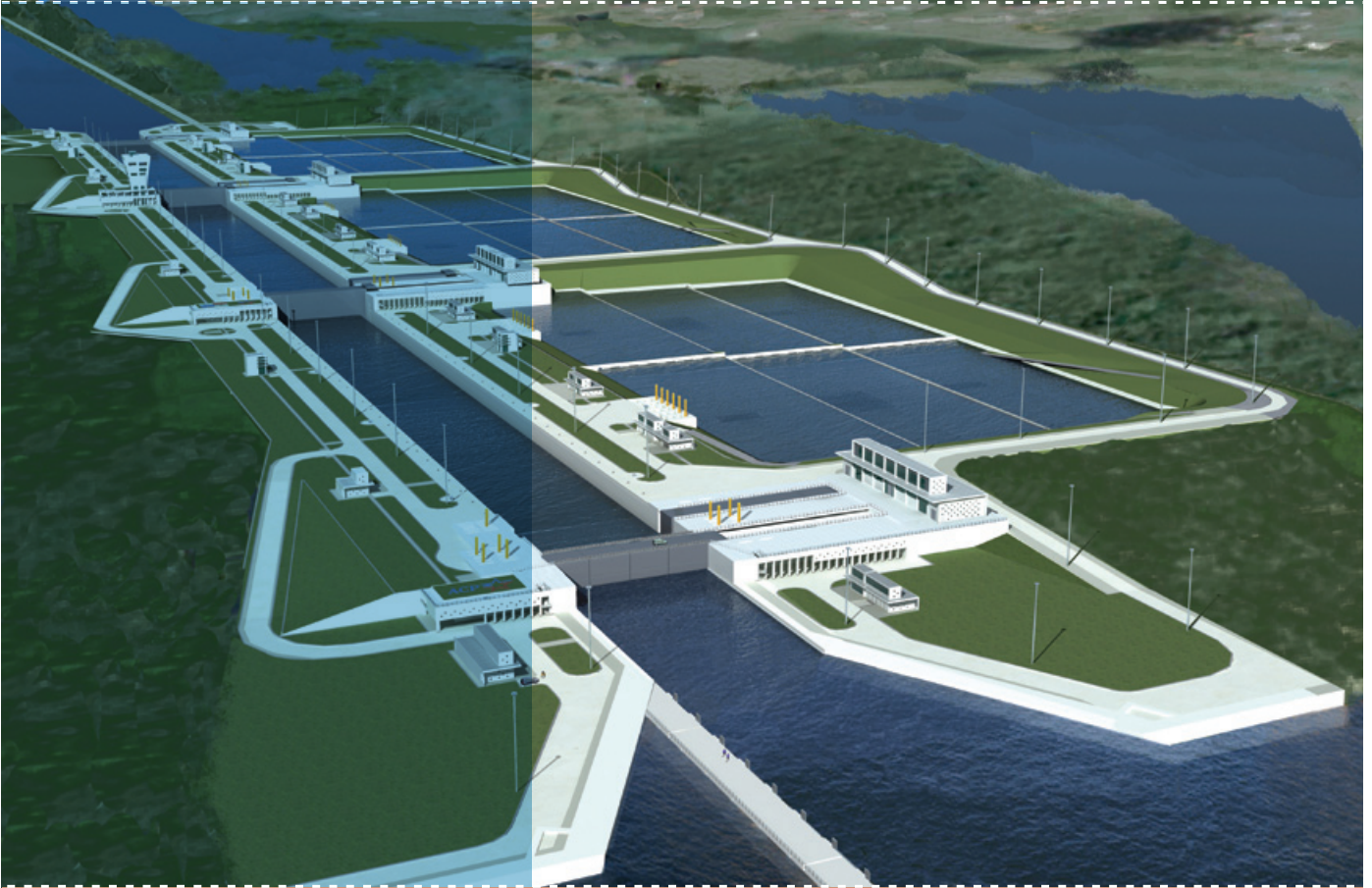


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The Business Value of BIM for Infrastructure

Addressing America's Infrastructure Challenges with Collaboration and Technology

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The Business Value of BIM for Infrastructure: Addressing America's Infrastructure Challenges with Collaboration and Technology SmartMarket Report

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Introduction

Horizontal BIM"... "Heavy BIM"... "VDC" ... "Civil Information Modeling" ... "BIM on its side" ... all of these phrases, and more, are being used in the construction industry to describe the way companies are deploying model-based technologies and processes to non-building projects.

This ground-breaking *SmartMarket Report* reveals the way in which BIM is poised to transform the infrastructure marketplace in the future. One of the most important findings of the research is that **exposure to BIM on vertical building projects increases the likelihood of the use of BIM for infrastructure as well.** This finding is important because it reveals a correlation between penetration of BIM use overall and BIM use for infrastructure, and, as a result, **BIM use in infrastructure will be adopted at faster rates than when BIM was first introduced for vertical building projects.**

Some other key findings:

- **ADOPTION:** Almost half (46%) of the firms report using BIM on their infrastructure projects, up from 27% two years ago.
- **LEVEL OF USE:** Organizations currently using BIM for infrastructure plan to use it on more of their infrastructure projects in the future. The percentage of those using BIM on more than 50% of their projects will grow from 30% now to 52% in just two years.

- **OUTLOOK:** 79% of current non-users feel positively about future adoption, with only 4% actually opposed. Therefore, **education and best practices should be effective at accelerating adoption.**
- **VALUE:** 67% of all users report a positive ROI on their BIM investments, even higher than the 63% of BIM users for buildings who reported the same in 2009, demonstrating that the value achieved will drive growth in infrastructure as it has in the buildings sector.
- **BENEFITS:** Top benefits achieved now include reduced conflicts and changes (58%) and improved project quality (48%). In addition, achieving lower project risk and better predictability of project outcomes is also perceived by 60% as a top benefit in the next five years, helping to drive wider BIM use for infrastructure.

The need for innovative and cost-effective approaches to both new and reconstructed infrastructure has never been greater or more urgent. This report not only demonstrates what is being achieved through BIM in infrastructure today, but it provides a critical baseline for the transition to new digitally-based collaborative processes for infrastructure in the future.

We are excited to release the findings on this important topic and would like to thank Autodesk, the American Society of Civil Engineers and all our other project partners for helping bring it to the industry.



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Stephen A. Jones leads McGraw-Hill Construction's (MHC) initiatives in BIM and integrated project delivery as well as developing alliance relationships for technology and content. Active in numerous industry organizations, he frequently speaks at events around the world about the business impact of emerging technologies and trends. Before joining MHC, Jones was a vice president with Primavera Systems (now Oracle), a leading provider of project management software. Prior to that, he spent

19 years in creative, marketing and management roles with design firms, most recently as a Principal and Board of Directors member with Burt Hill (now Stantec), a large, global architectural and engineering firm. Jones holds an M.B.A. from Wharton and a B.A. from Johns Hopkins.

Harvey M. Bernstein, F.ASCE, LEED AP has been a leader in the engineering and construction industry for over 30 years. Currently, he has lead responsibilities for

MHC's market research group, including MHC's thought leadership initiatives in areas such as green building, BIM, interoperability, innovation and global construction markets. Bernstein was one of the team members involved in launching MHC's *GreenSource* magazine. Previously, Bernstein served as President and CEO of the Civil Engineering Research Foundation. He has written numerous papers covering innovation and sustainability and currently

serves as a member of the Princeton University Civil and Environmental Engineering Advisory Council. He is a visiting professor with the University of Reading's School of Construction Management and Engineering in England, where he also serves on their Innovative Construction Research Centre Advisory Board. Bernstein has an M.B.A. from Loyola College, an M.S. in engineering from Princeton University and a B.S. in civil engineering from the New Jersey Institute of Technology.

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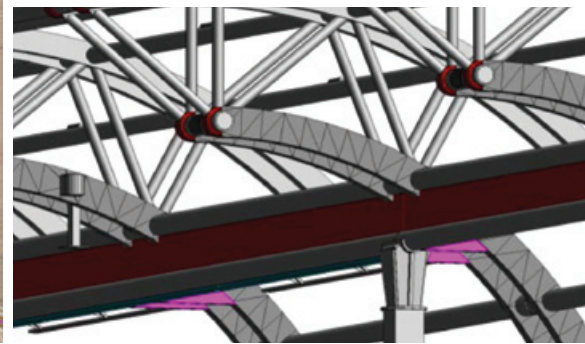
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Front Cover:
The Panama Canal team is using BIM for design currently and will soon use it for scheduling.

This page:
Left: Mortenson Construction's Renewable Energy Group models its wind farm projects.
Right: VivaNext Bus Rapid Transit System project in Toronto is using BIM.



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Executive Summary

BIM Adoption and Level of Use Will Increase at a Rapid Pace for Infrastructure Projects

The level of BIM adoption and use in the infrastructure sector is a few years behind vertical construction, but infrastructure projects are well-suited to benefit from a model-driven approach to design and construction, which bodes well for accelerating usage and broad acceptance of BIM in this sector.

THE BUSINESS VALUE OF BIM FOR INFRASTRUCTURE

Business Value of BIM for Infrastructure

Almost half (46%) of the infrastructure organizations surveyed are currently using BIM technologies and processes on some part of their infrastructure portfolio. Only 27% report using it two years ago, so the recent growth rate is impressive. The vast majority (89%) of these companies that currently use BIM for infrastructure report they are receiving value from it. They experience benefits that impact their projects as well as benefits that improve the internal business functions of their organizations.

PROJECT BENEFITS

- Reduced conflicts and changes during construction is unanimously cited as the number one project benefit for all participants, both currently and five years out.

- Reduced rework is a top project-oriented benefit identified by owners.
- Improved productivity is the BIM project benefit expected to increase in importance the most over the next five years.

INTERNAL BUSINESS BENEFITS

- Marketing BIM capability to win new work is the leading internally-focused benefit for A/E firms and contractors.

BIM for Infrastructure Has a Positive Return on Investment (ROI)

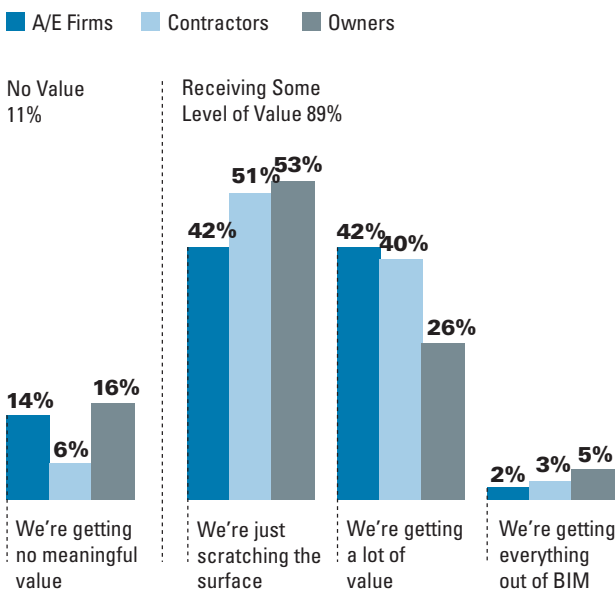
67% of all BIM users report a positive ROI for BIM use on infrastructure projects.

- ROI has a powerful correlation with BIM expertise. Those characterized as BIM experts comprise 43% of the group that reports high ROI (50% or greater).
- At 77%, more contractors report a positive ROI than any other industry player.

Metrics for the benefits and ROI of BIM are increasingly important to spur the investments required for adoption and greater implementation. Most current users (56%) are formally measuring the ROI of BIM, and over half of those that currently are not measuring it expect to do so in the future.

