefits by over one third (37%) of designers.

Other benefits are more rarely selected as the most important, including reduced material usage, increased project life expectancy and reduced emissions. It is possible that designers may already have other tools that they use to help achieve or understand many of these factors, so the other benefits of GIS therefore take on more importance.

Top Sustainability Benefits of GIS Capabilities
(Selected in Top Three by Designers)

Dodge Data & Analytics, 2020



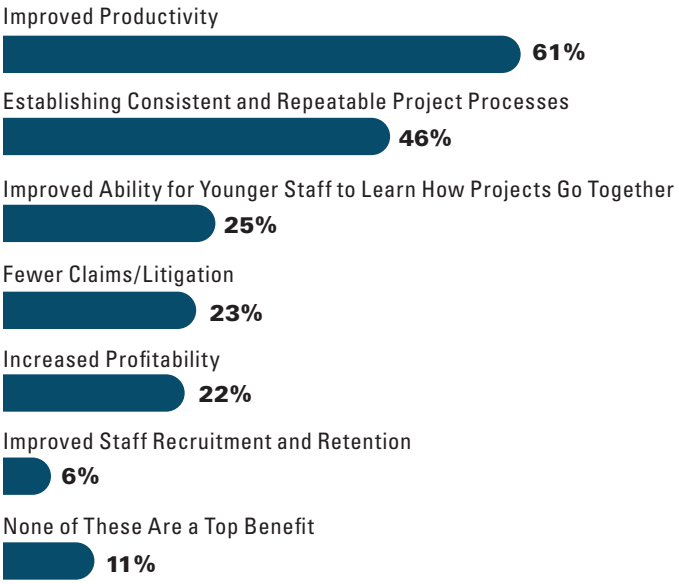
Internal Business Benefits From Use of GIS

Respondents were asked to select the top three most important ways that using GIS provides internal business benefits from a list of six options. They could also say that none of the options are important benefits of GIS. Since there are no significant differences in the responses of designers and contractors, the chart at right represents all the GIS users in the study.

- **As with the previous categories of benefits, nearly all (89%) believe that at least one of these options is an important business benefit they experience from using GIS.**
- **Nearly two thirds (61%) believe improved productivity is one of the most important top internal benefits provided by GIS.** This is not necessarily an intuitive finding, since more data can mean more time spent working with it. However, the strong response to this benefit demonstrates how addressing uncertainty on design and construction projects is a critical factor in improving productivity.
- **Nearly half (46%) regard establishing consistent and repeatable project processes as an important benefit of using GIS.** Again, having accurate, reliable data can help support consistent and repeatable project processes by avoiding disruptions during the project lifecycle.
- **About one quarter consider the value of GIS to support the building knowledge of younger staff, to avoid claims and litigation and increase profitability as some of the most important benefits.** While this is far fewer than the number of respondents who identify the two top options, it still demonstrates that many users are getting value from GIS data from each of these benefits.

Top Internal Business Benefits Due to GIS Capabilities (Selected in Top Three by All GIS Users)

Dodge Data & Analytics, 2020



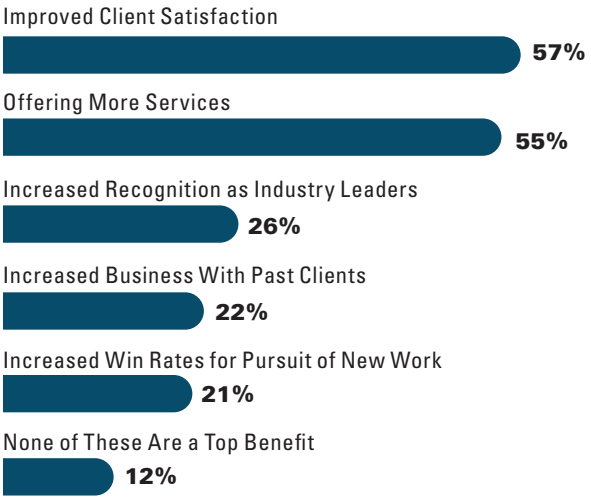
Market-Related Business Benefits From Use of GIS

Respondents were asked to select the top three most important ways that using GIS provides market-related business benefits from a list of five options. They could also say that none of the options are important benefits of GIS. Since there are few significant differences in the responses of designers and contractors, the chart at right represents all the GIS users in the study.

- **As with the other options, nearly all (88%) of the GIS users find that at least one of the five options is an important benefit from their GIS capabilities.**
- **Improved client satisfaction is the top benefit, selected among the top three by 57%.** Designers and contractors agree that this is a critical market-related benefit of GIS. Considering the positive impact for clients of other top benefits, including improved quality of the final asset, better construction coordination, reduction in errors and omissions from construction documents and design solutions that exceed performance requirements, it is not surprising that such a high percentage of respondents report improved client satisfaction.
- **Nearly as many select the opportunity to offer more services among the most important market-related business benefits.** As the uses of GIS reveal (see pages 9, 10, 11 and 12), designers and contractors can provide a great deal more to clients through access to the tools and data it offers.
- **Over 20% select three other benefits among the top three most important, suggesting that each is delivering value to a substantial number of GIS users.**
  - Increased recognition as an industry leader is the only benefit where there is a significant difference in the response by firm type. 36% of GCs regard this as a top benefit, compared with just 19% of architects.
  - Over 20% regard the ability to increase business with past clients and increase win rates in pursuit of new work as top benefits. It is notable that both of these may be the direct result of increased client satisfaction and increased offerings, the two top market benefits.

Top Market-Related Business Benefits Due to GIS Capabilities (Selected Among Top Three by All GIS Users)

Dodge Data & Analytics, 2020



case study

Web Maps for Infrastructure Management:

Lower Paxton Township Authority

HARRISBURG, PENNSYLVANIA

A screen image from the GIS solution implemented for LPTA, which is being used in the field by a GHD location intelligence analyst.

Over the last five years, the Lower Paxton Township Authority (LPTA), which provides sanitary sewer services for a 28-square-mile suburb of Harrisburg, Pennsylvania, has taken its use of GIS to a whole new level—from basic system inventory to records archive, public outreach medium and workforce productivity tool.

LPTA's GIS expansion parallels an overhaul of its physical infrastructure. Inflow and infiltration (I&I) issues from the original construction, built between the 1960s and the 1980s, required an extensive program of rehabilitation and replacement. Most of the sanitary sewer system—including sewer main, maintenance holes and even the private runs from the main line to the customers' buildings—has been rebuilt. "This gives us the ability to get the records right the second time around," says Tim Nolt, sewer department engineer with LPTA, "with a lot more technology at our fingertips than our predecessors had when the system was originally installed."

System Inventory and Records

LPTA's cloud-based solution, developed in collaboration with the Harrisburg office of GHD Digital, provides a comprehensive map of the sewer infrastructure. Up-to-date information on maintenance hole locations and depths, clean-outs, inlets, and pipe material and size, among other key aspects of the system, can all be accessed from a desktop computer or from a mobile device in the field.

The GIS solution also serves as a geospatial index to the library of documents generated over the course of the I&I remediation. A user simply selects a component of the system, and the database enables easy recall of associated record drawings, straight line diagrams, photographs, inspection reports, agreements and other information on the selected component. "When we decide on what level of as-built data needs to be stored in the GIS system," says Nolt, "we evaluate how it will be used by current staff, and also look ahead to what information might be useful to employees and residents 60 years from now."

GHD migrated LPTA's existing data to match the layers, fields and values of the new platform, and provided industry-standardized data fields and record values to enable users to enter new data easily and to simplify data maintenance.

Because the system is web-based, new data becomes immediately available to all users, whether within LPTA or at collaborating agencies and consultants, with no need to copy data to multiple computers. "3D CAD designers now have the ability to consume data straight from GIS online into their drawings, and to push design drawings back into the GIS platform," says Todd Plank, senior GIS analyst with GHD. "That's something big that's new." The system can also pull data from other agencies, such as tax parcel data via a live feed to the county's GIS.

Public Outreach and Increased Transparency

Streamlined access to comprehensive data is helping LPTA respond more effectively to customer inquiries. "To have that ability to call up the documentation—including property information—that a resident is phoning about has been huge for customer service," says Nolt.

In addition to helping staff provide quicker answers to callers, GIS offers answers directly. The public-facing component of the platform provides construction status maps

CONTINUED

Image Courtesy of GHD Digital

Lower Paxton Township Authority

HARRISBURG, PENNSYLVANIA

with schedule information as well as an automatic notification system to issue regular updates. LPTA currently has two sewer construction projects underway, totaling $21 million, and a similar scope going out to bid in 2021. "We needed a way to effectively show the public where our work is located and how they will be impacted," says Nolt. "Our projects are very disruptive and include excavation work on private property, so we need to communicate contractor schedules, road closures, service disruptions and other items to residents daily." Public-facing GIS maps allow LPTA to make changes internally and publish them in real time. "These tools help us communicate more effectively with the public and garner additional support for our construction," Nolt says. GIS maps also provide information on planned, in-progress and completed projects, so residents can see how their user fees are being invested.

LPTA also manages Lower Paxton's storm sewer system, which it acquired from the Township in December 2018. The introduction of stormwater fees based on the amount of impervious cover on customers' sites pushed the authority to develop tools for sharing information on how it calculates that billing. Public-facing GIS maps now allow residents to check and query the area of impervious site coverage that LPTA is using as the basis of their storm water fees. As with the sanitary system, the maps also illustrate how the fees are being used to make necessary system improvements.

The authority's GIS-based public outreach efforts have reduced the number of phone calls LPTA receives, Nolt reports, both in general inquiries and in complaints about construction.

Workflow Productivity

LPTA's GIS platform also includes a dashboard for internal use. As well as facilitating project progress tracking, it allows staff to document before and after conditions of roads and properties, simplifying the resolution of damage claims. Improved GPS locating ability allows the authority's construction division to collect as-built data without the need for surveys or extensive as-built drawings. And the mobile platform supports workers on service calls. On a maintenance hole inspection, for example, staff can record values, make sketches, take pictures and download the data to a prepopulated form template. "It has definitely improved our workflow productivity," says Hannah Brown, sewer department GIS technician with the authority.

Nolt expects the new system to be especially valuable in tapping the knowledge base of LPTA employees nearing retirement. This generation tends to rely on hard copies of maps and on notes that are sometimes independent of the larger records system. Integrating their records into GIS will make this information more readily available to other members of the organization and provide continuity as workers retire.

Looking Ahead

After seeing the Sewer Department's success with GIS—reflected in high levels of user uptake as well as improved data access, transparency and productivity—the township has expressed an interest in implementing GIS across all of its departments. Additional layers for storm water features, zoning, FEMA flood zones and historical property locations have been integrated to support LPTA staff with tasks related to zoning, permitting and storm water programs.

With a comprehensive system inventory in place, LPTA is now focusing on its remaining objectives: filling in gaps in system records, continuing public engagement initiatives and experimenting with ways to further enhance productivity by integrating daily inspection and maintenance activities into the GIS. "It's exciting to be a part of developing a GIS system that will be a critical part of our operations for many years to come," Nolt says. ■

Project Data stats

Utility Manager:
Lower Paxton Township Authority

Population Served:
Approximately 50,000

Township Area:
28.1 square miles

Sanitary System:
270 miles of sanitary sewer, four pumping stations, three permanent flow metering chambers. No WWTP.

Stormwater System:
120 miles of storm sewer

Billing:
Over 17,500 accounts

Sanitary Sewer Fees:
$153/quarter

Storm Sewer Fees:
$32/quarter/ERU

GIS for Disaster Resilience

Location-based data can help communities understand their risks due to climate impacts and contribute to better-informed decisions about the options and investments through which a community is most likely to improve its resilience.

With nearly every city (96%) reporting a climate-related impact in the last five years, according to the U.S. Conference of Mayors, communities are increasingly focused on ways to improve their resilience to disaster. Resilience is the capacity to survive, adapt and overcome acute shocks (such as wildfire, hurricanes and earthquakes) as well as chronic stresses (like aging infrastructure, a lack of affordable housing and increasingly hot summers). Because the challenges of resilience vary from region to region, municipality to municipality, and even neighborhood to neighborhood, GIS data is invaluable in facing these challenges.

Predictive Modeling

One of the strengths of GIS in resilience planning is its support for predictive modeling. The California towns of Portola Valley and Woodside, for example, in collaboration with the fire department that serves them both, have adopted a disaster preparation platform that integrates GIS, artificial intelligence and machine learning to model thousands of earthquake scenarios, at various locations, depths and intensities, to yield fine-grained predictions about human and environmental impacts. The patterns and predictions that emerge from this GIS- and AI-enabled modeling have improved the communities' resilience planning, according to Portola Valley's town planner, Jeremy Dennis, and the regular planning exercises that the modeling facilitates have fostered stronger working relationships among the community leaders involved. "By observing more natural disasters and by taking advantage of modeling, we can understand potential impacts sooner to more effectively plan for and mitigate them," says Shabaz Patel, director of data science at One Concern, the company whose platform underlies the town's resilience planning.

Disaster Response and Prevention

When a disaster does occur, GIS can support response teams. In wildfires, for example, GIS is helping resource advisors to locate and protect assets, such as archaeological sites and sensitive habitats. During the 2020 Creek Fire, the largest in modern Californian history, Yosemite National Park's GIS coordinator, Elizabeth Hale, bundled datasets that located the variety of resources in need of protection into an offline portable map package for resource advisors to access on phones and tablets in the field. Layers could be turned on and off as required, or clicked for additional information about specific features. GIS was also used to consolidate data collected during the day for review and quality control, so that the entire team could head out the next day with new data and a common map. "Equipping advisors with data layers of resources at risk in a way that's portable and searchable is something that's fairly new," says Hale, "and it's getting good reviews."

GIS is also helping communities worldwide prevent disasters from occurring in the first place. In the flood-prone province of Kerala, India, for example, Brian Tomaszewski, an associate professor at the Center for Geographic Information Science & Technology at Rochester Institute of Technology, reports that GIS is helping local planners understand how urban sprawl compromised the system of wetlands and green infrastructure that could have absorbed 2018's lethal floods. Building on that understanding, GIS models of structures, storm surge and water levels are informing the development of scenarios for reinstating those natural systems.

Throughout the process of disaster planning, mitigation, recovery and prevention, public-facing GIS-based applications can improve citizen engagement and democratic processes. Whether providing updates on water quality after a storm, alerting to the potential for park crowding during a pandemic, or facilitating consultations about a proposed development, GIS can help to inform the public about resilience-focused plans and proposals, and to gather valuable feedback. "If you're not using GIS," says Tomaszewski, "start." ■

Data: Investments and ROI

Investments Made to Support Use of GIS

Fully engaging with GIS requires investments in multiple areas beyond software and hardware. Typically, it also includes investing in training, and among those who wish to gain the most from the data, developing effective workflows and processes. Therefore, respondents were asked to identify the top three investments they have made in the past three years related to GIS. Since there are no significant differences in the responses of the architects, civil/structural engineers, general contractors and specialty trade contractors, the chart at right shows the responses of all the GIS users in the study.

- **By far, the biggest investment is in software that supports the use of GIS, selected as a high priority by 51%. About one quarter also are prioritizing investments in software customization and new/upgraded hardware.** To capitalize on the rich data available, good software tools are essential, and to use the data properly, the ability to exchange data across programs is also valuable. More sophisticated software often calls for hardware upgrades to support it.
- **However, three of the top four priority investments all involve people and processes, rather than the tools needed to use GIS appropriately.**
  - Training on GIS is a top priority for 36%, suggesting that user companies want to upskilll their staff, while the industry as a whole is also still learning how to get the most out of GIS data.
  - Developing internal collaborative GIS-based workflows is also a priority for 31%, while developing collaborative GIS-based processes with external parties is a priority for 26%. Both of these reinforce the findings that demonstrate the importance of accurate data in improving collaboration on projects (see page 17). In addition, the focus on internal workflows supports the investments in training, so users can maximize the value of GIS in their companies.

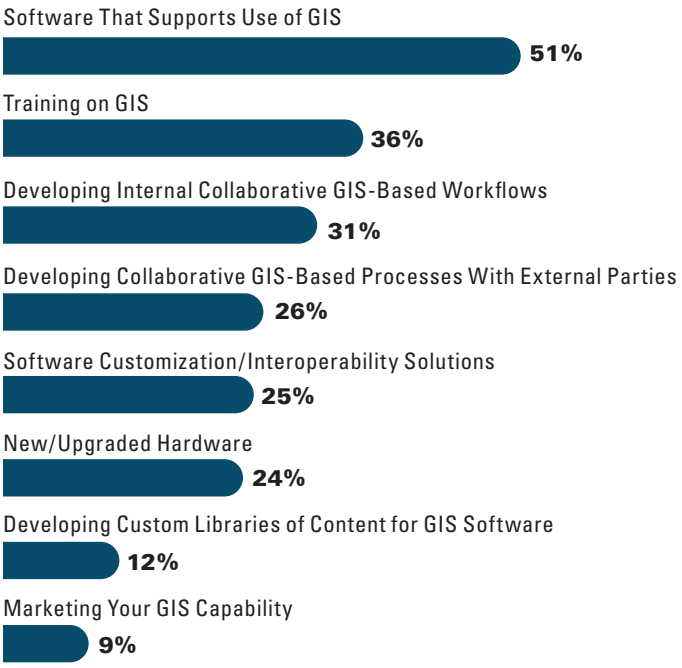
Fewer firms have prioritized investments in developing custom libraries of content for GIS software or marketing their GIS capabilities, which may be investments typically made by more sophisticated, advanced users of GIS. These findings suggest that many companies are in relatively early stages of their GIS journey and are still learning how to fully capitalize on its value in the market.

Variation by Size

47% of large GCs have invested in developing internal collaborative GIS-based workflows, compared with just 9% of small GCs.

Top GIS Investments Made in the Past Three Years (Selected in Top Three by All GIS Users)

Dodge Data & Analytics, 2020



ROI of GIS

For many companies, tracking the exact return on investment of technology investments is challenging. Certainly, this is the case with GIS, where the investments go beyond the software and hardware, but where users also report experiencing a broad range of benefits, including better project outcomes, risk reduction, improved sustainability, and internal and market-facing business benefits (see pages 16–21 for more details on the specific benefits of GIS).

Therefore, after the respondents were asked about the benefits they receive from GIS and the investments they are making in it, they were asked to consider the return on their investment in GIS. Those who report a positive ROI were then asked to try to quantify that ROI.

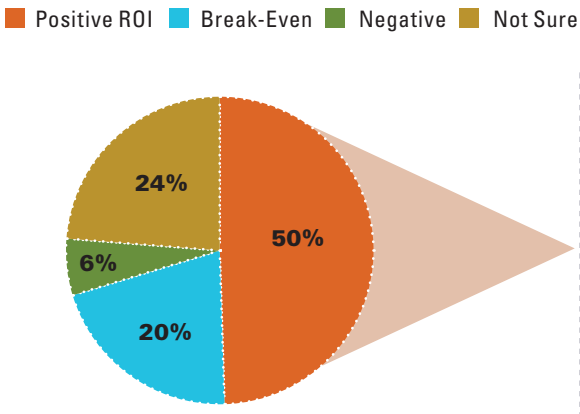
The pie chart below reveals that half (50%) of the respondents believe they have already experienced a positive ROI from their investments in GIS. Nearly half of the rest are not sure, and almost all of the remainder think that they have broken even, leaving only 6% who feel that they have had a negative ROI so far from investing in GIS.

Among those who believe that they have seen a positive ROI, less than one third (31%) think that the return on investment they have experienced is less than 10%. Over one third (35%) believe that they have already gained between 10% and 24% more than their investments in GIS, and 34% think that return is even higher.

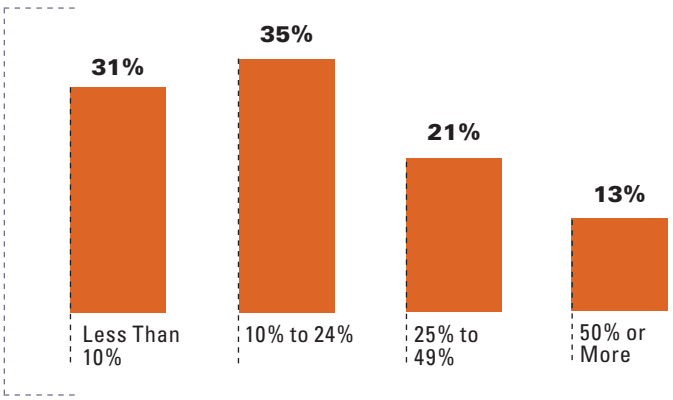
While it is likely that many of these estimates are not drawn from formal measurements of the ROI on their investments, the perception of a high level of value gained aligns with the reports of the benefits they have experienced from the use of GIS.

Experiencing ROI From GIS Investments
(All GIS Users)

Dodge Data & Analytics, 2020



Degree of Positive ROI



Data: GIS Use by the Project Team

Designers: Frequency and Value of GIS Use

by Project Team

The findings in this study have demonstrated the importance of GIS to support collaboration and multi-party workflows. However, each player has a very different perspective on the value they gain from having other project team members engaged with GIS data.

To analyze these differences, all GIS users in the study were asked two questions: one about the frequency with which other project team members engage with GIS and another about the value to their company from having other team members highly engaged. Consideration of both of these factors shows where more engagement with GIS most effectively improves projects.

Frequency of Use of GIS by Other Project Team Members

The charts at right and on the next page show how frequently architects and civil/structural engineers report that owners, other design firms/consultants and contractors are engaged with GIS. While the charts are organized by the responses of architects and engineers in order of frequency, the following paragraphs analyze the responses by type of organization engaged with GIS.

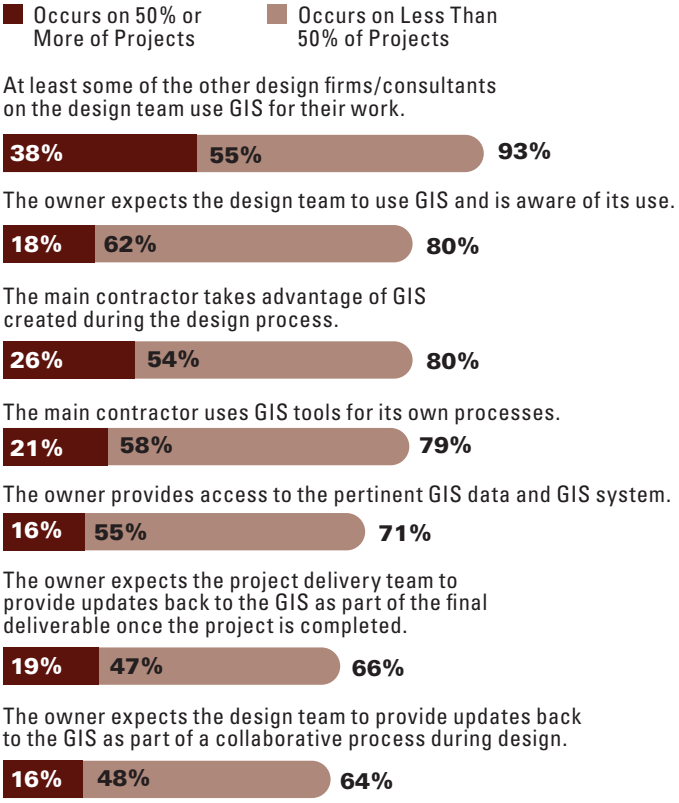
OWNERS

There are four options included for different ways that owners can engage in GIS on their projects. Not surprisingly, the deeper the level of engagement by the owner, the less frequently it is to occur.

- **Owners expect the design team to use GIS and are aware of its use:** While 100% of engineers and 80% of architects report this level of engagement on at least some of their projects, the vast majority say that it occurs on less than half of them, suggesting that many owners may not even be aware or have any expectations about GIS. This finding is important because owner awareness and expectation of use can help drive adoption across the rest of the project team.
- **Owners provide access to the pertinent GIS data and GIS system:** Owners of large assets may have valuable GIS data that can help create greater certainty during the design and construction process. Far more civil/structural engineers using GIS (97%) than architects (71%) report having experienced this. However,as with the architects, very few of the engineers report that it occurs on over half of their projects.
- **The owner expects the project delivery team to provide updates back to the GIS as part of the final deliverable once the project is completed:** Far more GIS-using civil/structural engineers (89%) than architects (66%) report

Use of GIS By Project Team
(According to Architects)

Dodge Data & Analytics, 2020



Designers: Frequency and Value of GIS Use by Project Team CONTINUED

experiencing this on any projects. Among architects, despite the lower percentage who experience it, the share reporting occurrence on half or more of their projects is consistent with the other options. Among civil/structural engineers, the share who experience this on more than half of their projects is higher than the other owner activities. This may suggest that these designers work with some owners who are particularly invested in GIS and are as likely to engage with it in very intensive ways as in less intensive ones.

- **The owner expects the design team to provide updates back to the GIS as part of a collaborative process during design.** The same patterns hold for this type of owner engagement with GIS. Civil/structural engineers more commonly report seeing it than do architects, and the percentage who report seeing it on 50% or more of their projects is roughly the same as on more widely experienced types of owner GIS engagement.

OTHER DESIGN FIRMS/CONSULTANTS

All of the civil/structural engineers (100%) and nearly all of the architects (93%) find that, on at least some of their projects, other design firms/consultants use GIS for their work. In addition, nearly the same percentage (38% of architects and 36% of engineers) report that this occurs on 50% or more of their projects. The consistent responses suggest that this provides a good estimation of the degree of engagement with GIS in the design industry.

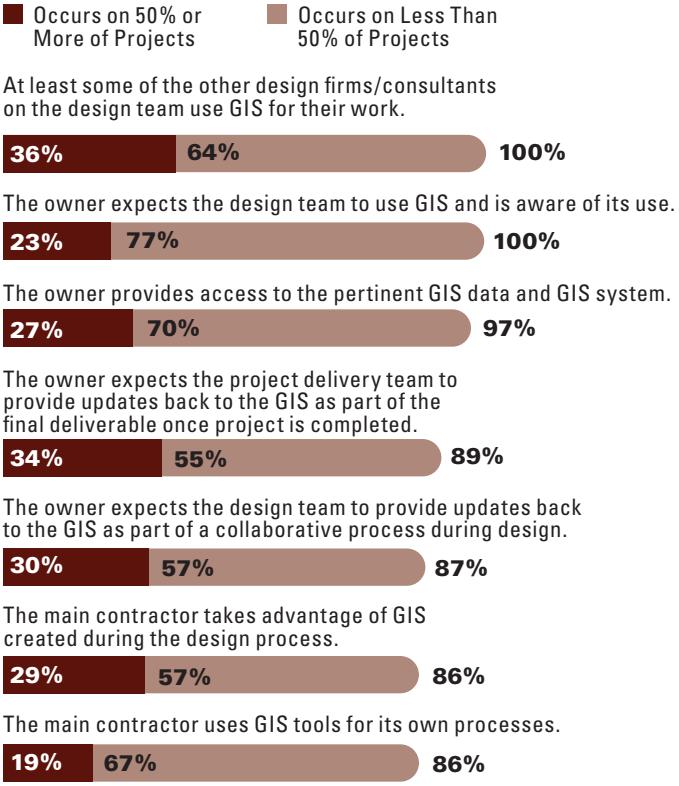
CONTRACTORS

Architects are more likely to report that contractors are engaged with GIS than they are to see owners deeply engaged beyond just expecting use of GIS and being aware of its use. Around 80% of architects report that contractors use GIS tools for their own processes and that the main contractor takes advantage of GIS created during the design process. Over 20% report that both of these happen on more than half of their projects.