Business Value of BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



Implementation Trends of BIM for Infrastructure

The implementation trends track the frequency of use, as BIM users evolve from using it on a few select projects to using it on the majority of projects in their portfolio.

Implementation Forecasts Predict Strong Growth

- 79% of current users expect to be using BIM on more than 25% of their infrastructure projects by 2013—a dramatic increase from the 43% reporting that level in 2011.

- The group of companies implementing BIM for infrastructure at a very high level (employing it on over three quarters of their infrastructure projects) increases most dramatically, rising from only 7% in 2009 to almost a third (31%) by 2013. This rapid increase in heavy users demonstrates the value BIM is bringing to projects.

VARIATION BY INDUSTRY PLAYER

- A/E firms and owners report the fastest adoption growth rates.
 - Two years ago, 73% of current A/E users were either not using BIM for infrastructure or using it at a low level. By 2013, that trend is reversed, with 78% expecting to use it on more than 25% of their projects.
 - Owners go from 74% with low/no levels of use in 2009 to 84% using it on 25% or more of their projects by 2013.

Non-Users Offer Strong Market Potential

Most Non-Users’ Perspectives on BIM Are Positive
Among the companies not currently using BIM on their infrastructure work:

- 79% are open to considering it or already evaluating it.
- Only 4% report having tried it and then rejected it.

Most non-users perceive that BIM is being actively deployed among their competitors and peers. **Over 70% of design and construction non-users believe their competitors and clients are using BIM.** A similar percentage of owners report the same perception of their peers.

DRIVERS AND CHALLENGES TO ADOPTION

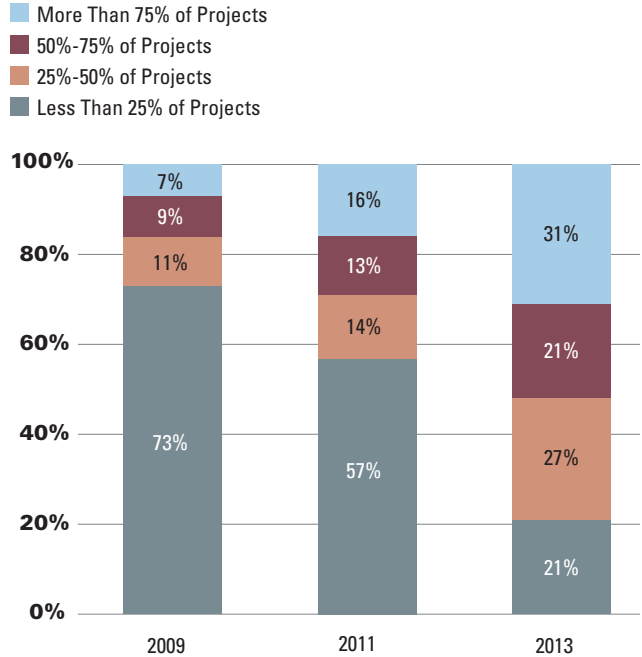
The top benefits that non-users identify as critical to encourage them to adopt include more accurate construction documents, reduced construction costs and schedule and improved communication—all well-documented benefits by BIM users.

Concern about BIM’s applicability to smaller projects and lack of time to evaluate it are identified by all non-users as leading obstacles to adoption. Other key challenges vary by player type:

- Design and construction firms: At 67%, lack of demand by clients is the top concern.

Level of BIM Implementation for Infrastructure Over Time (for Users)

Source: McGraw-Hill Construction, 2012



- Owners: At 55%, poor internal understanding of BIM is the top reason for delaying use of BIM on projects.

In an industry known for valuing previous experience in forming project teams, an additional adoption driver will come from A/E firms’ changing view on who they want to work with.

- 64% of A/E respondents currently using BIM for infrastructure place a high importance on having BIM-knowledgeable design professionals on the project, as opposed to only 41% that cite previous experience working with other companies on a project as equally critical to get the most of BIM.

Recommendations

Each company needs to develop a tailored approach to advancing its BIM objectives in order to meet its particular needs in the design and construction ecosystem. Below are insights drawn from the report for different players.

Architects and Engineers

Embrace collaborative modeling as the most effective way to unambiguously convey your team's design intent and help keep unscrupulous bidders from taking advantage of the discrepancies, errors and omissions that are inevitable in 2D drawings. Also, leverage BIM's powerful visualization capabilities to engage your clients more deeply in the solution-finding process, and align their expectations more closely with realistic outcomes.

Owners

Demand more from your teams and drive out ambivalence. Even for public projects, where you must take the lowest responsive bid, you can still require modeled deliverables in your scope throughout the process, as several federal and state entities are currently doing. The project-related benefits of model-based design and construction accrue directly to owners and are compelling.

Contractors

Get BIM to the field. Vertical project users have made huge strides in leveraging

the depth, accuracy and consistency of the data now available to generate new kinds of documents for daily use at the site. Often incorporating information from several sources (e.g., GIS, laser scans, BIM), reflecting existing conditions and providing a shop-drawing level of detail, these are true "construction documents," meant for precise implementation by craft practitioners in the field. Infrastructure projects can benefit just as greatly.

Fabricators

How much more can you make offsite? How much more can you preassemble prior to final installation? The accuracy of models is enabling an offsite manufacturing and prefabrication revolution in the vertical construction industry, especially with ever-larger structural and MEP assemblies. Cost, safety, quality and timeliness all benefit. Help extend this innovative trend to the infrastructure sector.

BIM Beginners

Keep the faith. Although initial projects may be challenging, the data show that benefits and ROI accrue in relation to increasing

experience. Join local BIM user groups and attend national events where you will meet a wide variety of BIM users, almost all of whom will gladly share advice and perspectives with you.

Advanced and Expert Users

Don't get complacent. As more companies adopt and implementation accelerates, innovation will distinguish the leaders. Your current capabilities may be unique and successful, but competitors will be actively trying to surpass you.

Technology Companies

Invest the time to understand the characteristics of infrastructure work that differ from buildings and don't assume your solution will apply equally well to any project. Seek out direct input from the firms currently engaged in this field and tailor your tools to meet their needs.

Regulatory Authorities

Every day, more companies upstream from you are developing and working with data-rich models. The process and the benefits

break down when authorities having jurisdiction (AHJs) require traditional 2D documents for review. Some AHJs are accepting models in addition to 2D documents as a way to clarify intent in the process of evaluating compliance. This is a good way to start moving up the learning curve of dealing with modeled data, and your feedback will help to create an appropriate deliverable.

Non-Users

Lack of demand is a leading reason for non-adoption, but marketing BIM capability to win new work (rather than waiting to be asked) is the top internal benefit being enjoyed by users. This indicates that the longer you wait to adopt BIM, the greater the gap will grow between you and these competitors. Start small, stay focused and commit to the process of change. It should pay off.

All BIM Users

Support data standards and demand data interoperability. The more quickly we can create a cohesive, data-rich environment without technology barriers, the faster the entire industry will enjoy the benefits of digital transformation. ■

BIM for Infrastructure on the Rise

In recent years, Building Information Modeling (BIM) has become an important strategy in vertical (building) construction to improve productivity and profitability. As the industry has struggled to emerge from the Great Recession, the business advantages of BIM and its collaborative tools have become even more pronounced and highly valued.

However, in the horizontal world of infrastructure construction, use of BIM is just beginning. In fact, even the term BIM presumes vertical buildings being constructed. A plethora of terms have been created for BIM for infrastructure, such as Civil BIM or CIM, virtual design and construction (VDC) and Heavy BIM, but all refer to the same capability to create data-rich models in three or more dimensions that facilitate better design, enhance construction efficiency and enable collaboration. These features hold equally strong benefits to horizontal, infrastructure construction, and the industry has begun to take notice.

This report provides the results of a groundbreaking study to measure the use of BIM in infrastructure design and construction. The results reveal an industry in the early stages of adoption, but they also demonstrate an even more exciting picture of expected growth in the next few years. In fact, the level of use and adoption rate closely mirror those for commercial construction originally reported by McGraw-Hill Construction in 2009—a prediction that has been borne out by the rise in BIM use for buildings over the last few years.

The forecasted growth of BIM use for infrastructure is no surprise given the expertise available from vertical construction, the high level of complexity involved in large infrastructure projects, the increased use of prefabrication in infrastructure, and the growing need for greater efficiency and effectiveness on all aspects of infrastructure projects. In fact, according to McGraw-Hill Construction's annual construction forecast, vertical construction activity is forecasted to improve over the next three years while the volume of infrastructure work is expected to shrink. This is in contrast to the start of the recession, when the American Recovery and Reinvestment Act made a major investment in infrastructure in many sectors, from transportation to water, leading to its slight growth through 2010 while the other segments of the industry declined dramatically. Now, however, as commercial construction improves, increased austerity in the public sector and funding uncertainty due to partisan politics during an election year are driving the volume of infrastructure work down.

In addition, as infrastructure financing becomes scarcer and the need for infrastructure improvements continues to grow, the industry has begun to explore alternative financing and delivery methods for infrastructure construction, such as public-private partnerships. Collaboration is often a critical part of these strategies, and BIM is well recognized in the construction industry as a process that enables collaboration.

In order for organizations doing infrastructure work to remain competitive, they will need to increase the efficiency and the profitability of their projects. Many of these organizations are also involved in vertical construction and have seen the benefits of BIM firsthand, and they are just beginning to recognize its value for infrastructure. This period of early adoption of BIM for infrastructure offers an extraordinary opportunity for organizations to become adept at using BIM and reap the rewards ahead of other industry players.

Note About the Data

Most of the charts in this report and much of the analysis focus on the differences among three groups: A/E firms, contractors and owners.

- **A/E firms include all firms that primarily do design and engineering work on infrastructure projects. If architects or engineers are mentioned separately in the analysis, it is in reference to a subset of the data just for those professions. (51% of total)**
- **Contractors include general contractors, construction managers, specialty contractors and fabricators. (36% of total)**
- **Owners include project owners and a few other respondents that do not fall into the other two categories listed above, such as consultants and educators. (13% of total)**

For a fuller description of the study participants and details on when the survey was conducted, please see the Methodology on page 60.

BIM Use on Infrastructure Compared to All Projects

While many organizations have been using BIM on vertical building projects for a number of years, its application to infrastructure projects has been slower to gain traction. **The use of BIM for infrastructure, in fact, appears to be about three years behind its use on other project types**, a conclusion supported when comparing the length of time using BIM for infrastructure to that for building projects reported in McGraw-Hill Construction's 2009 *The Business Value of BIM SmartMarket Report*:

- **1–2 Years**
 - 2012 Infrastructure: 50%
 - 2009 Buildings: 48%
- **3–4 Years**
 - 2012 Infrastructure: 27%
 - 2009 Buildings: 28%
- **5 Plus Years**
 - 2012 Infrastructure: 23%
 - 2009 Buildings: 24%

To establish a baseline of comparison among the respondents to this survey, companies that indicated they are using BIM for infrastructure work were also asked about their BIM experience on all project types.

- **Half of the companies using BIM for infrastructure have only one to two years of experience doing so, versus only 28% with that limited track record working on all project types.**
- **While 43% have five or more years of BIM experience on all project types, only about half that number (23%) have an equivalent length of experience using it on infrastructure work.**

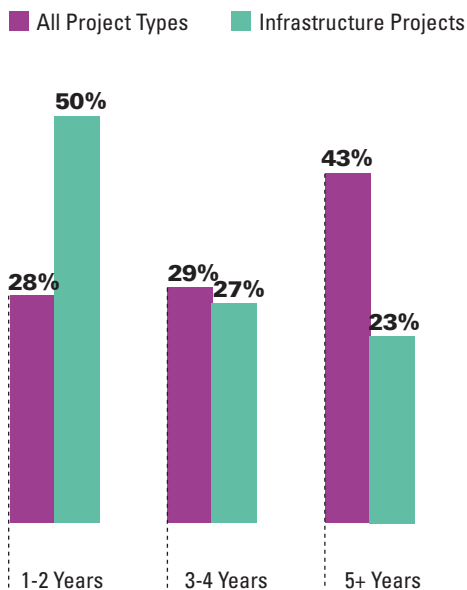
Variation by Player

Among the most highly experienced (five or more years) BIM user group, architects show the greatest disparity between those using BIM on all projects (45%) and on infrastructure (18%). This is likely due to longer-standing BIM use by architects on vertical projects. This conclusion is further supported by the finding that only 3% of architects reported one year of BIM experience on all projects, compared to 29% that are novices in using BIM for infrastructure work.

The lag in experience with BIM for infrastructure among the group having the greatest overall experience with BIM again supports the conclusion that BIM for infrastructure is lagging a couple of years behind its adoption in vertical construction.

Length of Time Using BIM

Source: McGraw-Hill Construction, 2012



BIM Expertise

In lieu of an industry standard for BIM expertise—and consistent with previous McGraw-Hill Construction *SmartMarket Reports* about BIM—survey respondents who use BIM for infrastructure were asked to self-describe their level of BIM expertise as beginner, moderate, advanced or expert. In addition, they were asked to rate their expertise on all project types and, separately, more specifically on infrastructure work.

44% of BIM users self-describe as advanced or expert on all projects, but only 33% are at that level for infrastructure.

Variation by Player

A/E FIRMS

Architects report an especially dramatic difference between their expertise with BIM for all project types and for infrastructure projects.

- BIM expertise on all project types: 55%
- BIM expertise on infrastructure projects: 35%

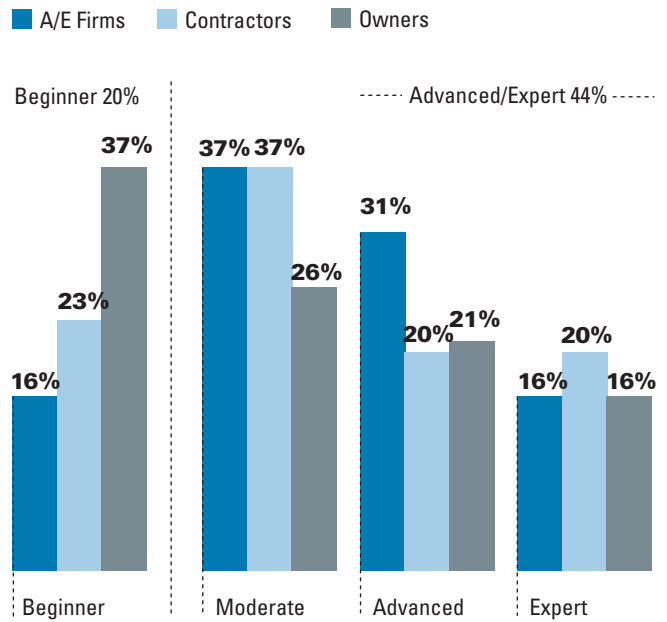
In addition, only 16% of architects and engineers self-describe as beginners for all projects, but that percentage jumps to 34% on infrastructure work.

OWNERS

Owners report the lowest expertise across both project categories. This is consistent with the findings of the 2009 *BIM SmartMarket Report* in which owners of buildings also reported the lowest expertise across all player types.

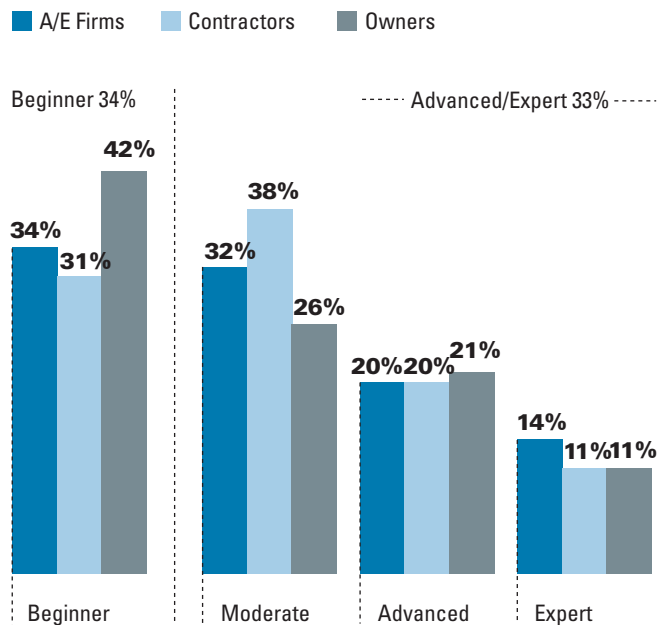
BIM Expertise: All Project Types

Source: McGraw-Hill Construction, 2012



BIM Expertise: Infrastructure Projects

Source: McGraw-Hill Construction, 2012



Current Implementation of BIM in Infrastructure

Consistent with previous McGraw-Hill Construction *SmartMarket Reports* about BIM, the term implementation refers to the percentage of a company's projects that are done using BIM technologies and processes.

Comparing Implementation on All Project Types to Infrastructure

Respondents that reported using BIM for infrastructure were first asked to baseline their level of BIM implementation on all project types, then asked separately about their implementation on infrastructure work. (Note: Some respondents indicate "none" for their current BIM usage because, even though they have used BIM in the past and plan to do so in the future, they had no BIM projects currently underway at the time of the survey.)

The findings confirm the trend that BIM use in infrastructure, and the extent of that use, lags several years behind vertical construction. Only 37% of respondents report low or no current BIM implementation on all projects, but that percentage jumps to 53% for infrastructure. In

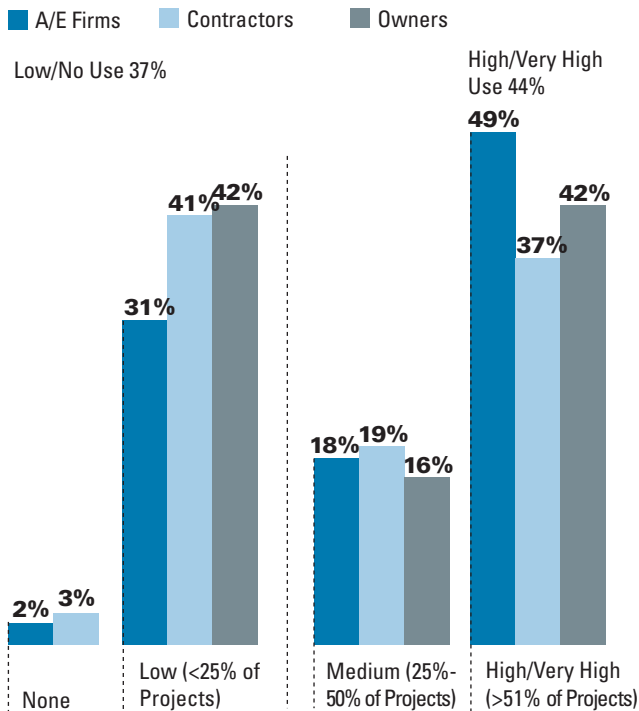
addition, the findings are again comparable to the 2009 *Business Value of BIM SmartMarket Report*, which reported BIM implementation for buildings. In that report, 27% report doing high/very high implementation, defined as more than 60% of projects using BIM.

Variation by Player

- A/E firms have a steep differential in the level of BIM use, with 49% reporting high/very high implementation on all project types, but only 30% reporting that advanced level for infrastructure.
- Owners report a consistent 42% high/very high level of implementation across both project categories, indicating a predominant focus on infrastructure by those owners, versus the A/E firms, which generally practice on a wider variety of project types and may have more experience using BIM on vertical projects.

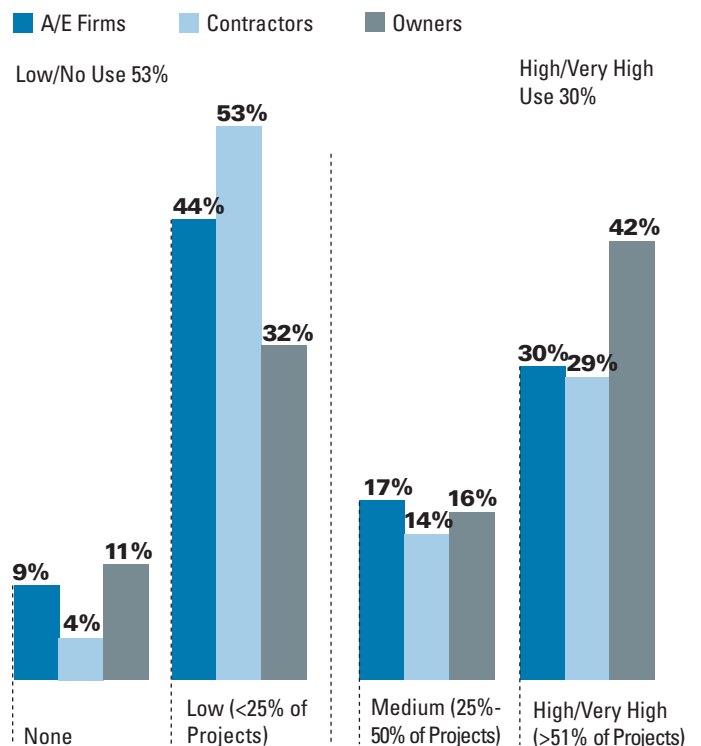
Current Implementation of BIM: ALL PROJECTS

Source: McGraw-Hill Construction, 2012



Current Implementation of BIM: INFRASTRUCTURE PROJECTS

Source: McGraw-Hill Construction, 2012



BIM Implementation Trends for Infrastructure

Comparing the past implementation of BIM for infrastructure with the expected implementation in two years reveals a striking increase in implementation expected. Again, the predicted growth parallels the results of the 2009 *BIM SmartMarket Report*, in which 52% of those using BIM for buildings report that they expect to use BIM on more than 60% of their projects.

- **Low/no usage, which dominates the past (73%) and current (53%) responses, decreases sharply in two years, with only 21% expecting low usage and no respondents expecting not to use BIM for infrastructure.**
- **Very high usage will grow dramatically, from only 7% two years ago to 30% two years from now, more than four times greater.**

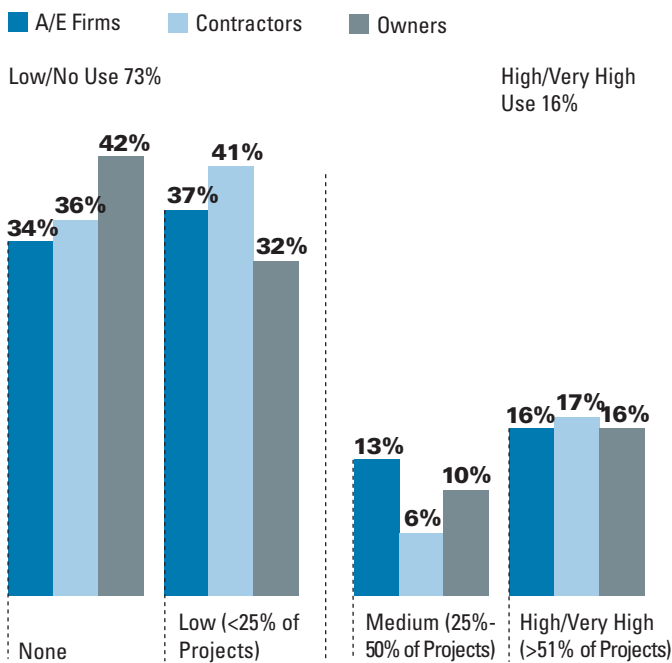
Variation by Player

Owners show the most growth, going from 42% not using BIM for infrastructure two years ago to 100% saying they will be doing some amount of BIM for infrastructure in two years. Over a quarter (26%) plan to be at a very high level of implementation at that time.