In contrast, while a higher percentage of civil/structural engineers than architects report seeing contractors engaged in these ways with GIS, the engineers are less likely to see contractors engaged than owners. This may be because they are not as regularly in contact with contractors during construction as architects are.

Use of GIS By Project Team
(According to Civil/Structural Engineers)

Dodge Data & Analytics, 2020



Designers: Frequency and Value of GIS Use by Project Team CONTINUED

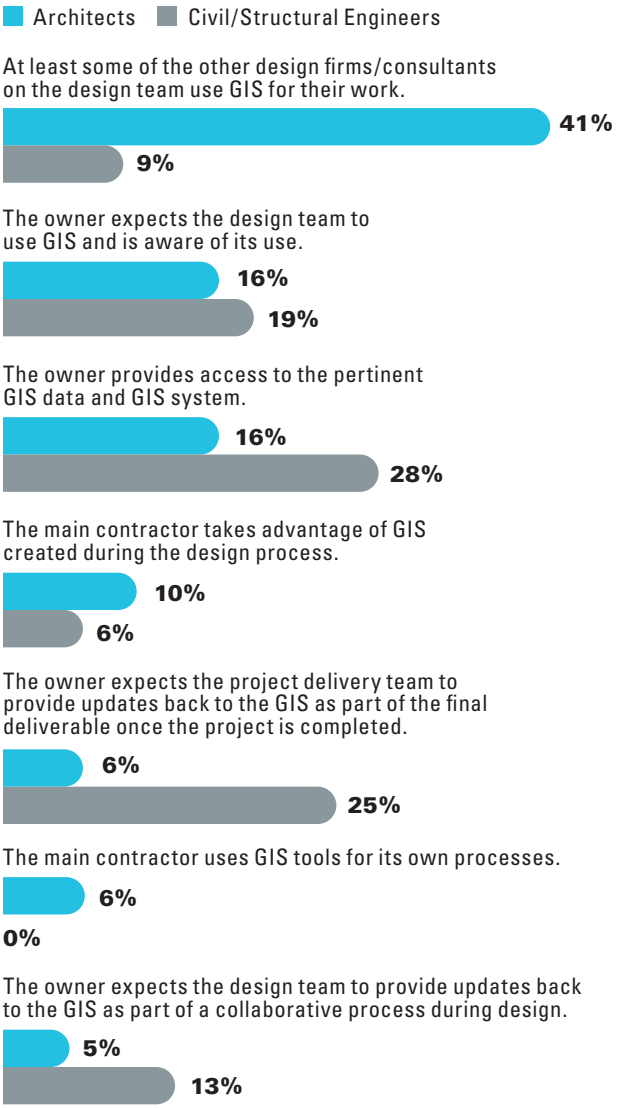
Most Valuable Engagement With GIS by a Member of the Project Team

After reporting the frequency of various types of engagement with GIS, respondents were asked to identify the one engagement type that provides the greatest value to their projects. The chart at right shows distinct variations in perspective between architects and engineers.

- **The highest percentage of architects select the use of GIS by other design firms/consultants as the most valuable, with more than twice the percentage selecting this option compared with the others provided.**
- **For civil/structural engineers, the owner's engagement with GIS is the most valuable, with access to the owner's pertinent GIS data and GIS system the most frequently selected, and the owner expecting the project delivery team to provide updates back to GIS as part of the final deliverable once the project is completed a close second.**
- **Only 10% or fewer of the architects select either of the options referencing contractor use of GIS, and engineers are even less likely to select contractor engagement with GIS than the architects.**
- **Only 6% of civil/structural engineers consider the contractor taking advantage of GIS created during the design process valuable, and no engineers select the main contractor using GIS tools for their own processes.**

Most Valuable Engagement With GIS By Project Team (According to Architects and Civil/Structural Engineers)

Dodge Data & Analytics, 2020



Contractors: Frequency and Value of Team Use of GIS

General and specialty trade contractors who use GIS were also asked about the frequency of engagement with GIS by other project team members and which type of GIS engagement adds the most value to their projects. Since the number of specialty trade contractors using GIS is relatively small, they are combined with the general contractors in the chart at right and on the next page.

As with the designers, the chart at right is in the order of highest frequency, but will be discussed by type of company.

Contractors

Contractors with GIS experience report most frequently that the main contractor is using GIS or takes advantage of GIS in the design documents. Nearly all contractors (97% and 96%, respectively) report that this occurs on at least some of their projects, and over one third report that it occurs on half or more of their projects. Since the majority of these respondents are the main contractor, and they are all GIS users, it is not surprising that the use they report for contractors is much higher than that reported by architects or civil/structural engineers.

Most contractors (92%) also report that another company on the construction team uses GIS for their work, and 30% report that this occurs on 50% or more of their projects.

These findings suggest that use of GIS by contractors is widespread but not ubiquitous.

Design Team

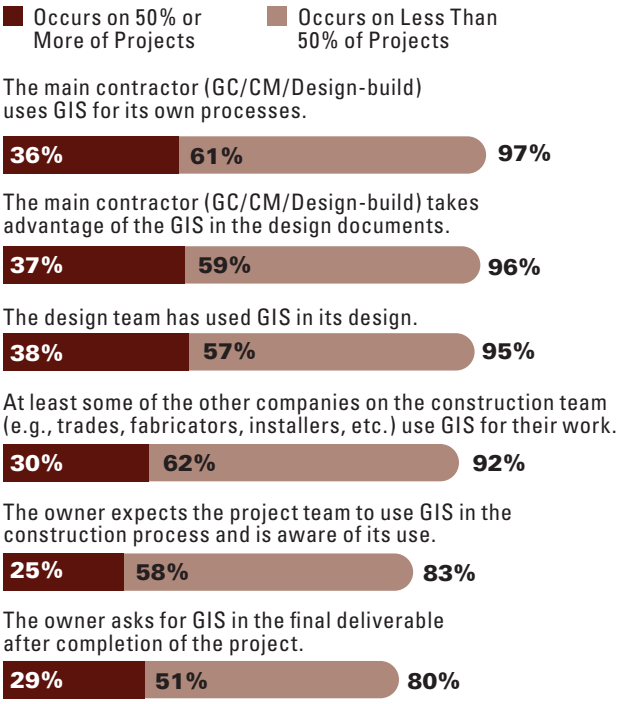
Most contractors using GIS (95%) also find that on at least some of their projects, the design team has used GIS in its design. A relatively high percentage (38%) say that this happens on half or more of their projects. It is possible that when GIS is used during design, it is more likely that a contractor with GIS capabilities is also selected, which may account for the robust frequency with which they report design teams are engaged in GIS.

Owners

While the share of contractors who observe owner engagement with GIS on at least some of their projects is quite high (80% or more), it is lower than they report seeing with design firms and contractors.

Use of GIS by Project Team
(According to Contractors)

Dodge Data & Analytics, 2020



- **Most contractors using GIS (80%) report that owners ask for GIS in the final deliverable after completion of the project, and a relatively high percentage (29%) report that this occurs on half or more of their projects.** Interestingly, the percentage who find that it occurs on over half of their projects exceeds the percentage who report that owners expect the project team to use GIS and are aware of its use.
- **The percentage of contractors who find that the owner expects the project team to use GIS for the construction process and is aware of its use on at least some of their projects (83%) is comparable to architects reporting owner expectation for GIS use in the design process (80%), but the percentage of contractors who find this occurs on over half of their projects (25%) is higher than that of architects (18%).** This corresponds with a general tendency of contractors using GIS to report that other team members are engaged with GIS on a higher share of their projects, compared with architects.

Contractors: Frequency and Value of Team Use CONTINUED

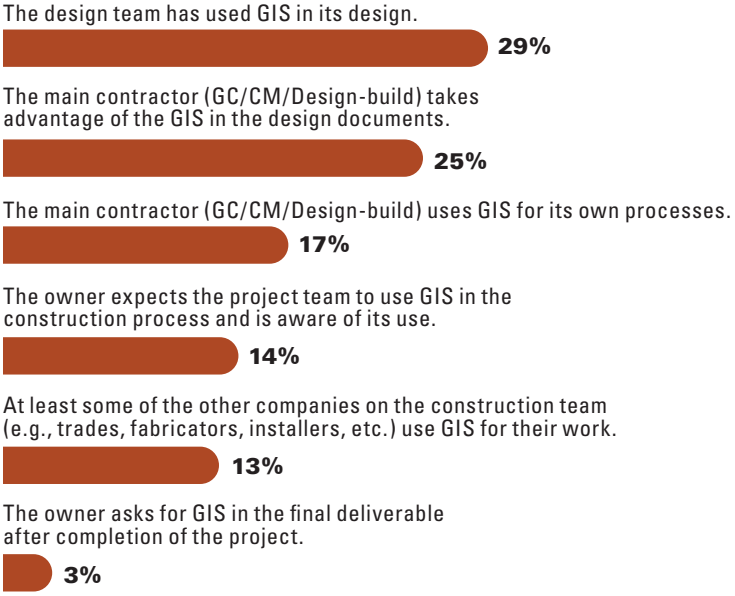
Most Valuable Engagement With GIS by a Member of the Project Team

The contractors were asked to select the single most valuable engagement with GIS by the project team from the same list of options they rated for frequency. The responses are in the chart at right.

- **The highest percentage select engagement by the design team using GIS in its design as the most valuable.** Having a design that includes GIS data would provide more certainty in the bid process and more data during the construction phase.
- **Use of the GIS in the design documents by the main contractor is the second most valuable, and selected by nearly as many who note the design team using GIS in its design.**
- **Despite the prevalence of GCs responding to this question, the main contractor using GIS for its own processes only ranks third in the list of the most valuable options.**
- **A small but notable percentage consider the owners' expectations for the project team to use GIS and use of GIS by other construction team members important, but very few rate the owner asking for GIS in the final deliverable as among the most valuable types of engagement.**

Most Valuable Engagement With GIS by Project Team (According to Contractors)

Dodge Data & Analytics, 2020



Working During COVID-19

The COVID pandemic forced the design and construction industry to rethink how it conducts work. Digital tools are helping contractors to deal with the unprecedented impacts of the efforts to contain the COVID-19 virus and helping to keep jobsites safe and productivity high.

With a general emphasis on promoting distancing protocols, remote work has become a necessity, even for an industry that traditionally practices means and methods that are inherently in-person and hands-on. Technology is playing a major role in how the industry keeps working during the pandemic, sparking an unprecedented push for the expanded adoption of digital tools.

Necessity Drives Innovation

Jim Barrett, vice president and chief innovation office at Turner Construction, says leadership and employees at his firm—driven by necessity—are adopting digital tools at an unprecedented rate.

"Within the past five months, we've accelerated the implementation of innovations and new technologies by five years," he says. "There's more openness and more willingness to trust some of these technologies and to explore the opportunities. Pre-COVID, innovation and trying out new things seemed very abstract and nebulous. With COVID, it's tied to something much more tangible, which is the health and well-being of people. We're in a place where people feel a moral imperative to explore new technologies because not doing so potentially puts our workers and our employees at serious risk."

One recent example is the use of wearable technology. Barrett says that before the pandemic, workers in the field were hesitant to use wearable technology. "We've been talking about wearable technology forever, but people resisted because they were afraid of being tracked," he says. "Now, we can use these wearables to help with things like social distancing and contact tracing. Under that rubric, people are far more open to it than they have ever been."

Barrett says the company is now looking at additional ways to leverage wearable technology, such as ergonomics. "We can analyze movement and provide better feedback to workers," he says. "Reducing stress and strain is important with an increasingly aging workforce. This helps address a huge category of insurance issues."

Need for Trust

Barrett notes that in many cases, "technology is the simple part, but trust is the hard part." For example, he says video technologies—from 360-degree-view cameras to simple cellphone cameras—have been leveraged extensively during the pandemic to reduce the need for site visits. At the start of the pandemic in many parts of the country, building inspectors refused to do site visits or would only do so under extremely stringent protocols. In response, many companies and agencies began doing virtual inspections via video technology.

This augmented device is used by Turner's staff to facilitate virtual inspections and remote site walks.

"With building inspectors we've now created a trust in the reliability and accuracy of the technology," he says. "Once you get over that hurdle, now we can introduce more sophisticated solutions like augmented reality or virtual reality. It's just cracking open our brains to new ways of thinking. Building that trust is necessary because you need trust to explore. Once you get that trust, now you start working with architects, engineers, building inspectors and others, who will start to look at different ways to engage."

Working Remotely

Generally speaking, the need to connect and collaborate virtually is more important than ever, Barrett

Images courtesy of Turner Construction

A worker uses Hololens technology that overlays virtual conditions into physical spaces.

says. While Turner employees had access to Microsoft Teams before the pandemic, it wasn't widely used. Now, it's a regular part of the workday.

"In terms of adoption, pre-COVID we were in a plane just taking off, now we're in the cloud," he says. "We all have to work remotely together."

Nearly all contractors (89%) and engineers (94%) reported making changes to the way they work due to COVID-19, according to a recent *Civil Quarterly* survey. About three quarters of contractors and engineers have changed their work procedures to increase social distancing, making this the most frequently used practice, according to the report. The same percentage of engineers and half of contractors encouraged office staff to work remotely.

Greg Haldeman, northeast regional leader and management committee member at DPR Construction, estimates that staffing at DPR jobsites is between 40% to 100% compared to pre-COVID, depending on the demands of a specific project. Office occupancy ranges from 5% to 50%, depending on location and local restrictions.

"It has forced us to be more creative, he says. "Once, it was all 'butts in seats' and no one could imagine how to do any of this remotely. Now, we've learned more skills, new ways of doing things and new ways of communicating with people."

At a business unit level, Haldeman says virtual meetings are more frequent and take less time and resources than bringing people together in person. Long quarterly in-person meetings have been replaced by shorter biweekly virtual meetings. "There's been increased interaction on some level," he says. "Every other Tuesday, there is a leadership call that has 200 people on it from around the world, being interactive and sharing. It's increased opportunities for two-way communication."

Need for Good Data

From a management level, being more remote has driven a higher demand for good data. The company extensively leverages dashboard technology to track jobsite progress, including jobsites affected by COVID-related shutdowns and limits.

"The demand that we've seen internally for ways to use data and ways to analyze that data internally has increased dramatically," he says. "The hard part is determining what to collect and why. We make sure we go through that first, so we're not needlessly collecting data that's not useful."

Offsite Construction

The pandemic has also prompted the need to take a fresh look at productivity. On jobsites, DPR says the current climate has presented a good business case for expanded use of prefabrication and offsite production. By moving more activities from the field to a controlled environment, Haldeman says safety protocols can be implemented more reliably.

"If we can take half the workers off the jobsite and put them in a more controlled environment, that's a huge benefit for the project," he adds. "Customers want predictable results. The more they can plan and get ahead to control that outcome, the better."

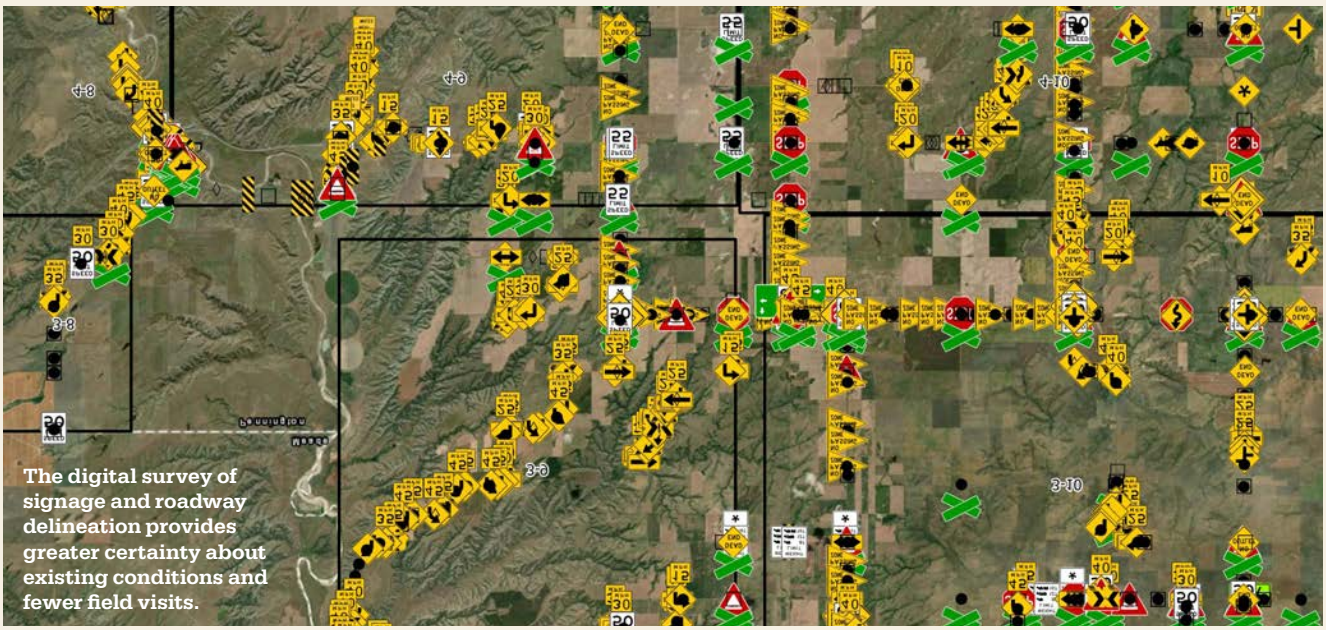
Coming out of the tragedies and hardships caused by the COVID pandemic, Haldeman sees the recent jump in adoption of new technologies as leading to positive change."The world is changing and that's a good thing for all of us," he adds. ■

case study

Productivity Gains From Digital Data

Countywide Signage and Delineation Inventory Project

PENNINGTON COUNTY, SOUTH DAKOTA



The digital survey of signage and roadway delineation provides greater certainty about existing conditions and fewer field visits.

Image courtesy of Ferber Engineering

As part of an effort to enhance safety on roads in South Dakota, the state DOT and the Pennington County Highway Dept. launched a project to analyze and improve signing and delineation on more than 1,000 miles of road in the county. By creating a comprehensive inventory of the county's road signs, pavement markings and other road markers, the project aimed to facilitate analysis for improving its facilities and ultimately reduce the risk of vehicular road departure crashes. In addition, the project would provide an assessment of sign condition and placement.

To meet the project's goals, Rapid City, S.D.-based Ferber Engineering devised a strategy that utilized a wide range of geospatial technology to efficiently and accurately capture, organize, manage and analyze data. Linda Foster, senior project manager at Ferber Engineering, says the firm initially considered using more conventional methods, but decided to explore these new tools after seeing the potential benefits.

"I saw a better way to use different geospatial technologies to acquire the data and then lean on GIS extraordinarily heavily to help us manage that information and design the lion share of the project," she says.

Gathering Data in the Field

One departure from convention was the use of digital ball-banking—integrated with GPS information—to obtain road curve information. Ball-banking with a traditional mechanical inclinometer would require driving through each curve multiple times to get an accurate reading. Foster says using more accurate digital ball-banking allowed drivers to only have to make one pass on each side of a curve. Trips could also be made at safer speeds than with traditional ball-banking as GPS helped improve the accuracy of calculations, even at lower speeds. Foster says the combination of reduced trips and standard highway speeds reduced safety risks for field personnel.

Another significant benefit is improved accuracy, which Foster says also helps from a liability standpoint. "All of that data that was being recorded in real time is being spit back out in a consistent format," she says. "If you put me in the driver seat to drive around a corner and then you put someone else in the driver seat, there's some subjectivity there. From a liability standpoint, it's great knowing we're going into design with data that was gathered in a consistent way."

To further aid in consistent data gathering, 360-degree mobile imaging technology was used on vehicles to record existing signage. The imaging data was corrected against a local CORS [continuous operating reference station] GPS station to ensure the accuracy of

CONTINUED

case study CONTINUED

Countywide Signage and Delineation Inventory Project

PENNINGTON COUNTY, SOUTH DAKOTA

photogrammetric imagery. The system also provided horizontal and vertical road data.

Within six weeks, the field team was able to inventory existing county road signage, as well as signage for four towns, five townships and 42 road districts, spanning a combined 1,018 miles of road. Field workers assessed the condition and placement of more than 20,000 signs and delineators and gathered data on 2,740 curves. Ultimately, the firm collected about 40,000 records of data.

Using the Data in Design

With accurate and consistent data collected from the field, Ferber Engineering was able to use a mix of GIS technology to store, organize, analyze and design replacement signage. By collecting a georeferenced dataset, Foster says the design team was able to save countless hours by reducing the need for repeat visits to the field. Existing signage was largely evaluated in the office with field visits made for quality assurance/quality control, as necessary.

"Think about that designer, who is sitting at their desk wondering, 'Is there a culvert here? Is there a bridge deck there? Is there this? Is there that?'" she says. "Before, you might have to go into the field. Now, it's all right there at your fingertips."

Foster says the combination of quality data leveraged by GIS technology enabled the team to save countless hours of rework and verification. A significant amount of design parameters were automated, such calculating quantities and having accurate road grades readily available for designers. Multiple employees were able to leverage the same data at the same time.

Foster says the level of data available also helped improve communication with stakeholders. Paper maps could be produced in GIS and coupled with web maps to facilitate discussion during meetings with each jurisdiction to discuss existing and proposed signage.

A model builder and other automation tools were utilized to aid in the production of construction plans to determine quantities. A biddable set of plans was also produced almost exclusively in GIS software.

Using the Data After Design

Although its design work is complete and the project is now under construction, Ferber says the data could continue to be used throughout the project's lifecycle. Ferber expects that some data could be used for as-built purposes during construction.

Foster notes that the county could also realize future benefits as the project's GIS data could be used for operations and maintenance purposes. "The county already has an existing database of their sign assets that they have been working on for years and using somewhat in their own O&M," she says. "So, they were very excited about the technology we were using because, when this gets to the as-built phase, they can update their database."

Benefits of GIS Use

Foster says that although there were added costs associated with using the new tools, the firms saved significantly on workhours by reducing the amount of time required in the field and reducing the need for rework and verification in the office.

"We came in right at budget," she says. "We even did a little bit of out-of-scope work along the way for the client."

Going forward, Foster says she sees the firm's new capabilities as a competitive advantage when bidding work. "I think it certainly has positioned us well to continue doing this type of work," she says. "The State of South Dakota has been very proactive in these types of projects and there are quite a few of them out there. We look forward to showing people what we can do." ■

stats

Project Facts and Figures

Project Location:
Pennington County, S.D.

Firm:
Ferber Engineering

Project Scope:
Inventory and analysis of signing and delineation on more than 1,000 miles of road.

Tools Used:
- Digital ball-banking
- Mobile imaging technology corrected against CORS GPS station to create photogrammetric imagery
- GIS software

Benefits:
- More accurate data
- Improved safety in the field
- Greater efficiency due to less rework and verification
- Reduced liability
- Consistent data collection

Data: Top Areas to Improve Use of GIS

Top Challenges When Using GIS

While the use of GIS has led to many benefits (see pages 16 to 21), there are still areas that users find challenging. Addressing these issues could help further the use of GIS in the industry, with greater implementation among existing users and wider adoption by others, as well as increasing the benefits it provides.

To help provide insight into these challenges, designers and contractors were asked to rate seven possible ones on a five-point scale. The charts at right and on the opposite page represent those who experience each of these challenges at a high or very high level.

Designers

ARCHITECTS

The top challenge most frequently experienced at a high/very high level by architects is the lack of interoperability with other tools. While the value in GIS is clear, the findings in this study reveal the particular importance of utilizing the data fully in the design of the project (see page 31 for contractor assessment of the value of GIS employed in the design of a project), and interoperability remains a major obstacle for 50% of architects when attempting to optimize use of the data.

Many architects (45%) also struggle with finding qualified staff to manage GIS. Interestingly, there are no notable differences in the percentages of small, midsize or large firms that report this challenge, despite likely differences in their ability to have dedicated resources to manage data at their firms. This may suggest that the bigger challenge is finding those with design skills who are also adept at utilizing this particular type of data.

A moderate percentage (39%) also consider data quality issues and finding access to the right tools/data to be a challenge to their ability to use GIS effectively. Though identified by the fewest percentage of architects among the six challenges studied, explaining the value of GIS (30%) and the cost of the data (29%) are still notable issues.

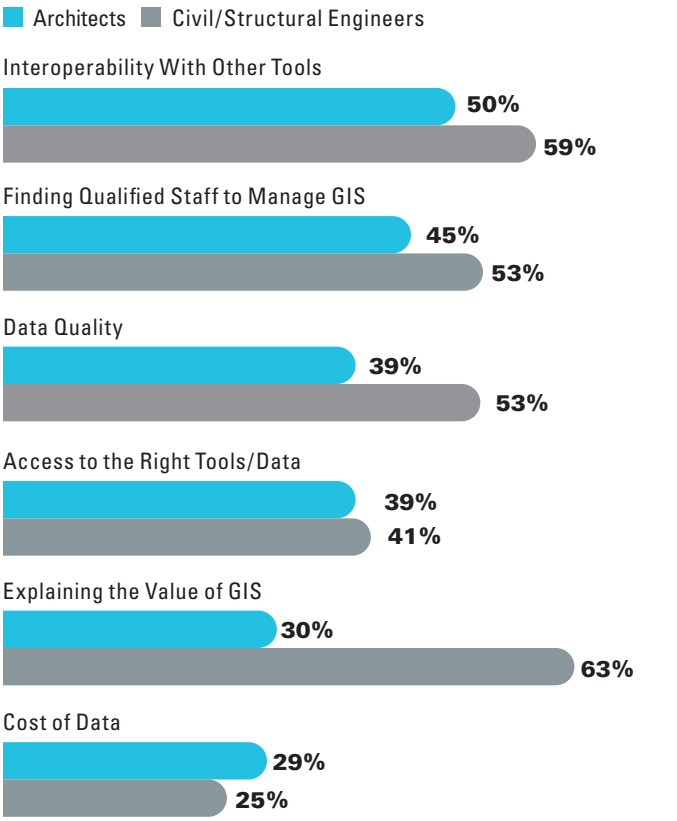
CIVIL/STRUCTURAL ENGINEERS

Many of the responses of the civil/structural engineers mirror those of the architects, with slightly higher percentages reporting most of these concerns. However, two stand out as being more problematic for engineers than they are for architects.

- **Explaining the value of GIS is the top challenge for engineers, rated as a major issue by 63%, and even exceeding interoperability issues.** The importance of

Challenges When Using GIS
(Experienced at a High/Very High Level by Designers)

Dodge Data & Analytics, 2020



Top Challenges When Using GIS CONTINUED

investment by their own companies in GIS and/or the value of having other team members using GIS data may influence this finding.