Because owner demand is cited as a top factor that will encourage adoption among non-users, this trend has the potential to be the biggest driver of BIM adoption for infrastructure. As more owners increase the number of projects they commit to this approach, implementation levels will increase across the board for design professionals and contractors.

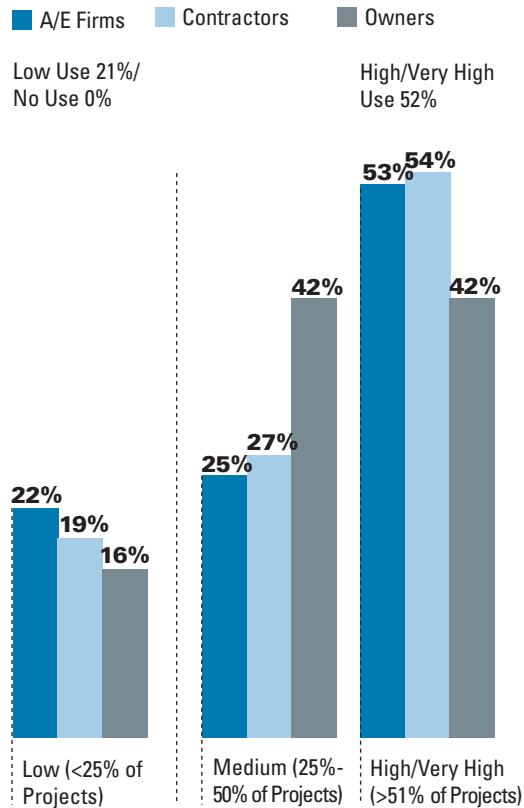
2009 Implementation of BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



2013 Implementation of BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



BIM Implementation by Project Type

THE BUSINESS VALUE OF BIM FOR INFRASTRUCTURE DATA

All project types show substantial growth over the four-year period, more than doubling, on average. Much of the growth for these project types will derive from increasingly sophisticated civil design tools for BIM, which allow users to more accurately capture existing conditions, as well as greater latitude in exploring alternate design solutions and robust analysis of project performance.

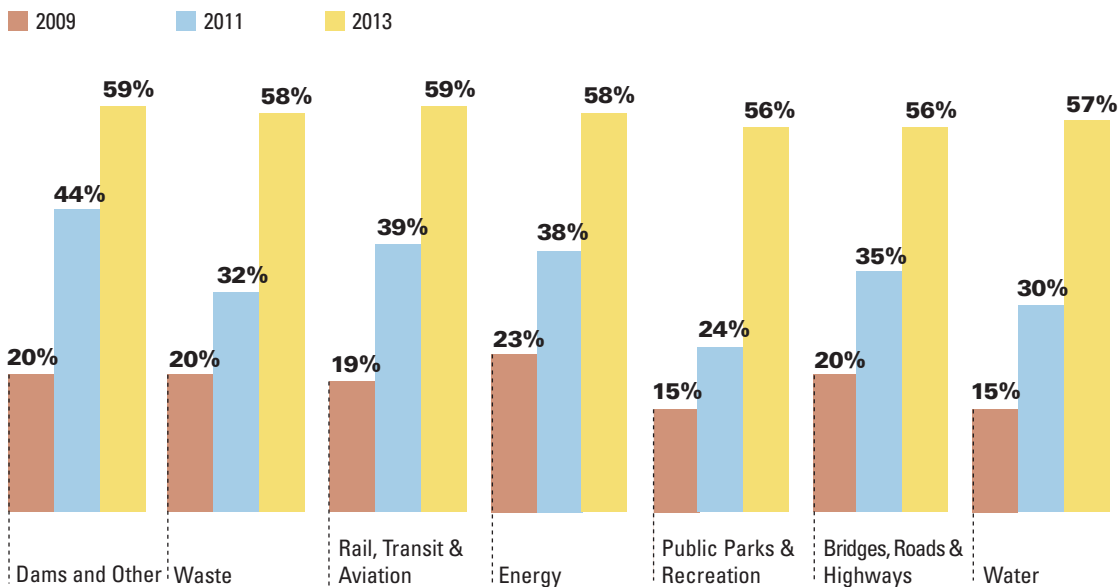
In fact, every project category is anticipated to have well over half of its practitioners using BIM on more than 50% of projects within two years.

Variation by Project Type

The greatest expansion over the four-year period is predicted for water projects and public parks and recreation. Only 15% of respondents in these sectors report a high use of BIM two years ago, but 57% and 56%, respectively, forecast that they will be using a high level of BIM two years from now, almost quadrupling.

BIM Implementation on More than 50% of Infrastructure Projects by Project Type

Source: McGraw-Hill Construction, 2012



BIM Implementation by Organization Size

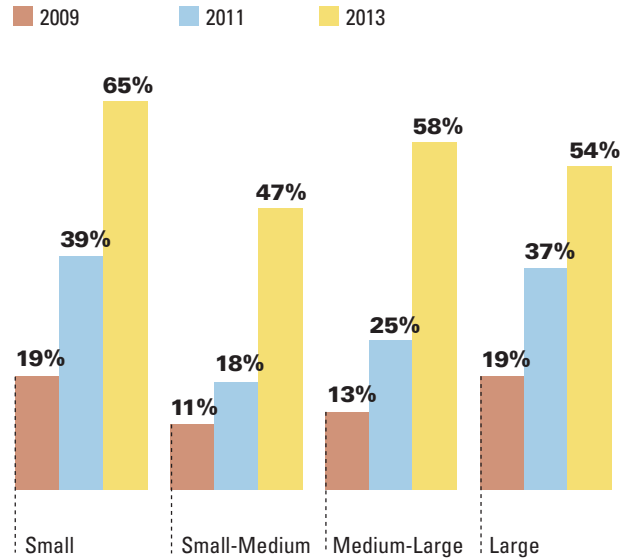
Organizations of all sizes foresee increasing their implementation of BIM to more than 50% of their infrastructure projects, but the size of the organization has implications for the pattern of high infrastructure BIM usage over the five year span. (Refer to the Methodology section on page 60 for organization size definitions.)

- Midsize organizations show the pattern of greatest growth, more than quadrupling the percentage of high-level implementers from 2009 to 2013, with the small-medium group expanding from 11% to 47%, and medium-large organizations expanding from 13% to 58%.
- By 2013, small organizations will lead the way in high-level implementation, when almost two thirds (65%) predict they will be practicing at that level.

Although small organizations express concerns about BIM's cost and applicability to small projects, once they have adopted BIM, their size actually provides an advantage in driving higher levels of implementation. Small projects have shorter durations, thereby creating more opportunities to start them off using BIM. Larger organizations, which tend to work on larger projects with longer durations, are unlikely to introduce BIM during the course of an existing project and therefore will take longer to get the majority of their projects using BIM. Once a small organization has become a user, its higher rate of project turnover will tend to accelerate its level of BIM implementation.

BIM Implementation on More than 50% of Infrastructure Projects by Size of Organization

Source: McGraw-Hill Construction, 2012



Use of BIM on Road and Highway Projects

THE BUSINESS VALUE OF BIM FOR INFRASTRUCTURE

From complex megaprojects to standard roadway work, designers, contractors and owners are seeking ways to merge BIM into their workflows.

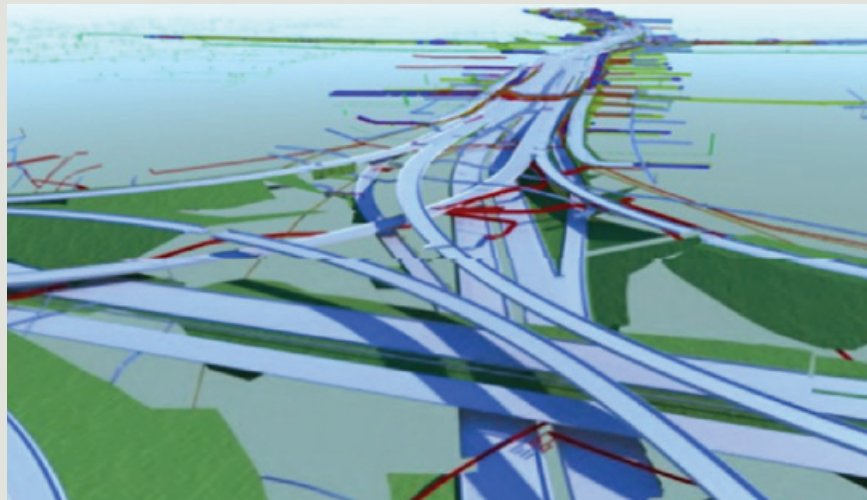
Wisconsin DOT Projects

The Wisconsin Department of Transportation (WisDOT) is taking a lead role in testing the application of BIM on state roadway projects. Within its design methods group, the state is seeking the best ways to maximize return on investment in BIM, says Lance Parve, senior project engineer in the Southeast Region of WisDOT and co-chair for the Transportation Research Board's Virtual Design and Construction Joint Subcommittee.

Parve says he sees value in the collaborative aspects of BIM, but, because the state mandates design-bid-build procurement, early integration of teams is not possible. WisDOT is testing a hybrid approach that uses its in-house design and construction departments to collaborate on design models to gain many of the benefits of working in an alternative delivery method, such as design-build.

"Pure design plans can have issues," Parve says. "There's a lot of coordination and design reviews between different disciplines, but that's not enough. We're taking a construction-oriented approach that really impacts the design in a beneficial way."

Parve says the process gives the team a greater likelihood of fixing issues virtually, rather than in the field. "We've found that on projects, there can be 5% to 10% of costs coming from [change orders]," he says. "On some of these projects, that is more than adequate payback. It doesn't take



Wisconsin Department of Transportation is taking a lead role in testing the application of BIM on state roadway projects, including the \$1.7 billion Zoo Interchange.

more than avoiding a few incidents, and you've paid for a whole boatload of BIM software."

WisDOT is testing its approach on two current projects—the \$162.5 million Mitchell Interchange Project and the \$1.7 billion Zoo Interchange. On the Mitchell project, modeling was done after design was complete. Still, the team was able to use the model for visualization and clash detection that reaped savings, says Parve. In addition, the team used that model for 4D scheduling of the construction phase.

On the Zoo Interchange project, the team was able to start earlier, creating a robust model that could be provided for contractor bidding. Both 4D schedule simulation and 5D cost estimation are possible with the model. The models include mobile, static and aerial light detection and ranging. In total, the team expects to scale up to a 20,000-page set of design plans using models created by more than 200 designers.

Under the state's design-bid-build method, Parve says, WisDOT encourages contractors to use

its models but does not require it. "There's a lot of room for the contracting side to develop models further and recognize this as a design-level issuing of the model that could have further enhancements," he says. "If they find a shorter way to do something, that saves us money and saves them time. On a lump sum contract, there's a lot to be gained."

Fore River Bridge Replacement

Regardless of an owner's outlook on BIM, some firms see big benefits in modeling on their own. STV has been using BIM on vertical buildings since 2006 but decided to test its application on the Fore River Bridge Replacement in Quincy, Mass., for Massachusetts DOT. The design calls for a vertical-lift bridge with towers that are nearly 300 feet high.

After starting the design in CAD, STV decided that the bridge's complexity required modeling, says Greg Spears, a designer at STV. "The coordination of the different disciplines was a huge part of this

Use of BIM on Road and Highway Projects

project," he says. "We have a lot of equipment that requires electrical conduit that had to be designed for extremely tight places. By designing in 3D, we're able to see what our electrical engineers are doing and have immediate feedback over the placement of their components."

In addition to MEP, STV created a structural model and architectural components of the bridge. However, no analysis was done in the models.

Although BIM was not required by the owner and the owner was not charged extra fees for the models, Spears says, the effort paid off. "It streamlined our process," he says. "There is a tight schedule for this project, and modeling is one way we were able to speed up the process internally." The client also gained direct benefits through better over-the-shoulder reviews of the models as they progressed.

Still, the benefits were limited to the designer. Although the project is being delivered using design-build, the contractor is not creating construction models. "That was not part of the initial contract," Spears adds.

Spears says he expects STV to incorporate BIM into future heavy civil projects, particularly on complex facilities. "We've learned that this is really effective at the intersection between infrastructure and [vertical] buildings," he says. "If there are minimal building elements, we can still do it, but we don't get the same kind of benefits as when there are many disciplines to coordinate."

Chesapeake Roadway Projects

While large, complex roadway projects seem a more likely candidate for BIM use, some firms are testing

its applicability on small projects as well. Clark Nexsen used modeling on two intersection projects for the City of Chesapeake, Va., with combined design and engineering fees of less than \$100,000.

The roadway project, which began in 2009, aimed to realign an intersection. Drainage improvements and stormwater management were included in the scope. Clark Nexsen was contracted the following year to design a new mast arm traffic signal at the intersection.

The team modeled the roadway and performed stormwater design analysis based on the model. Quantity takeoffs were performed for engineer's estimates for inclusion in a bid package. With the roadway model in place, Clark Nexsen added its traffic signal study. The city commissioned a laser scan to identify existing above-ground utilities and other features, such as trees. The model, laser scan and additional digital drawings were integrated to create a virtual project "drive-through" for visualization and analysis.

A plan to integrate the model with the city's GIS (global information system) was considered, but was shelved for future consideration because the city was updating its GIS system at the time.

Kyle Jacocks, a civil engineer at Clark Nexsen involved in integrating BIM into the firm's infrastructure-related disciplines, says modeling the project improved visualization, enabled faster design reviews, enhanced coordination, ensured better constructability and increased collaboration.

Jacocks says that while BIM provided considerable benefits, it did add time to the process. However, he believes it proved valuable on the project. "We know some things took extra time, but it's hard to measure what didn't happen," he adds. "There was probably an additional cost, but down the road, as we get more experienced and faster [with modeling], I anticipate that will be less of an issue." ■



Clark Nexsen found value in modeling a \$100,000 intersection in Chesapeake, Va.

Use of BIM on Airports

Multibillion-dollar airport expansion programs often include a mix of complex vertical and horizontal projects split among numerous bid packages. To better manage projects, many airport authorities encourage designers and contractors to collaborate in BIM. Since many of these programs are split into multiple phases, some build teams are crossing competitive lines for the greater good of the program.

Delta Air Lines Redevelopment at JFK

Satterfield & Pontikes (S&P) is providing project-control services for the \$1.2 billion Delta Air Lines Redevelopment project at John F. Kennedy International Airport (JFK) in New York City. The program is split into multiple packages. Turner Construction and Lend Lease each oversee separate concourse packages. Turner's scope also includes significant civil work. Peter

Scalamandre & Sons was awarded a separate taxiway package. Several stakeholders are involved as well, including Delta, JFK International Air Terminal and the Port Authority of New York and New Jersey. Numerous businesses housed within the concourses are also affected by the program.

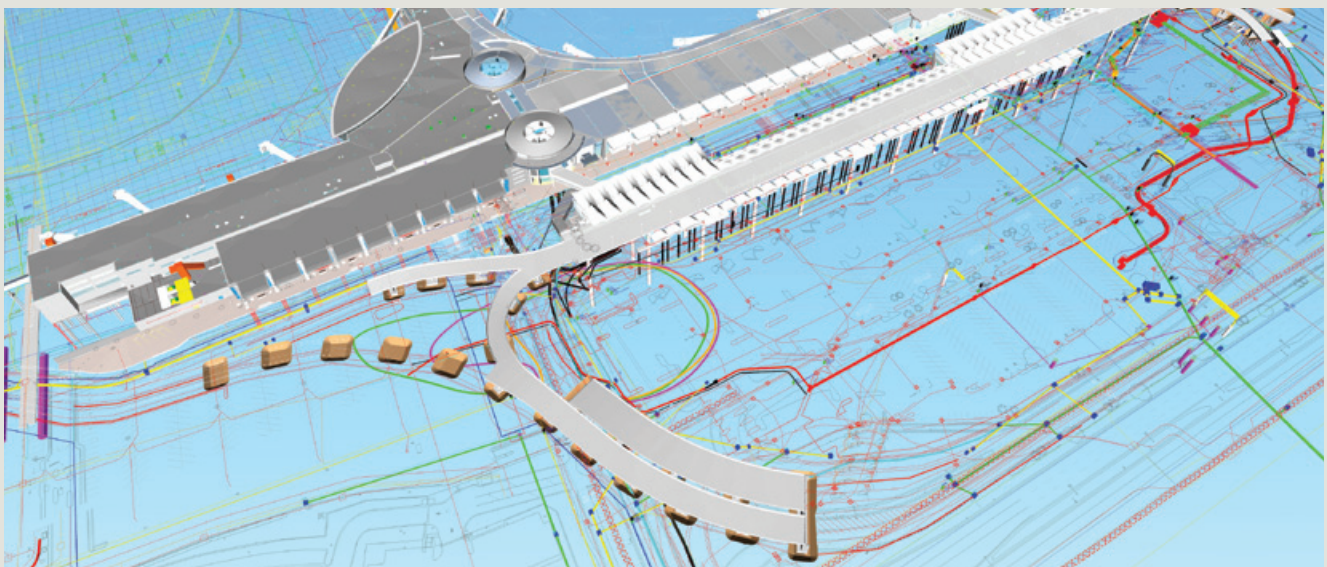
To better monitor all contracts and keep stakeholders informed, S&P is modeling the project, providing estimating and scheduling analysis and cost controls. When S&P joined the project, the design was already complete, but S&P was able to work from the design team's models to build its own, says Tim Kelly, technical services manager at S&P. S&P also incorporated models generated by contractors and some of their subs.

The teams conduct coordination and constructability reviews. Visualization is another major component. Team members work collaboratively in an on-site virtual studio on schedule planning, site

logistics and other aspects of project execution.

S&P broke out its model in accordance with how the project would be built, enabling 4D scheduling capabilities. S&P also can conduct rough 5D cost estimates. Through 4D, Kelly says, the team can better track production. "We track early, late and actual finish of tasks in the model," he says. "We then analyze it to show how things are tracking going forward."

If the schedule starts to slip, the team can react quickly to recover. Frank Roetzel, senior vice president at S&P, says that kind of knowledge yields significant benefits. "When you're on a big project, you can lose control and not even know it," he says. "It's too much to handle in the traditional way with 2D blueprints. Once you've modeled and you can tie these other applications to the model, then you have incredible real-time knowledge about where your project is. That allows managers to focus on issues, and you can filter out the background noise."



On San Diego International Airport's Green Build, the team that handles the main roadway and parking aspects of the project coordinates in BIM with a team under a separate contract that is building a terminal expansion, new gates and a new taxiway.

Use of BIM on Airports

The Green Build at San Diego International

On the \$1.2 billion Green Build project at San Diego International Airport, major contractors on separate contracts work in harmony through BIM. The program is split primarily between the team of Kiewit, Sundt Construction and URS, which handles the main roadway and parking aspects of the project, and the team of Turner Construction, Flatiron Construction, PCL Construction Services and HNTB, which is building a terminal expansion, new gates and a new taxiway.

From the outset of the program, the airport authority envisioned a fully integrated program from design through construction with modeled content that was created as a deliverable for the facilities management side, says AECOM's Mark Hughes, who serves as BIM manager for the airport authority.

When the teams were selected in 2007, both were contractually obligated to collaborate in BIM and create data-rich models, Hughes says. "We entered a 90-day validation period, where the three parties locked ourselves in a room and came up with a game plan," he adds.

Hughes says the team had very open dialogue about technology options and expectations of deliverables. Although a plan was set in place, Hughes says the team understood that BIM technology was still evolving. "We all recognized that this was really only a starting point," he says. "We left the door open for exploration along the path. If we found a better solution, the opportunity was brought to the table to discuss. Simple things like platform changes and platform products had to be discussed. New products came online that we couldn't even dream of initially."

On the civil side, Rob Foster, BIM manager for the Kiewit/Sundt/URS team, says a major initiative for his team was to model utilities and create highly accurate as-built drawings. When the team began its work, Foster says the provided as-builts were very unreliable. "Like any good utility contractor, we tossed those aside and started drilling potholes [to locate utilities]," he says. "They cost about \$1,000 each, and we did more than 500 of them. We kept track and modeled the existing and new utilities so that when the as-builts are sent to the next contractor, you're saving another half million dollars."

An overarching goal is to produce a data-rich deliverable model for future facilities management, Hughes says. "Currently, for every dollar we spend in design, we spend \$50 to \$60 in maintenance," he says. "If we can spend an extra dollar in design and save \$10 in maintenance costs, that's significant savings for us."

Hughes says that the process significantly accelerated the program, trimming costs and keeping more of the airport open for business. He estimates that between hard and soft costs, the \$1.2 billion program might have cost nearly \$2 billion using traditional means. "We were able to start foundations at 30% construction documents," he says. "If we waited for the design to be done, we'd still be waiting today, and we're two years into construction now. That's a lot of lost airport revenue."

Terminal Renewal and Improvement at Dallas/Fort Worth

Joint ventures on the Dallas/Fort Worth International Airport's \$2.3 billion Terminal Renewal and Improvement Program (TRIP) are

also crossing competitive lines to work together. Dwain Brown, TRIP implementation director and program manager at Freese and Nichols, says the airport authority wanted teams to work in common platforms to enable high-value BIM use and consistent communication.

The airport also had a separate sustainability goal to go paperless on the project, necessitating greater use of BIM and related tools. The joint venture of Balfour Beatty Construction, Azteca Enterprises, H.J. Russell & Company and CARCON Industries was the first team in, so Brown worked with those firms to establish an implementation plan.

Recognizing the potential savings, the airport agreed to pay for items such as software and plan rooms with large computer displays. The airport also purchased hundreds of iPads to allow managers, superintendents and subcontractors digital access to all plans. WiFi throughout the site enabled access to a cloud server for updated models and plans. "These are tools to achieve our goals," he says. "We would pay for them one way or another."

When a second joint venture of Manhattan Construction Co., Thos. S. Byrne, James R. Thompson and 3i Construction came on board, Brown asked the Balfour Beatty team to get all parties on the same platforms.

Brown estimates that its paperless initiative alone could save the airport more than \$8 million in printing costs and added efficiencies. ■

Use of BIM on Transit Projects

The intersection of vertical and horizontal building is often referenced by BIM users as an ideal opportunity to use the technology in infrastructure. Many transit projects, which combine stations with roadways and rail lines, fit that description perfectly.