- **Data quality is also selected by a much higher percentage of civil/structural engineers (53%) than by architects (39%).** The engineers report very active engagement with GIS activities (see page 10), so they are likely to be particularly sensitive to issues of data quality.

Contractors

General and specialty trade contractors were asked about the same challenges as the designers.

GENERAL CONTRACTORS

The challenge faced by the highest percentage of general contractors is finding qualified staff to manage GIS, with nearly the same percentage (52%) of GCs reporting that they experience this challenge at a high/very high level as the engineers that do (53%).

Similar to the architects and engineers, GCs also struggle with interoperability (42%). Again, the ability to use the data in many different digital tools is critical to extract its full value.

GCs fall between civil/structural engineers and contractors in their concern about the impact of being able to explain the value of GIS. But since it ranks third among the challenges for them, that suggests that they also need internal champions and wider use across teams to fully benefit from the use of GIS.

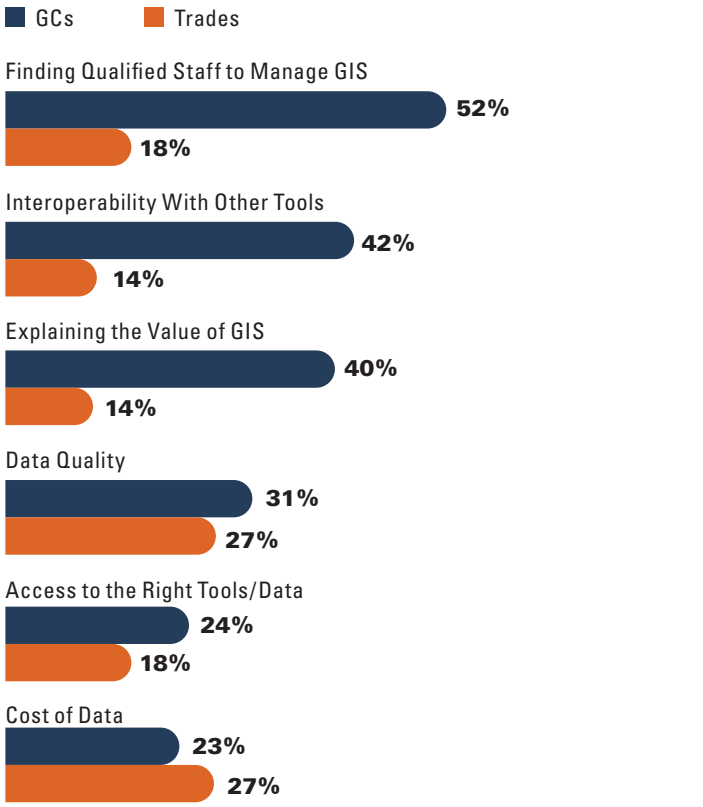
Since the GCs providing these rankings are already using GIS, it is perhaps not surprising that the fewest express a high level of concern about the cost of the data, since they have already made their investments in GIS.

SPECIALTY TRADE CONTRACTORS

Very few specialty trade contractors using GIS tend to rate any of the challenges provided at a high or very high level. Even their greatest concerns, data quality and the cost of data, are only rated at that level by 27%. Engagement with GIS may influence this finding. A higher percentage of trade contractors use many of the GIS activities and types of data on 50% or more of their projects than do the GCs, even though the total percentage using the tools overall tends to be lower (see page 12). This suggests that the trade contractors using GIS tend to be more intensive users, and their deeper engagement may make these challenges seem less severe to them than to the GCs.

Challenges When Using GIS
(Experienced at a High/Very High Level by Contractors)

Dodge Data & Analytics, 2020



Interoperability Challenges and Impacts

Interoperability is a major challenge to the use of GIS for around half of architects and civil/structural engineers, 42% of GCs and 14% of trade contractors. However, interoperability is a broad topic, so those who rated it as a major issue were asked a follow-up question about what specific interoperability challenges they face. Their responses are shown in the chart at right.

Generally, the challenges are ranked in the same order by designers and contractors, but designers are far more concerned about most of the challenges.

- **Using GIS data in BIM applications is the top interoperability issue for both designers and contractors, but nearly 63% of designers rated it as a high/very high challenge, compared with 50% of contractors.**
- **Nearly as many designers (62%) also consider preparing presentations comprised of CAD/BIM and GIS a significant issue, but the percentage of contractors who rate this as a serious challenge is only 43%, which may reflect a less frequent engagement in this activity rather than a better ability to deal with it.**
- **Over half of designers also struggle with using GIS data in CAD applications (55%) and using BIM data in GIS applications (54%), but only 38% of contractors rate each as a major challenge.**
- **The only area selected by nearly the same share of designers and contractors is using CAD data in GIS applications, which is the least concerning of the interoperability challenges overall.**

Negative Impacts Due to Interoperability Challenges

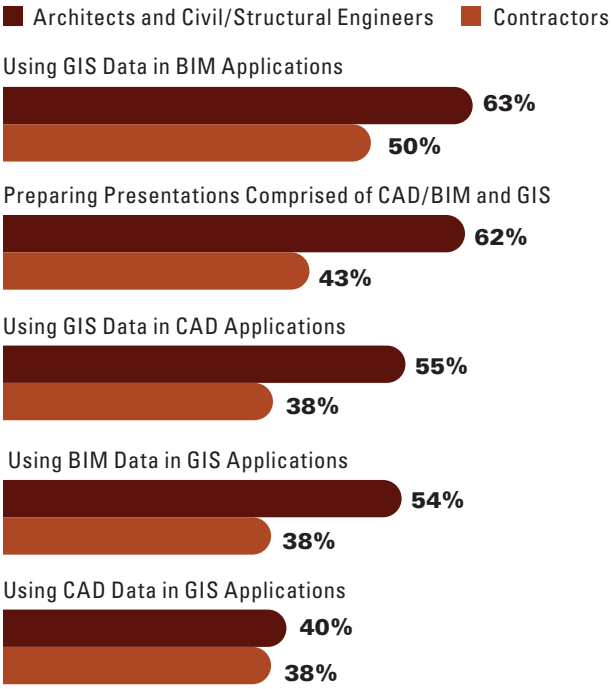
Those who say these challenges are significant were provided with a list of 10 possible negative impacts, and asked to select the top three that they experience.

- **Productivity is the top negative impact, selected in the top three by 57%.**
- **Around one third also rank impacts on team collaboration and generating rework and errors in the field among their top three biggest challenges.**
- **Few believe these challenges exert a serious negative impact on budget or schedule compliance, the quality of construction or sustainability objectives.**

Interoperability Challenges

(Rated High/Very High by Those Who Reported Interoperability to Be a Major Challenge)

Dodge Data & Analytics, 2020



Data Quality Issues

Data Quality Challenges

Data quality was rated as a challenge by 39% of architects, 53% of civil/structural engineers, 31% of GCs and 27% of specialty trade contractors in their use of GIS. These respondents were all asked to rate the severity of several types of data quality issues. Since there were not enough specialty trade contractors who qualified to answer the question, the chart at right shows the responses from architects, civil/structural engineers and GCs.

ARCHITECTS

Around half of the architects rate five of the six data quality issues as major challenges, with the top problems being data completeness, currency of data and data accuracy. Only a quarter identify duplication of data as a major challenge.

CIVIL/STRUCTURAL ENGINEERS

Significantly more civil/structural engineers rate each data quality issue as a major challenge than do architects or general contractors. Their top two data quality issues are data completeness and availability of the data, each selected by over 70%. Around two thirds also rate challenges with the currency of the data and data accuracy as major issues, and over half cite availability of data and duplication of data. These findings point to an industry need for improved data standards and quality control processes in order to optimize the benefits of GIS.

GCS

GCs less frequently rate most of these data issues as a major challenge than do architects and civil/structural engineers. Their top three concerns are currency of the data, data accuracy and data completeness.

Top Negative Impacts Due to Data Quality Challenges

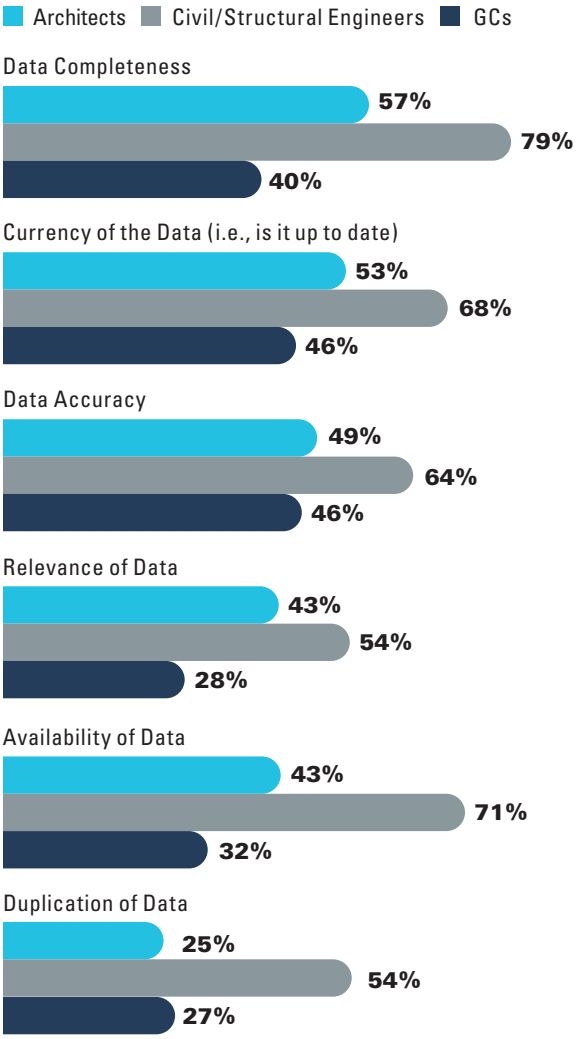
Those who rate these challenges at a high/very high level were asked to select the top three from a list of 10 possible negative impacts from these issues.

- **As with interoperability challenges, the biggest impact is on productivity, selected in the top three by 46%.**
- **Around one third find that generating rework in the field and generating errors in the field are among the top three biggest impacts of data quality issues.**
- **Respondents are least concerned about impacts on the quality of construction or on sustainability objectives, each selected by less than 10%.**

Data Quality Challenges

(Experienced at a High/Very High Level by Those Experiencing Data Quality Issues)

Dodge Data & Analytics, 2020



Interview: Thought Leader

Cory Dippold, PE, Vice President, Special Projects Applications, Mott MacDonald

Since joining Mott MacDonald, Cory Dippold has worked as a lead design engineer, project manager and applied technology professional on a wide variety of infrastructure projects, including industrial facilities, water and wastewater treatment plants, pump stations, solid waste facilities, subsurface infrastructure and tunnels.

When did you start using GIS software and data?

DIPPOLD: My company has been using GIS data for decades primarily as a mapping and planning tool, for asset identification, things like that. My personal experience with GIS began in 2016 … . As a PM, it was always frustrating that I had this great collection of data in one database that was stuck in maps and another collection of rich data that was stuck in models. In 2017, we undertook [the effort to integrate GIS and BIM] and ultimately were able to be somewhat successful and were given the opportunity to present that work at a major industry conference in July 2018.

What specific challenges did you face with that effort to integrate the two sets of data?

DIPPOLD: At that time, the integration tools at a technical level were relatively immature in terms of allowing GIS data to be exchanged or integrated with BIM data. Some things, like location information and geometry, mapped very well from BIM into GIS, but things like color, texture and parametric information [did not]. We found that there was not an equal level of integration [between the two datasets]: Getting BIM data into a GIS tended to work better than getting GIS data into a BIM model.

What was your solution to this issue?

DIPPOLD: We worked closely with the vendor to sort that out. We developed workflows that played to the strengths of each. But our main solution was to join a small customer council with some of the major BIM and GIS vendors and share our project data to help develop the tools and help integration become more mature.

What are the biggest impacts on your projects or your bottom line that you've experienced from your use of GIS?

DIPPOLD: Early planning and concept design is where GIS has traditionally sat in our company. Now, with some of the new tools available, we [are using] GIS to do very rapid field data collection, existing conditions capture. Most of our staff use apps on their own devices that allow them to collect data very efficiently. It is geolocated and uploaded directly into the GIS. [This process is] very, very quick. It has reduced a lot of manual duplication. We do not have to take notes on paper or transcribe photos back in the office. Everything, the notes, the photos, produced in real time in the field is uploaded right into the GIS cloud, which has had a very positive impact on our bottom line.

Any other benefits from your use of GIS?

DIPPOLD: We have started to recognize the value of the underlying data that is embedded in GIS. All the major GIS vendors have datasets beyond the maps themselves that have so much potential value. [We have used] that type of embedded data to provide more compelling proposals to our clients that show, not only how major projects can [have a positive impact], but some of the potential risks to the project. Using the embedded GIS data is proving to be a real benefit to strengthen our proposals and provide better outcomes for our clients.

What are some examples of the embedded data you use?

DIPPOLD: People typically think of GIS as spatial mapping data, but you can get all sorts of information, including social and economic data. [You can use] data on pedestrian movements or pedestrian concentration areas to understand health and safety relative to a major transportation or roadway improvement, and be able to show the previous number of pedestrian accidents and how that changed over time due to improvements to a right-of-way or road by providing a safer crossing.. . We can show our clients [that kind of data] and validate the social outcomes we are trying to deliver.

Are there challenges you still struggle with?

DIPPOLD: The integration of GIS and

BIM, on a maturity scale of zero to 10, with 10 being fully integrated and zero being not started, I would probably rank around a five or a six right now. There are still technical challenges to ensure a full fidelity data transfer in each direction. Another challenge we are seeing in our project delivery work is that traditionally well-known workflows are becoming blurred. ...There are opportunities to use GIS tools where traditionally AEC engineering tools existed and vice versa. One of the challenges we are trying to overcome is to provide a better understanding of what preferred workflows would look like between GIS and the traditional engineering BIM tools. In the absence of that, engineering companies are all left to their own devices, and that seems like a longer road to the finish line.