Use of BIM on Transit Projects

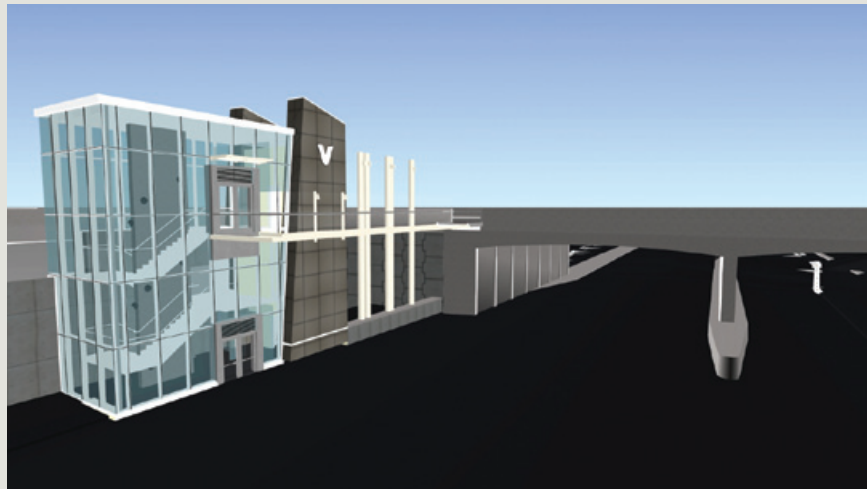
Parsons Brinckerhoff (PB), an early adopter of BIM in vertical building sectors, has seen a interest in BIM slowly increasing within the transit world. Starting in 2006, the firm used BIM to deliver the 4th Street Bus Station in Reno, Nev.

Tom Brooks-Pilling, vice president and architectural practice leader at PB, says the firm used modeling early in the project for conceptual design to identify the best site concepts. Architecture, MEP and structural elements were modeled by PB, but electrical and plumbing were not because the functions were not well developed at the time, he says. Civil engineering was also not modeled. The model was used for systems coordination and cost estimating.

Since then, the firm has seen expanded use of BIM on transit projects, including the Fulton Street Transit Project in Manhattan, on which PB served as the construction manager. The firm is also currently using BIM on mass transit stations in Mumbai and Los Angeles.

Brooks-Pilling says he expects use of BIM on mass transit work to gain momentum as more owners request it.

"Once owners request it for facility management, then there is a lot of value to be gained," he says. "We see more sophisticated clients taking



Seven kilometers of roadways, 22 stations and two new pedestrian bridges were modeled for a section of the VivaNext Bus Rapid Transit system project in Toronto.

an interest in things like modeling underground utilities. Knowing where those are would be very useful for a long-term facilities owner."

Jay Mezher, manager of virtual design and construction at PB, says the firm's use of BIM on its transit jobs, regardless of owner requirements, is garnering interest from transit authorities. In places like New York City, where the firm has worked extensively on the city's subway system, use of BIM is proving its value.

"We weren't required to use it, but they have been really supportive of it, especially on the trickier issues that help with scheduling, RFI or anything that makes project controls easier," he says. "The Port Authority [of New York and New Jersey] now has a published BIM standard. That tells you a lot."

BIM is being used extensively for transit projects in Toronto, Canada. Multiple firms working on the \$730 million Toronto-York Spadina Subway Extension Project are modeling segments with the encouragement of the Toronto Transit Commission. Hatch Mott MacDonald (HMM) modeled its

work on a 6.7-kilometer tunnel segment of the project. Given the tight spatial restriction, the model was used for coordination of various disciplines.

"The clearances were very tight," says Chris Tattersall, vice president of transportation in central Canada for HMM. "One area had a tight curve with utilities and a fire main running through it. We had no confidence we were clear in there until we modeled it."

Although HMM made good use of its model, the information was siloed. "The real value for BIM on these projects is the downstream usage," he says. "The problem is that public procurement models tend to silo the disciplines. The only way to span across the silos is for the authorities to get involved. We're seeing some heading that way."

VivaNext Bus Rapid Transit System

Also in the Toronto area, extensive modeling is being used on the VivaNext Bus Rapid Transit system project. A partnership of Kiewit and EllisDon is modeling much of

CONTINUED

Use of BIM on Transit Project

a 7-kilometer section of the project that will include road-widening for dedicated bus lanes, 22 stations, two pedestrian bridges and five new bridges built for environmental protection along the corridor.

The team converted 2D drawings into 3D models to help analyze road structures, corridors, intersections and culverts for constructability. The team also generated quantity takeoffs and earthwork calculations from the model. For the stations and bridges, the team modeled structural elements; coordinated existing and proposed utilities; and performed quantity takeoffs. The model was also used for 4D scheduling with site superintendents to help them visualize the process.

Denis Erlich, senior BIM coordinator with EllisDon, says the team came in after the first phase of

design was well underway, so it had to build its model from scratch. For the second phase, Erlich says, the team got designers to work in 3D to speed up the modeling process.

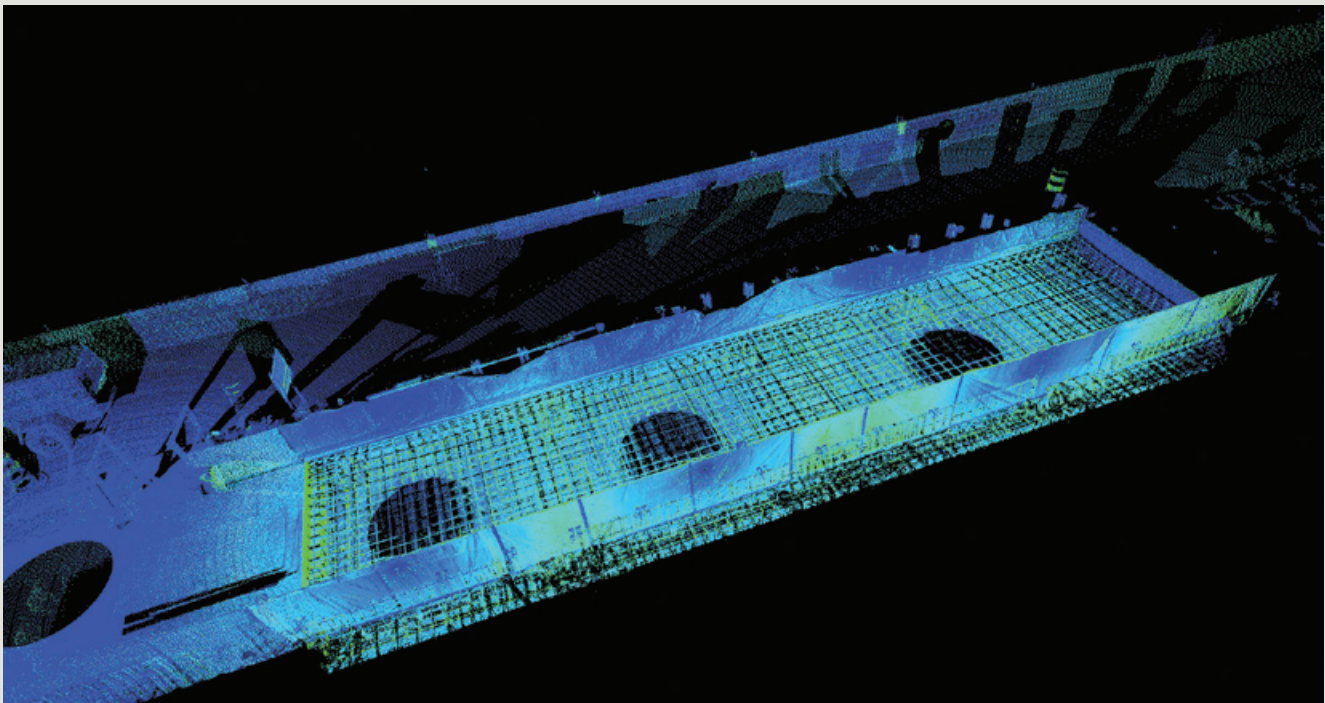
Perhaps the most robust tool used in its modeling effort is laser scanning. The team, which purchased its own scanner, is regularly scanning all conditions as construction progresses. Kiewit/EllisDon sees multiple benefits from the process. Erlich says the team uses the point clouds produced by the scanners to ensure quality, particularly at the interfaces between the civil works aspects of the project and the vertical construction. Those point clouds can be pulled into the 3D model to compare site conditions with the design. When discrepancies are found, they can be addressed quickly.

The point clouds are also used for quantity takeoffs and estimating. Erlich says the scans are accurate to “within a couple of millimeters.”

The team is also scanning the roadways, using an outside firm with a vehicular scanner. Again, getting accurate measurements is a major benefit. “A centimeter difference over seven kilometers adds up to a lot in quantities.”

During construction, the point clouds allow the owner and other team members to monitor progress of the project.

Potentially, one of the most valuable aspects of scanning will be realized after completion. Because the project is being scanned regularly, the point clouds can be combined after completion to create highly accurate as-built models, Erlich says. “You can see the station peeled like an onion,” he says. ■



The VivaNext project is scanned regularly, creating a series of point clouds that are added to the model.

Data: Business Benefits

Assigning Value to BIM Benefits

The benefits of BIM manifest in a variety of ways. In some cases they accrue directly to the individual company that is deploying it in the form of improved productivity, profitability or efficiency. In other cases, the benefits are enjoyed by the entire team and often contribute directly to better overall projects.

In addition to this variety of benefits, each type of player involved in a project experiences the value of BIM from its own perspective of needs, risks, rewards and objectives. **One common thread running through the findings of this study is the positive impact on the business aspects of running organizations and designing, building and operating projects.**

To determine the relative value of BIM benefits across these dynamic dimensions, respondents were asked to assign one of five levels of importance (none, low, medium, high or very high) to:

- **A variety of specific benefits that result from using BIM technologies and processes**
- **Project phases and project processes which benefit from BIM to varying degrees**
- **Project factors that most affect the ability to generate benefits from BIM**
- **Current versus future benefits**

To focus on the aspects with the most impact, the graphs in this section of the report show just the percentage of respondents that assigned high or very high levels of importance to any choice offered.

The top four benefits noted by users of BIM for infrastructure are the same as the top benefits noted for buildings in MHC's 2009 *Business Benefits of BIM SmartMarket Report*, and they are ranked in the same order. This demonstrates the consistent results experienced from BIM across project types, especially to create new business and improve project outcomes.

Several of the most critical benefits of using BIM for infrastructure hold equally strong appeal to A/E firms and contractors.

Marketing New Business

An equally high percentage (45%) of A/E firms and contractors rank the ability to leverage BIM capabilities and experience to win new work as a top benefit, making it the most universally important among all internal benefits. This competitive advantage aspect has scored well consistently in previous BIM research conducted by McGraw-Hill Construction.

Other factors related directly to business concerns were also selected as important by over one third of A/E firms and contractors:

- Offer New Services
- Maintain Repeat Business

Reduce Errors in Construction Documents

A/E firms and contractors also agree (42% and 41%, respectively) on the high importance of BIM's ability to reduce construction document errors.