What would you recommend to companies about how to improve their use of GIS or even begin using GIS data?

DIPPOLD: For companies that have not yet taken that step and think GIS is simply a tool to just allow mapping of assets and infrastructure, it is probably worth spending time to understand what data is available and what that data can do for your business. Certainly, I didn't understand that until just a few years ago when I had the opportunity to sit down with one of the vendors and really look at what they had available. And if you are just entering that space now, take the time to understand what the real capabilities are because they are significant. They are potentially disruptive if you are not paying attention to them and potentially significant benefis if you can adopt them and implement them in a way that makes sense for your business. For companies that are mature in their use of BIM and GIS together, I recommend that they are proactive with vendors on both sides to explain how they are using the tools and the types of integration needed to take it to the next level. We are in the early stages, and there's a lot of opportunity to provide guidance and input.

What do you think is next for your company in terms of your use of GIS and BIM?

DIPPOLD: We are developing a new business line called Digital Twin Services that I have had the opportunity to be part of. Our intention is to use all the core strengths of both GIS and BIM, along with our platform capabilities and domain knowledge, to deliver on this vision of the digital twin. [We envision the digital twin as] something that uses spatial information, location data, BIM data, asset information—both static and transient—along with enterprise level knowledge to help our customers achieve better-performing assets, better outcomes and reduced risk. And I think that would be largely unachievable without the use of GIS.

What do you think is the future of GIS for the industry overall?

DIPPOLD: I think GIS is going to go full 3D. GIS has amazing capabilities to rapidly capture, structure and interrogate information in large quantities. It provides a high-performing tool, not only on the analytic side, but on the way we can surface that data and show it to others. In terms of construction, the logical fit would be linear assets that have a long geospatial component to them. But I would continue to look for GIS to make headway in vertical construction as well. [For example,] use of drones to build photogrammetry models and upload those instantly to a GIS to show construction progress over time is certainly ripe for development.

Is there anything we haven't discussed that you think is particularly critical to the use of GIS to improve projects?

DIPPOLD: Major project delivery, especially civil infrastructure and the built environment, is really about changing and benefiting society. Understanding how these projects are going to change the face of communities over time, understanding how potentially what we design and install can improve the environment, how it can make things safer, how it can reduce carbon emissions [is really important]. These are factors that once would be really complicated to try and quantify early in the process and incorporate through the entire lifecycle of a project. That's not the case anymore. We are sitting on enough data with enough computational power where these types of dynamic variables can be identified, quantified early and given KPIs through, not just the design and construction process, but for 50 years to show whether the projects are really meeting their intended goals. I think there is a huge opportunity to improve the social outcomes of projects through the use of this kind of data. ■

Drivers for Increased Use of GIS

All respondents with GIS experience were asked to select the top three factors that would increase their use of GIS and related collaborative workflows. Notably, there are no significant differences in the responses of architects, civil/structural engineers, general contractors or specialty trade contractors, so their combined responses are shown in the chart at right.

By far, the most widely selected factor is better interoperability between GIS and other design/construction technologies, chosen by 54%. This finding suggests that those already using GIS clearly understand the value of the data, and a critical factor that prevents them from using it more widely is the ability to employ it as part of their digital design and construction workflows.

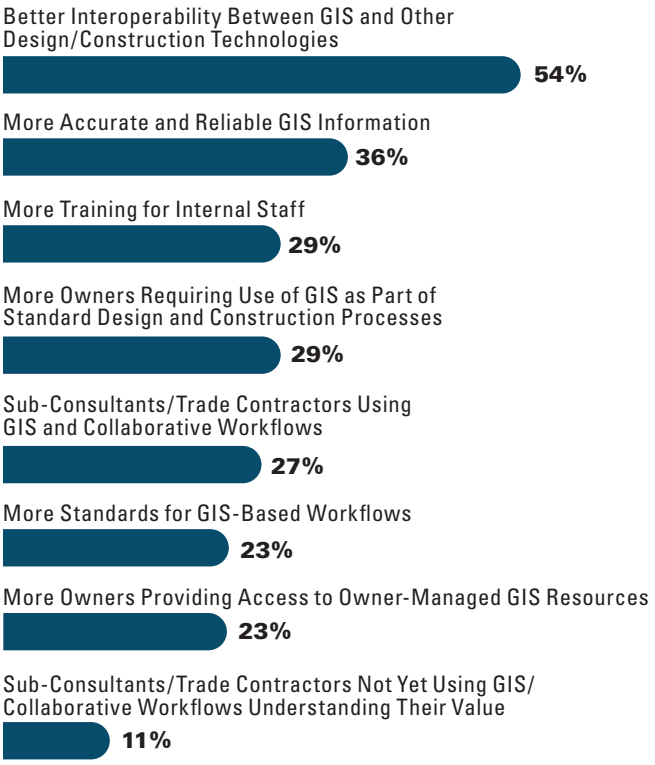
Over one third (36%) also consider more accurate and reliable GIS information to be one of the top drivers to increased use of BIM and related collaborative workflows. Data quality was noted as a particularly major challenge for engineers using GIS (see page 36), but, surprisingly, they are not more likely than the rest of the respondents to note that better data would increase their use. This may suggest that the value they get from using GIS data outweighs the data quality issues they encounter.

The cluster of five other drivers, selected by between 23% and 29%, suggests that in addition to improved interoperability and better data, there are a variety of factors that would be influential in increasing the use of GIS among those already using it, from training issues to increased use up and down the supply chain to improved workflows.

It is also notable that while 27% consider the use of GIS and collaborative workflows by sub-consultants and specialty trade contractors to be one of the top drivers, only a few (11%) believe that wider recognition of the value of GIS among sub-consultants or trade contractors is a top driver, suggesting either that they believe that these players already know its value and are consciously deciding not to use it, or that gaining comprehension of its value would not be sufficient to drive them to use it.

Top Factors to Increase Use of GIS and Related Collaborative Workflows
(Selected in Top Three by GIS Users)

Dodge Data & Analytics, 2020



GIS + BIM = Smarter Cities

As cities and the challenges they face increase in size and complexity, data interactions between BIM and GIS can help them grow smarter, too, at multiple levels of scale.

Smart Cities depend on data. Whether it's information about air quality and energy consumption to keep sustainability goals on track, about housing and transportation to improve quality of life or about demographics and public opinions to support more equitable governance, data-informed decisions are better-informed decisions.

BIM Data in GIS

At the city scale, data from BIM can make long-range systems modeling in GIS easier and more reliable. Urban systems modeling, projection and analysis are data-hungry processes, and analysts typically spend as much as 80% of their time collecting, creating, cleaning and/or refashioning data from multiple sources. BIM, however, offers an existing dataset that GIS can simply consume. "As BIM becomes more ubiquitous for design, engineering and asset management, it creates a rich data source for GIS that doesn't exist now," says Scott Edmondson, a senior planner-economist with San Francisco Planning's Data Analytics Group. "The potential is huge."

Using BIM to generate GIS objects of the existing built environment enables planners to compare existing and proposed scenarios against environmental, social and economic performance parameters. How reduced parking requirements will play out as a neighborhood develops, how the buildout potential under current zoning will impact urban infrastructure, how a program or development under consideration will catalyze changes in trips or population or land use, all become more foreseeable.

A building is a system; a city is a system of systems. As the marriage of BIM and GIS makes data exchange possible across those levels of scale, "all of a sudden you can see the implications of things that we've never been able to see before," Edmondson says, "and you have a rigorous way for thinking about the dynamic relationships between them." Using BIM-generated data to inform rapid scenario development and testing enables a new capacity: systems planning and design. "That to my mind is the big thing," he says.

GIS Data in BIM

Data also flows the other way. As BIM projects become more complex and fully integrated into surrounding street, utility and building infrastructure, and as information about the world is increasingly digitized, "the use of GIS context and location awareness in BIM processes becomes essential to enable designers to have a higher probability of meeting projects' environmental and social needs, as well as operational and performance needs," says Chris Andrews, group product manager for Geoenabled Systems at Esri. Andrews cites the example of a California Coastal Commission berm construction and lead waste removal project, with goals that included minimizing the impact of heavy vehicles on adjacent neighborhoods. Instead of simply drawing the shortest path between the site and the highway, the project team integrated GIS data on such factors as traffic patterns, area demographics, and school and playground locations. Merging this information with construction schedule information from BIM enabled the team to develop a set of routes that varied with time of day so as to minimize disadvantaged communities' exposure to the traffic noise and dust, reduce impacts on residential neighborhoods when people were typically home and distribute impacts fairly across have and have-not districts, all while keeping the project on schedule.

With data from BIM and GIS growing increasingly interchangeable, a digital twin of a city might look like the ultimate smart goal. But experts caution it's a goal that is overhyped. Stephen Brockwell, senior product owner at Esri, reminded an Autodesk University session this year that, "it's not about the digital twin. The goal is the change you make in your city." Instead of a digital twin, Brockwell recommends making incremental improvements on existing conditions. A smart city is a collaborative, human outcome with local relevance, he says, and, with data integrations across BIM and GIS, "dynamic, thriving cities have never been more possible." ■

Data: Nonusers

Interest in GIS Among Nonusers

While the majority of the survey focused on those with experience with GIS, a small group of respondents who do not have that experience were asked their own set of questions. In order to expand the use of GIS in the design and construction industry, it is critical to understand why these companies are not using GIS currently, their perceptions about GIS use and the top drivers and obstacles that would impact their decision to use it in the future.

Awareness of GIS Among Nonusers

Most respondents who say that they have no experience with GIS (hereafter called nonusers) report that they are aware that they can access geospatial data and software for design and construction processes. Awareness of this availability is higher among designers than contractors.

Interest in Using GIS

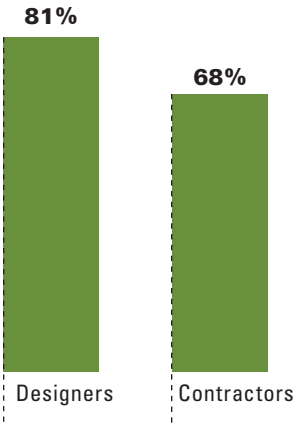
Nonusers were also asked about whether or not they are interested in, or have even explored, integrating GIS workflows with design and construction processes.

- **Most nonusers (87%) are interested in using GIS.** The majority are simply open to exploring its potential value, but one quarter already believe it will be valuable for them, even if they have not yet begun to formally evaluate its use. A small share of nonusers are actively evaluating whether or not to use it.
- **Only 13% are opposed to using GIS in the future.** Those who are not interested in using GIS most frequently cite the lack of a real application for what they do, not enough demand from clients or other organizations for its use or the lack of a dedicated team to help with adoption—or the budget to create one—as reasons for their current perspective on GIS.
- **There are no notable differences in the levels of engagement between designers and contractors.**

These findings suggest that if a strong business case can be made to the design and construction industry, and owners can become more supportive of its use on their projects, there is interest and openness to the possibility of adopting GIS among current nonusers.

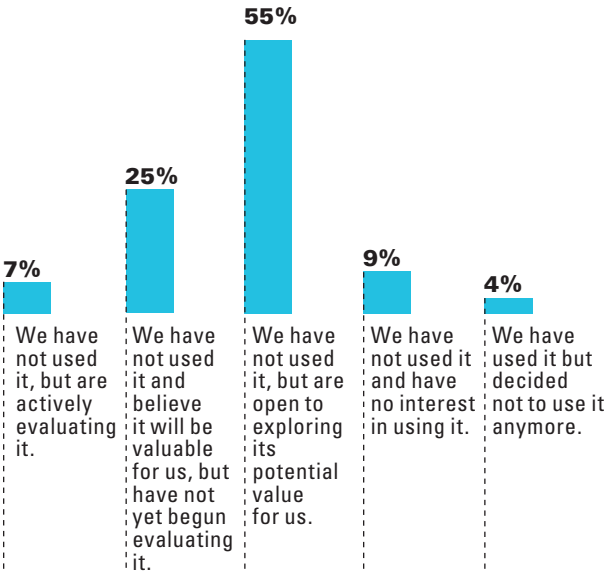
Nonusers Aware That They Can Access Geospatial Data and Software for Design and Construction Processes

Dodge Data & Analytics, 2020



Nonuser Degree of Interest/Engagement With Integrating GIS Workflows With Design and Construction Processes

Dodge Data & Analytics, 2020



Interest in GIS Among Nonusers CONTINUED

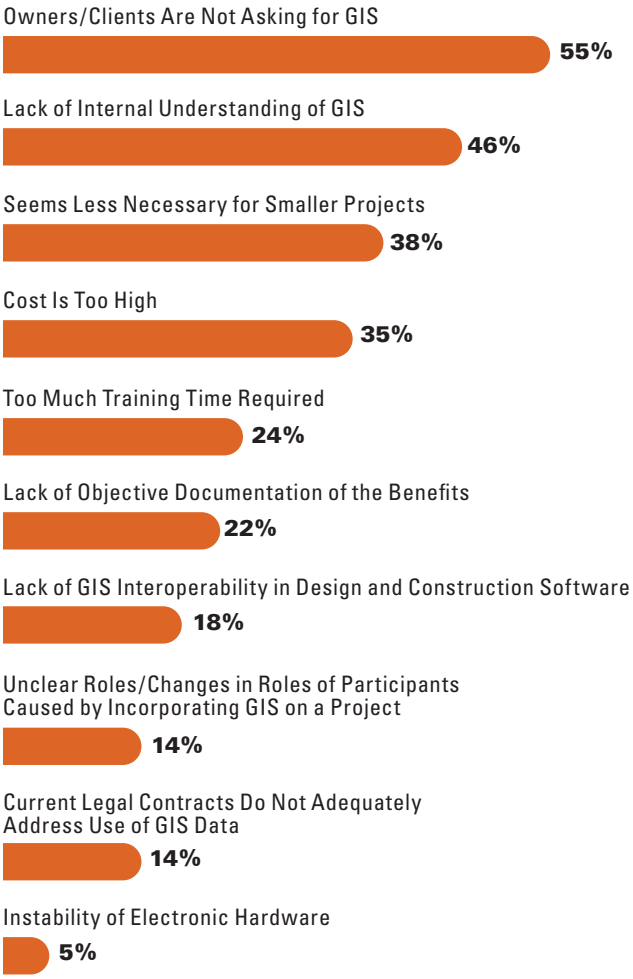
Top Reasons Nonusers Who Are Interested in GIS Are Not Using It Yet

The 87% of nonusers who express possible interest in using GIS in the future were asked to select the top three factors delaying their adoption of GIS from the list of 10 items in the chart at right.