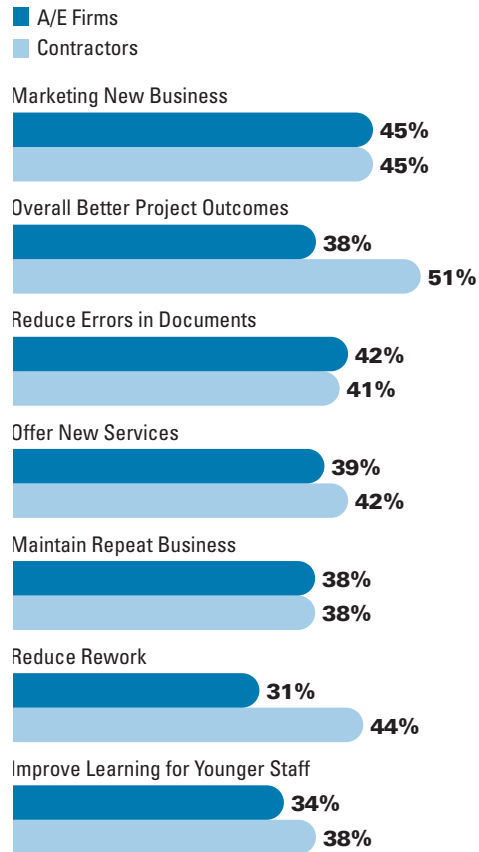
Improve Learning for Younger Staff

A/E firms and contractors also highly regard BIM's usefulness for working with younger staff, an important aspect of attracting and retaining the emerging tech-savvy workforce in the construction industry.

Benefits scoring lower among A/E firms and contractors include reduced claims/litigation and increased profits. This result does not suggest that these are unimportant benefits, but that they are not yet demonstrated to the extent that many firms can report experiencing them.

Top Internal Business Benefits of Using BIM for Infrastructure Projects for A/E Firms and Contractors

Source: McGraw-Hill Construction, 2012



Variation by Player

There are a few benefits that appear to carry greater weight with contractors than with A/E firms.

- Over half (51%) of the contractors report overall better project outcomes as a top internal benefit from using BIM. This benefit allow respondents to assign an internal value to the sum of all of the project-oriented benefits they experience, which is of particular concern to contractors.
- Reducing rework is rated more highly by contractors (44%) than A/E firms (31%), likely because they are affected most directly by this issue.

Top Business Benefits for Owners

As the entities ultimately responsible for project outcomes, owners have their own unique perspective on what constitutes an internal benefit of BIM on infrastructure projects.

- **Tied for first place at 44%, overall better project outcomes and reduced rework are significant benefits of BIM.**

This is understandable because both are highly visible on projects in an owner organization and reflect directly on the individuals responsible. This is especially the case with reduced rework because unbudgeted changes on projects that result in rework are, in many cases, avoidable and indicate gaps in the project delivery process. A process enhancement, such as BIM, that can positively impact this perennial problem will be highly valued. Not surprisingly, a large percentage of owners of vertical projects in MHC’s 2009 *Business Value of BIM SmartMarket Report* also find these benefits important.

- **Fewer claims/litigation is owners’ next most important internal benefit.**

Claims and litigation may rank highly with owners because of their visibility and the potential financial risk they involve.

- **Tied for third place at 33% are reduced errors in documents, reduced workflow cycle time and reduced project duration.**

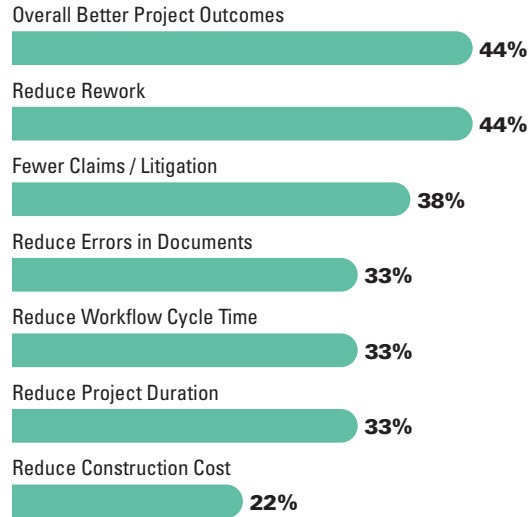
These specific benefits are critical because they impact aspects of project processes that owners believe contribute to better project outcomes.

- **Reduced construction cost rates least important of these benefits.**

As with several other low-ranking factors, the challenge of attributing this benefit reliably to BIM use is more likely the cause of its low rank than its lack of importance.

Top Internal Business Benefits of Using BIM for Infrastructure Projects for Owners

Source: McGraw-Hill Construction, 2012



BIM Capabilities that Benefit Infrastructure Projects

The specialized nature of infrastructure projects creates the opportunity for a number of benefits resulting from BIM technologies and processes. Even clash detection, a staple of vertical BIM, has special significance on infrastructure projects. According to Dan Klancnik, VDC manager at the Walsh Group in Chicago, “Conflicts tend to be much more expensive in treatment plants and heavy construction than in commercial work, so the benefits [of BIM] are easily realized.”

Civil Conditions

A building has a defined footprint where it touches the earth, and once the foundation is in place, the complex realities of the geophysical environment that surrounds it have minimal impact on construction. Horizontal projects, by contrast, are subject to every nuance of the extensive amount of terra firma with which they engage. “No two feet of a roadway is like any other two feet,” says Eric Cylwik, BIM engineer for the Heavy and Civil Group of Sundt Construction in Tempe, Ariz.

Many firms putting BIM to work on civil projects believe in using a variety of inputs including GIS data, underground radar, laser scanning, test borings, and any other source of reliable information to develop a complete-as-possible model of the existing civil conditions with which they will be working. Once that model is in place, engineers can leverage it for nearly endless types of analysis, simulation and visualization to optimize design solutions. Says Jay Mezher, VDC Manager for Parsons Brinckerhoff (PB), “You can model and analyze as many issues in horizontal projects as you can in buildings.”

Simulation

Once surface and subsurface conditions are modeled, engineers can simulate the impact of their proposed design solutions. For example, by using computational flow analysis, an engineer can assess the downstream impact of a dam on the existing natural water system. It is also possible to simulate the effect of a natural disaster on the built environment. This was done in Seattle to assess the impact of an earthquake to an elevated highway and the surrounding grade level improvements. To see the video, go to <youtube.com/watch?v=hos_ulKwC-c>.

Engaging Community Stakeholders

Large roadway and tunnel projects in urban areas are complex and can require choices between many alternative approaches before the final engineering solution is approved for implementation. This process is further complicated by required involvement from numerous stakeholder groups whose members are often non-technical and have difficulty understanding the differences between options based on the handful of design documents and renderings that are typically produced for these purposes.

The Alaskan Way Viaduct and Seawall Replacement project in Seattle, Wash., is just such a project. Coursing through the heart of the city’s downtown business area, its impact is enormous. The project’s engineering firm, PB, developed 98 different alternatives, from elevated highways to tunnels, which had to be comparatively evaluated and then narrowed down to a final plan with the involvement of a large array of

parties. By modeling the existing surface and subsurface conditions of the entire downtown, PB could produce numerous highly descriptive and compelling animations that definitely accelerated the complex evaluation and approval process. See an example at <youtube.com/watch?v=mWfwnkEbc4Q>.

Visualization for Business Development

Marketing BIM capability is one of the top internal business benefits of BIM for infrastructure reported by current users in this *SmartMarket Report* (see page 21). Combining that goal with the power of visualization for highly complex engineering solutions, many firms are modeling proposed approaches to projects during the marketing phase. This allows them to demonstrate their BIM prowess at the same time they impress the client with their understanding of the unique aspects of the project. ■

Top Benefits by Phase

BIM is still maturing in its applicability throughout the lifecycle of a project. As a result, benefits are not being experienced at equal levels across all phases by every player type. Respondents were asked to report on the level of value they are currently receiving, by phase, from the use of BIM on infrastructure projects.

Design and construction documentation are assigned the highest values by the most respondents (53% and 51%, respectively). Predictably strong rating from A/E firms (59% and 53%, respectively) contribute to this high valuation, which align with the results of MHC's 2009 *Business Value of BIM SmartMarket Report* on vertical construction.

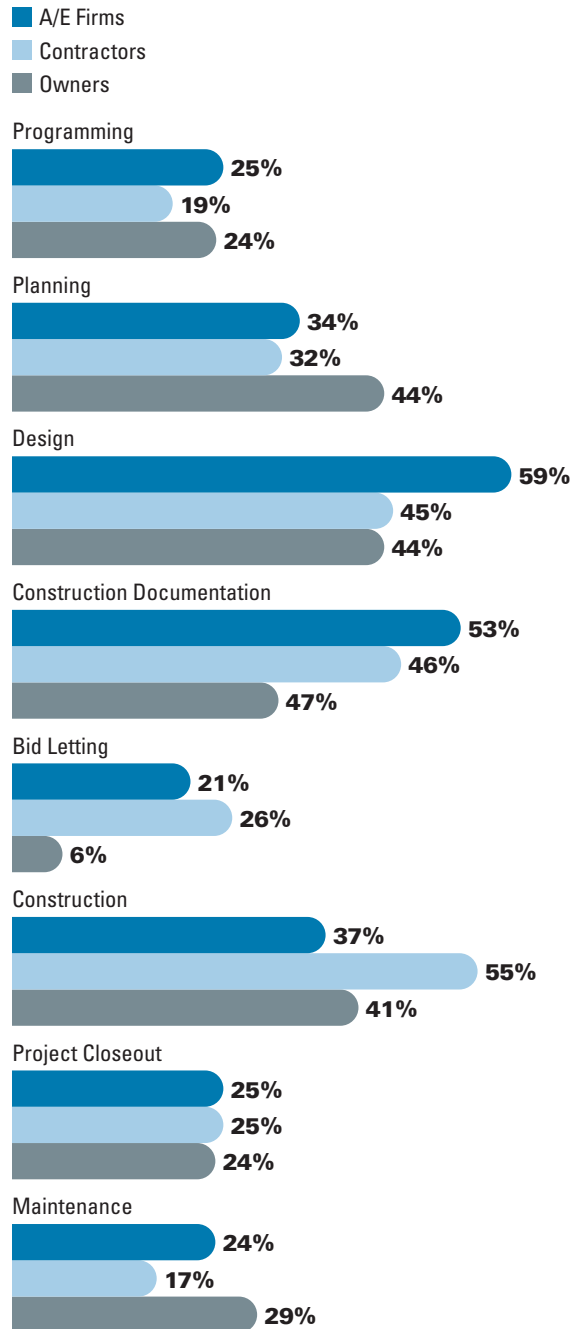
However, design and construction documentation also have high value to contractors and owners. In fact, the strong recognition of this benefit by contractors highlights broad acknowledgement of the growing importance of collaboration between A/E firms and contractors during these phases. These are also the phases for which BIM has been implemented the longest and on the most projects, so it is not surprising that more people are familiar with those benefits.

The high levels of importance assigned to other phases point to a few emerging trends.

- **44% of the owners assign high value to the use of BIM for the planning phase, where its ability to visually convey complex engineering solutions is proving increasingly valuable for review and approval processes with nontechnical stakeholder groups.**
- **29% of the owners also assign high value to BIM's contribution to the maintenance phase, an aspect of rapidly growing interest in operations and maintenance throughout the industry.**
- **There is increased interest in using BIM for closeout and operations throughout the industry. This is supported by comparison with the results of MHC's 2009 *Business Value of BIM SmartMarket Report*, which examined BIM adoption in building construction. While a comparable percentage perceived the value of BIM during the design and construction phases, only 16% from the earlier survey found BIM added value in project closeout and 15% during the operations and maintenance phase, compared to roughly one quarter of the current respondents.**

High/Very High BIM Value for Infrastructure by Project Phase

Source: McGraw-Hill Construction, 2012



BIM generates varying degrees of value for each player type across different project processes:

- **Spatial coordination is identified by the largest number of contractors (65%) and A/E firms (56%) as a process where BIM provides high value.**

Owners view it with less enthusiasm (25%), probably because the process is not as visible to them, and in most cases they already expect a fully coordinated project.