- **The top reason selected by more than half (55%) is that owners/clients are not asking for the use of GIS.** It is clear in this finding and others in the study that owners can play an important role in promoting the use of GIS in the industry, not only by requiring it, but also by providing access to their own GIS data.
- **Nearly half (46%) of nonusers also believe the lack of internal understanding of GIS is delaying adoption.** While many nonusers are aware of GIS (see page 44), this finding suggests that most are not yet familiar with exactly what kind of data it contains nor how it can help them improve projects. Without that kind of compelling vision, there is less of a drive to use GIS on their projects.
- **Over 30% question the applicability of GIS for smaller projects (38%) or are concerned about the cost of working with it (35%).** While these are important issues, it is likely that competitive pressure to use GIS or client requirements would be sufficient to overcome them, as they have with so many other types of industry advances.
- **While interoperability is a big concern for current users of GIS (see page 36), it is far less significant as an obstacle to its use among those not yet using it, selected only by 18%.**

Top Reasons That Are Delaying Interested Nonusers' Decision to Use GIS (Selected Among the Top Three by Nonusers)

Dodge Data & Analytics, 2020



Perception of Industry Use of GIS Among Nonusers

The perception that the design and construction industry is shifting to a new technology or workflow can apply pressure on those lagging behind to adopt it. Therefore, to better understand what would encourage the current nonusers to consider implementing GIS, it is important to understand whether they believe their competitors are using it and whether clients will be expecting it in the future.

Competitor Use of GIS

Among nonusers, nearly all designers (89%) and most contractors (78%) believe that their competitors currently use GIS on their projects. However, the vast majority believe that their competitors do so on fewer than 30% of their projects. The actual usage figures (see pages 9–12) clearly show that the nonusers are greatly underestimating the use of these data and workflows by their competitors, especially for conducting the most common activities. For example:

- **Over half of architects and civil/structural engineers who use GIS deploy it on 50% or more of their projects to do project planning and permitting/ urban planning and to classify land use, buildings, highways and infrastructure.**
- **Contractors who use GIS deploy it on more than 50% of their projects to do site data collection, and project information delivery (digital handover), with the percentage of specialty trade contractors (67% and 50%, respectively) notably exceeding general contractors (44% and 43%, respectively) in their intensity of use of GIS for these two activities.**

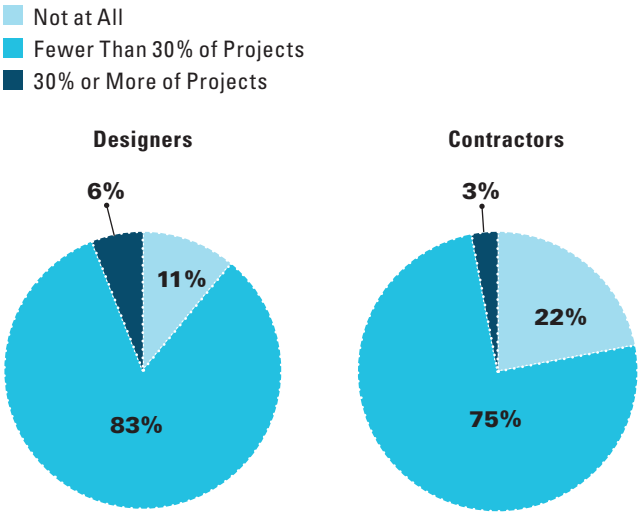
Increasing industry awareness of the extent of GIS usage should spur significant adoption among nonusers as well as increased implementation by current users.

Client Requests for GIS

Most designers (84%) and contractors (78%) who do not currently use GIS believe that their clients are or will be requesting the use of integrated GIS workflows on their projects. Even though most believe that this will not be a common occurrence and is likely to happen on fewer than 30% of projects, it is still important to establish that most nonusers expect at least some clients to require GIS. This owners' trend is likely to be an important driver for wider use of GIS in the design and construction industry.

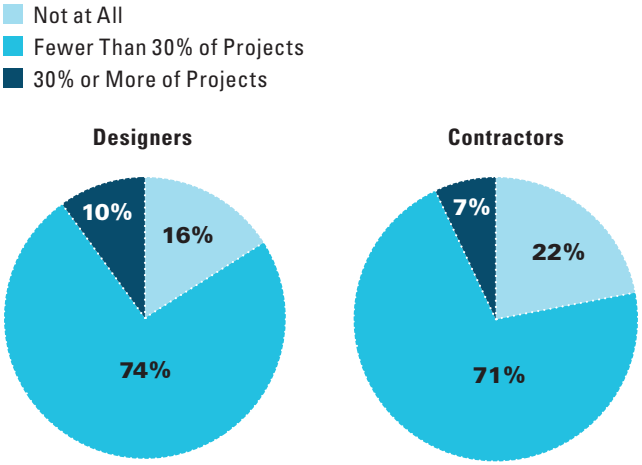
Belief That Competitors Use GIS for Their Design/Construction Projects (According to GIS Nonusers)

Dodge Data & Analytics, 2020



Belief That Clients Are/Will Be Requesting the Use of Integrated GIS Workflows on Their Design/Construction Projects (According to GIS Nonusers)

Dodge Data & Analytics, 2020



Benefits That May Influence the Decision to Adopt GIS

In order to better understand what would increase use of GIS in the design and construction industry, respondents who currently have no experience with it were asked to select the top benefits that would encourage them to begin using GIS if it could be demonstrated to provide meaningful value for each. They were presented with three separate lists of benefits (those related to project processes, project outcomes and their businesses) and asked to select up to three that would be most influential from each category.

Most Influential Process-Related Benefits

The nonusers were asked to select the top three from the list of 10 process benefits in the chart at right. Not surprisingly, responses vary between designers and contractors.

DESIGNERS

Two benefits are most likely to influence designers:

- **Improved field data collection during planning and design is selected in the top three by 45% of designers. The certainty and additional analysis available from GIS allows designers to make better decisions in the early stages of design.**
- **Improved project understanding of all stakeholders is selected in the top three by 40% of designers, which has an important value for designers in helping to maintain design intent throughout the project.**

It is also notable that, while not ranked among their highest-scoring influences, far more designers than contractors believe the increased ability to analyze the design scheme and expanded services would encourage them to use GIS.

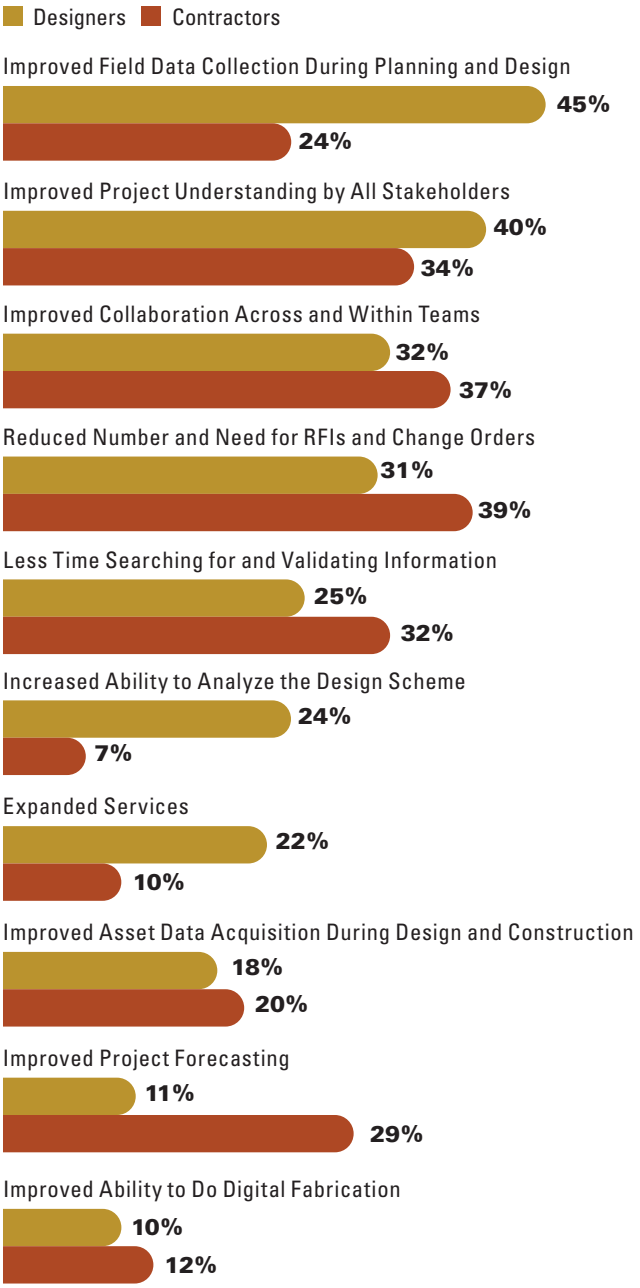
CONTRACTORS

Four process benefits are selected by over 30% of contractors as one of the top three that would influence them to use GIS.

- **More than one third (39%) say having reduced number and need for RFIs and change orders is among the top three most influential process benefits. RFIs can have a negative impact on schedule and productivity, and reducing them would enhance certainty on their projects.**
- **Nearly as many (37%) regard improved collaboration across and within teams as an influential benefit.**

Process-Related Benefits Most Likely to Influence Adoption of GIS (Selected in Top 3 by GIS Nonusers)

Dodge Data & Analytics, 2020



Benefits That Would Influence Decision to Adopt GIS CONTINUED

- **About one third (34%) consider improved project understanding by all stakeholders to be influential.**
- **Less time searching for and validating information is also important to 32%, and again contributes to improved productivity on projects.**

Improved project forecasting is selected by nearly one third (29%) of nonuser contractors, significantly more than by designers (11%).

Project Outcome Benefits

Designers and contractors were also asked to select the top three project outcome benefits that would encourage their adoption of GIS from a list of eight, shown in the chart at right.

While not in the same order or selected by the same percentage of designers and contractors, two project outcome benefits stand out as the most influential for both.

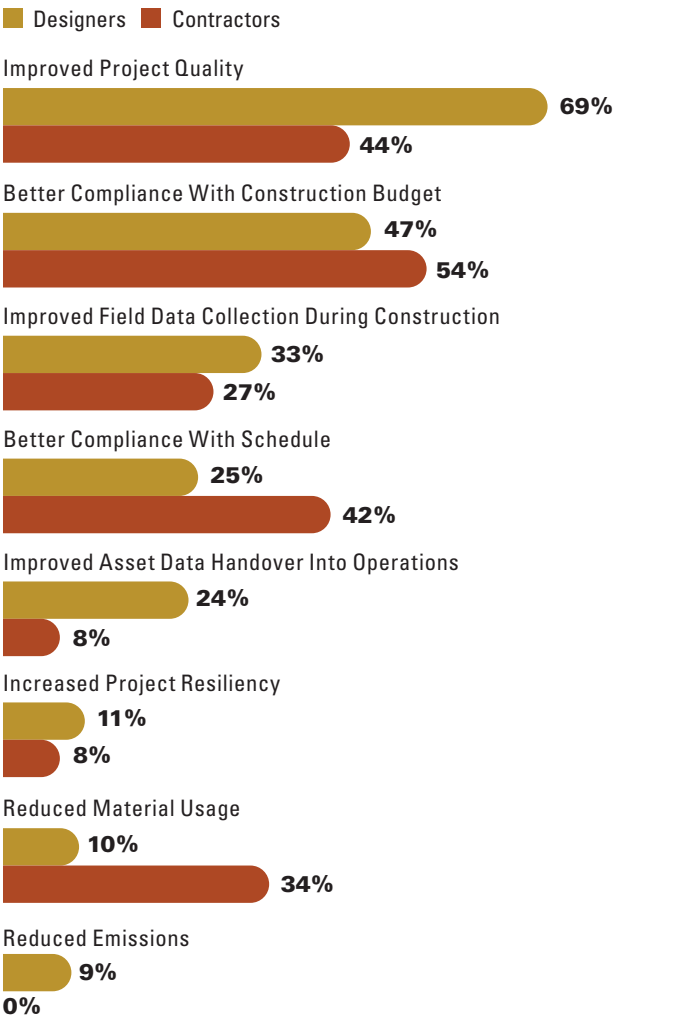
- **Improved project quality would be particularly important to designers not currently using GIS, with 69% selecting this as one of the three most influential project outcomes.** This is also the second most frequently selected outcome for contractors, demonstrating the powerful impact of being able to improve quality. Perhaps most notable, though, is that improved project quality is the second most important outcome benefit reported on their GIS projects by designers and contractors who are currently using GIS (see page 16), reinforcing the positive impact of this benefit across the industry.
- **Better compliance with construction budget is the top benefit for contractors, selected by 54%.** Nearly as many nonuser designers (47%) consider this an influential benefit as well, even though far more contractors who use GIS rate reduced total construction cost as a top outcome improvement on a GIS project than do the designers who use GIS do (see page 16).

Ranking third for architects and fourth for contractors, but selected among the top three by a similar percentage of both, is improved field data collection during construction. While the benefit to contractors is evident, in terms of maintaining schedule and budget compliance, it is clear that designers also recognize the value of improved field data collection during construction and find it influential in encouraging them to adopt GIS.

A few other benefits carry more weight with either designers or contractors.

Outcome Benefits Most Likely to Influence Adoption of GIS (Selected in Top 3 by GIS Nonusers)

Dodge Data & Analytics, 2020



Benefits That Would Influence Decision to Adopt GIS CONTINUED

- **Designers would be more influenced by improved asset data handover into operations.** This is a surprising finding, given the likelihood of contractors being more engaged with the data handover than the designers. However, this could increase the possibility of designers gaining feedback on asset performance, data that is typically difficult to obtain.
- **Contractors are more likely to be influenced by better compliance with the project schedule and reduced material usage than are designers.** Schedule certainty is of particular value to contractors, since it not only allows them to satisfy clients but allows them to more accurately forecast their overall workload across projects, thereby providing a business benefit as well as an improved project outcome. Reducing material usage not only improves sustainability outcomes, but it also saves contractors money.

Business Benefits

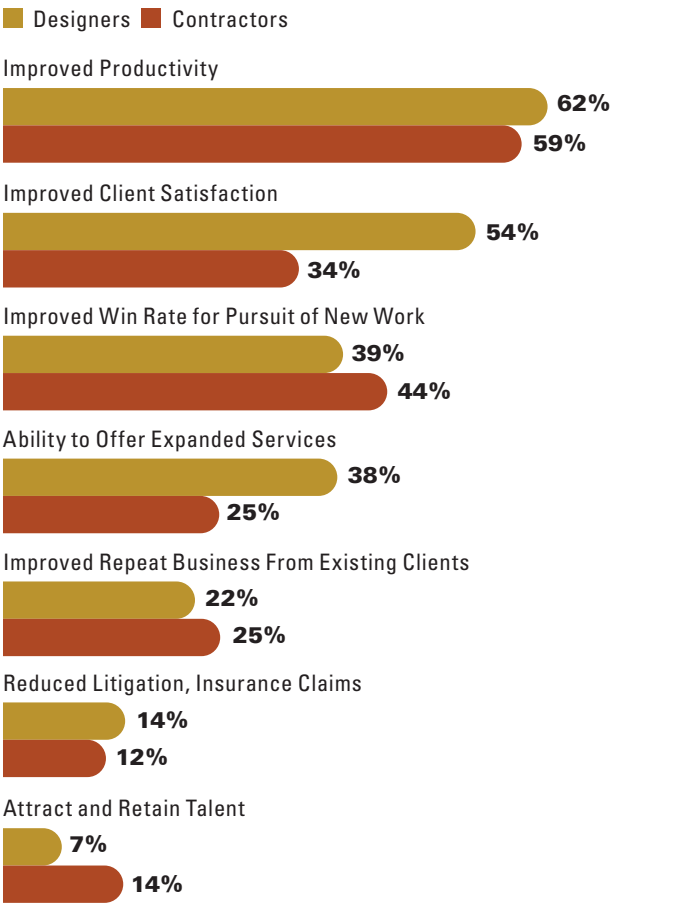
Designers and contractors were also asked to select the top three business benefits that would encourage them to use GIS, from the list of seven shown in the chart at right.

While there is agreement between designers and contractors about the ranked order of the most influential business benefits that would encourage them to use GIS, there are some notable differences in the percentages of each that say they would be influential.

- **Improved productivity is by far the most influential business benefit for designers and contractors alike.**
- **Improved client satisfaction ranks second for influence among designers and third for contractors. However, there is a much higher percentage of designers who find this influential than contractors.**
- **Far more contractors select improved win rate for pursuit of new work (44%) among their top three than improved client satisfaction (34%), ranking it in second place for them. A notable percentage of designers (39%) also consider the ability to improve their win rate influential.**
- **Designers more frequently consider the ability to offer expanded services influential than do contractors.**

Business Benefits Most Likely to Influence Adoption of GIS (Selected in Top 3 by GIS Nonusers)

Dodge Data & Analytics, 2020



Expected Importance of GIS

To Design/Construction Industry in Five Years

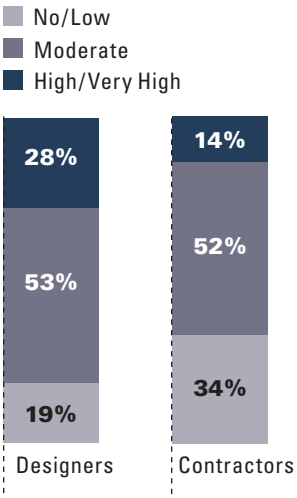
Similar to the influence of believing that their competitors are engaging in GIS and that project owners are likely to seek it on their projects, the degree to which nonusers believe that GIS will be important to the overall design and construction industry in the near future can influence the likelihood of them adopting it. Therefore, designers and contractors with no GIS experience were asked how important they think GIS will be to the design and construction industry in five years.

Generally, designers are more enthusiastic about the likelihood that GIS will be important to the industry in five years, with twice the percentage (28%) rating its likely importance as high/very high compared with contractors (14%). Conversely, contractors (34%) are more likely to expect GIS to be of little to no importance than are architects (19%).

However, despite these differences, it is clear that the majority of designers and contractors not using GIS currently do expect GIS to be at least moderately important to the construction industry in the near future, which bodes well for its increasingly wider use.

Expected Importance of GIS to the Design/ Construction Industry in Five Years
(According to GIS Nonusers)

Dodge Data & Analytics, 2020



Interview: Thought Leader

Sanjay Kumar, Founder and CEO of Geospatial Media and Communications

A social entrepreneur and geospatial evangelist, Sanjay lends his time and experience to many not-for-profit organizations, including Open Geospatial Consortium and World Geospatial Industry Council, to help them further societal goals.

What types of GIS data are currently providing the greatest benefit to the design and construction industry?

KUMAR: Geospatial data lies at the core of the design and construction industry. And there are different types of data which we use, in different phases of the workflows. So for example, when we start planning, we start with geography and base maps ... The moment we go into design, we deal with much higher resolution cloud points, much higher resolution sensor-based surveying capabilities. And the construction phase is where GIS brings a huge advantage to the entire workflow [because] it helps you monitor what you design and construct.

What types of GIS data are being underutilized?

KUMAR: Everything. Just everything. The power of geospatial has been absolutely underutilized by the infrastructure sector, though its adoption is growing very fast. ... An integrated information system that has a spatial dimension is absolutely necessary for the next-generation infrastructure... In my view, the geospatial technology companies [need to make] a proactive approach to educate, engage, converge and deliver geospatial solutions for the architecture, engineering, and construction market. ... [Previously] there was no solution centric approach by the geospatial software and hardware companies, but in the last five to 10 years, integration of hardware and software have become the norm. That's where I think we are moving, in a direction that is quite exciting.

What are the top benefits that designers and contractors have experienced from using GIS?

KUMAR: GEO-BIM technologies are helping the construction industry to be more efficient and productive. GEO-BIM solutions bring along contextual relevance to the design in terms of the habitat. They are improving productivity by saving time and effort and providing clash detection. And they [are helping organizations be compliant and improve transparency]. Compliance is a major challenge ... [For example, a contractor may submit a building plan and then alter that plan.] But with geospatial technologies now, you can actually see the satellite image of every building on a particular interval. And you can see what was built when.

What are the biggest challenges preventing the design and construction industry from fully engaging with GIS?

KUMAR: [First] engineering is an old discipline and so is mapping, both of them have a huge amount of legacies... . Traditionally these two domains have been developing in their own directions. Second, the geospatial industry was driven by products: hardware products, software products, data products. Now in the last five to 10 years, it has been driven by solutions. Third, public policies still do not see geospatial as an important set of information that is critical for the infrastructure sector.

What is the future for the use of GIS data in design and construction?

KUMAR: Everything will be GIS. We are in the fourth industrial age, which is driven by sensors, AI, big data, all conversions of digital to physical to conversions of physical and biological to digital. All this is dependent on the geospatial knowledge infrastructure, [which consists of four things]: geospatial data infrastructure, the positioning infrastructure, public policies and a regulator [to help defend GIS data against attacks and privacy issues].

Anything else we haven't discussed that is important?

KUMAR: Moving forward, there will be one BIM workflow and one GIS workflow. Right now, you have CAD, CAM, GIS, BIM. All the CAD would become GIS. It could be subsumed by GIS, which means that the 2D will become 3D and 4D in real time, and BIM will be the construction workflow. Companies will see greater collaboration within software, sensors, workflows leading to productivity and efficiency. Very soon all these technologies are going to come together. ■

Methodology:

GIS Study Research

Dodge Data & Analytics conducted the 2020 GIS survey to identify common benefits, challenges, best practices, investments, and determine future needs of users of GIS data and digital design practices. Additionally, analysis of nonusers provides insight on their current awareness about GIS and digital integration, the objections that have kept them from adopting and triggers they need to spur adoption.

Research

The research in this report was conducted through an online survey of industry professionals from Aug. 20 to Sept. 28, 2020. The survey data was collected from the following sources:

- **The Dodge Data & Analytics Architect and Contractor Panels:** These panels contain representative samples of construction contractors and architects across the US.
- **buildingSMART and Open Geospatial Consortium (OGC):** Each association was responsible for sending the survey to its members.
- **Esri:** Esri sent the survey to its contact list.

Respondents

The survey had a total of 473 respondents and took 11 minutes to complete on average.

REQUIREMENTS FOR SURVEY PARTICIPATION

Respondents were eligible to take the survey if they had experience in using relevant software (e.g., computer-aided drafting, 2D or 3D modeling applications, mobile apps, data visualization and mapping, collaboration tech, project management software, etc.) on at least half of their projects.

PRIMARY TYPE OF PROJECT

Respondents worked on both vertical structures and horizontal infrastructure projects in the last five years, with wider representation among those doing vertical projects.

- **Most Projects Have Been Vertical Structures Such as Buildings: 79%**
- **Most Projects Have Been Horizontal Projects (i.e., Infrastructure or Industrial Projects): 21%**

TYPE OF COMPANY

The survey was open to designers, construction contractors and design consultants who did work in the United States in 2020. The participants include:

- **304 Designers**
  - 228 Architects (Including 10 Planners)
  - 43 Civil or Structural Engineers
  - 33 Other Consulting Engineers and Design Consultants
- **169 Contractors**
  - 113 General Contractors, Construction Managers and Design-Builders (referred to as general contractors or GCs for the sake of simplicity in the report analysis)
  - 56 Specialty Trade Contractors

SIZE OF COMPANY

The analysis examines differences by size of company, determined by the category they select for their companies' annual revenues in 2019.

- **Designers**
  - Small (Less than $10M): 46%
  - Midsize ($10M to less than $100M): 23%
  - Large ($100M or more): 16%
  - Did Not Provide Revenue Information: 15%
- **Contractors**
  - Small (Less than $10M): 25%
  - Midsize ($10M to less than $100M): 40%
  - Large ($100M or more): 31%
  - Did Not Provide Revenue Information: 4%

ROLE AT COMPANY

While the survey did not include a question on the specific role/title the participants have, it did ask whether they are primarily responsible for projects or whether they are technology leaders at their companies. Designers and contractors both had the same distribution, with 75% who work directly on projects and 25% who are technology leaders at their companies.

GIS EXPERIENCE

The survey divided the respondents who participated into two groups, each with its own set of questions:

- **GIS Users: Those With Experience Using GIS in Their Design/Construction Processes: 327 Respondents**
- **GIS Nonusers: Those with No Experience Using GIS in Their Design/Construction Processes: 146 Respondents**

Resources

Organizations, websites and publications to help you get smarter about using GIS for design and construction.

DODGE DATA & ANALYTICS

Dodge Data & Analytics

Main Website: **www.construction.com**

Dodge Construction Central: **www.construction.com/products**

Market & Competitive Intelligence: **www.construction.com/products/construction-market-data**

Sweets: **www.construction.com/products/sweets**

SmartMarket Reports: **www.construction.com/toolkit/reports**

ACKNOWLEDGEMENTS:

We would like thank Esri and Autodesk for their vision in funding this project and their support throughout the process.

We also thank buildingSMART and The Open Geospatial Consortium for joining in as research partners and distributing the survey to their members.

Finally, we thank all the experts featured in our sidebar articles, case studies and thought leader interviews for sharing their insights, data and images with us in order to help the industry learn more about this vital topic.

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Research Partners

buildingSMART: **www.buildingsmart.org**

The Open Geospatial Consortium: **www.ogc.org**

Other Resources

BIMForum: **https://bimforum.org**

Digital Twin Consortium: **www.digitaltwinconsortium.org**

Geospatial World: **www.geospatialworld.net**

ISO: **www.iso.org**

National Institute of Building Sciences: **www.nibs.org**

United Nations Statistics Division Global Geospatial Information Management: **http://ggim.un.org/**

U.S. Geological Survey (USGS): **www.usgs.gov**

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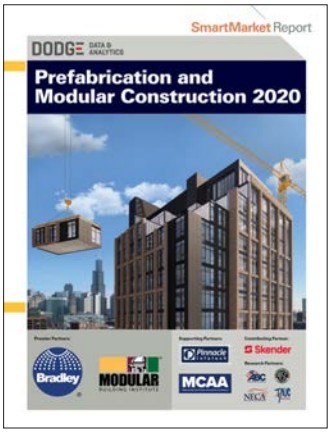

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