- **Structural analysis is valued at the second highest for A/E firms (41%).**

Not surprisingly, it lags with contractors (23%) and owners (25%), again likely because of their relative lack of direct involvement with that activity.

- **Surprisingly, more A/E firms cite the high contribution of BIM to quantity takeoff (38%) and cost estimating (31%) than contractors (22% and 17%, respectively).**

This is likely a result of contractors' long-standing reliance on traditional methods and the fact that reliable, detailed quantity takeoff and estimating directly from BIM is still an emerging practice, whereas it provides a newfound capability for design firms.

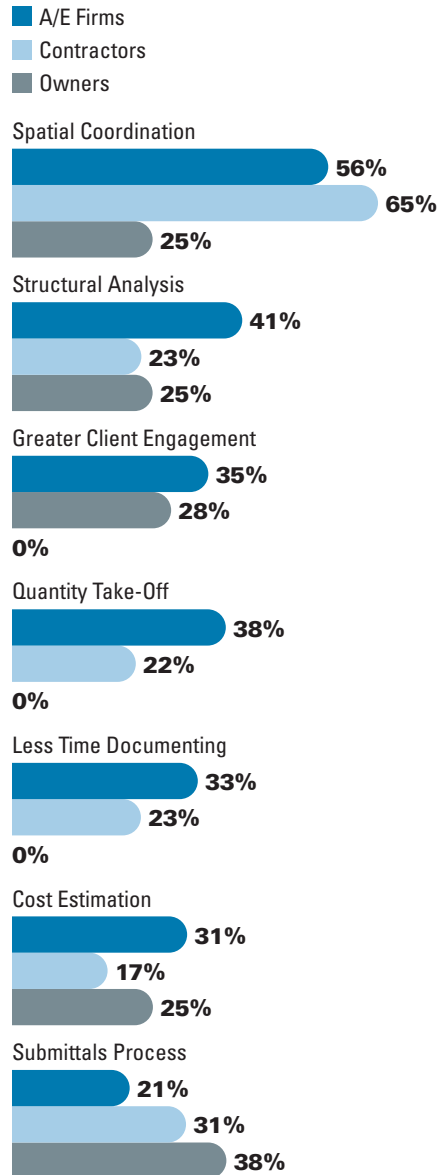
- **35% of A/E firms consider BIM's ability to foster greater client engagement important.**

This result spotlights the important contribution of enhanced visualization to that process. Almost as many A/E firms (33%) value spending less time on documentation, a benefit of the front-end loaded BIM process.

Lower-scoring processes include submittals, 4D scheduling, automated machine guidance, environmental impact/feasibility studies, and operation and maintenance of an asset (which no player rate as high or very high). As BIM usage matures and technology advances, the value of BIM to each of these important, but currently low-scoring, processes is expected to increase. Certainly, the importance that 29% of the owners and 24% of the A/E firms place on the value of BIM during the maintenance phase of a project (see page 24 for more information) indicates that the industry believes that BIM offers great potential in these areas.

High/Very High BIM Value for Infrastructure by Project Process

Source: McGraw-Hill Construction, 2012



While there is much variability among the value of project factors by player, **one factor, project complexity, rates equally high (total of 61%) among all respondent types.** This strong result for infrastructure projects emphasizes the perceived value of BIM for managing large amounts of information among multiple participants more effectively than traditional approaches, a benefit that impacts all users equally.

Project complexity is also one of the few top factors for which an equivalent percentage (63%) found value in vertical construction in MHC's 2009 *Business Value of BIM SmartMarket Report*; however, for buildings, this was the third highest rated factor rather than the first. In fact, all the other top five factors were selected by a larger percentage of organizations using BIM in buildings in 2009 compared to those using it for infrastructure in 2011. One of the few exceptions is project size, which was only selected by 41% of the 2009 respondents. This combination of size and complexity reveals that it is the complexity of large projects that is perceived to offer the greatest opportunity in the infrastructure sector.

Variation by Player

A/E FIRMS

A surprising 64% of A/E firms place high importance on having BIM-knowledgeable design professionals on the project. This result is particularly striking when compared to the 41% who cite previous experience working with the other companies on a project as critical. In an industry known for valuing long-term relationships, this signals a very important cultural change driven by the perception of tangible value.

CONTRACTORS

Interestingly, a relatively small number (27%) of contractors assign a similarly high importance to project budget. This may indicate a belief that projects of any budget can benefit from BIM, not just the most expensive ones.

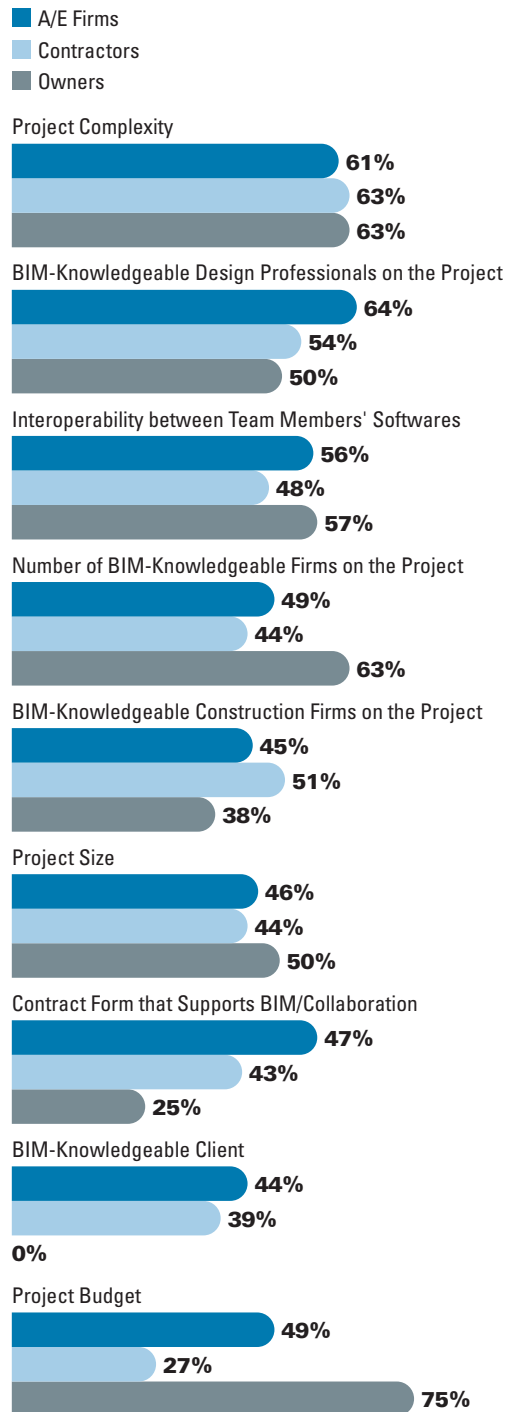
OWNERS

The most popular choice (75%) among owners is project budget, probably closely linked in their minds to project complexity, to which 63% of them assign top importance.

Owners also place strong value on working with firms with BIM experience. 63% consider the number of BIM-knowledgeable firms on a project important, the same percentage that recognize the importance of project complexity.

Most Important Infrastructure Project Factors that Add Value to BIM Use

Source: McGraw-Hill Construction, 2012



Top Current Benefits

Not surprisingly, each player has a very different view of the top current benefits of using BIM for infrastructure.

Variation by Player

A/E FIRMS

The A/E responses are largely in agreement with the owner's responses. The only area selected by significantly more A/E respondents than owners is reduced conflicts and changes during construction. One factor that may make this benefit particularly appealing to A/E firms is BIM's ability to convey design intent, which reduces the likelihood that the contractor will make major changes to the project during construction.

CONTRACTORS

69% of contractors cite reduced conflicts and changes during construction as important, the highest percentage of any group for any of the benefits. It also has the highest combined total percentage (58%) across all player types.

46% of contractors also give high marks to prefabrication of larger and more complex parts of projects, a BIM trend that is well established and growing. Among the company types that comprise the contractor category, specialty contractors are especially enthusiastic regarding this benefit, with 38% reporting it as having very high importance and none rating it with low or no importance.

OWNERS

The highest percentage of owners (59%) select improved overall project quality as an important BIM benefit, making this the second most important benefit overall, with a combined total of 48%.

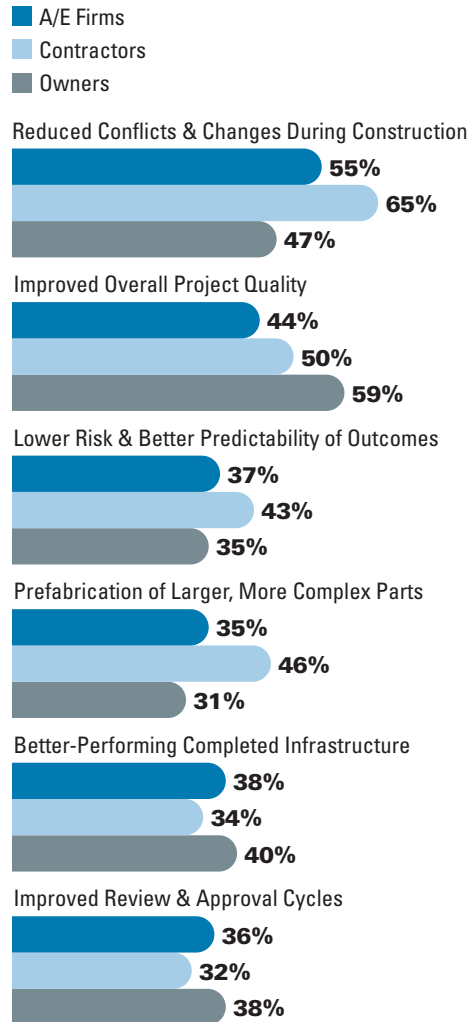
The benefits of reduced total project cost and reduced overall project schedule are also selected by a significant percentage of owners (44% and 38%, respectively), but their relatively low level of selection by design and construction respondents keep them out of the top group of BIM benefits as shown in the chart at right.

Other Benefits

Falling short of the top group of current BIM benefits are improved individual participant productivity and improved profitability of participating companies. While certainly desirable outcomes, these benefits are likely selected by fewer respondents as important due to a lack of reliable track record of achieving them, a persistent trend throughout all the lower-ranked data. As more data are collected from BIM teams across the industry, these benefits are sure to rise in perceived value.

Most Important BIM Benefits that Contribute Value to Infrastructure Projects

Source: McGraw-Hill Construction, 2012



Top Benefits in Five Years

All players believe that reduced conflicts and changes during construction will be their top future benefit of using BIM for infrastructure. This finding corresponds to the top current benefit of using BIM (see page 27). Reducing conflicts and changes during construction can have the greatest impact on improving project schedule and productivity and reducing the risk of cost and schedule overruns.

Lower risks and better predictability of outcomes is also an important benefit for all of the players. A similar percentage (64%) considered this to be an important benefit of BIM for buildings in the future in MHC's 2009 *Business Value of BIM SmartMarket Report*, which demonstrates how valuable it is across project sectors.

Variation by Player

The owners outpace the A/E firms and contractors in their selection of improved productivity (71%) as a highly valued future benefit of using BIM for infrastructure. This result is striking because it indicates an understanding that although this benefit accrues first to the companies providing the labor, it ultimately controls cost on a project—always a critical concern for owners.

Reflecting their unique perspective on what constitutes a benefit of BIM, the group also shows the strongest level of support for:

- **Improved review and approval cycles (63%)**

This result demonstrates an awareness of the value that streamlining decision making provides for everyone.

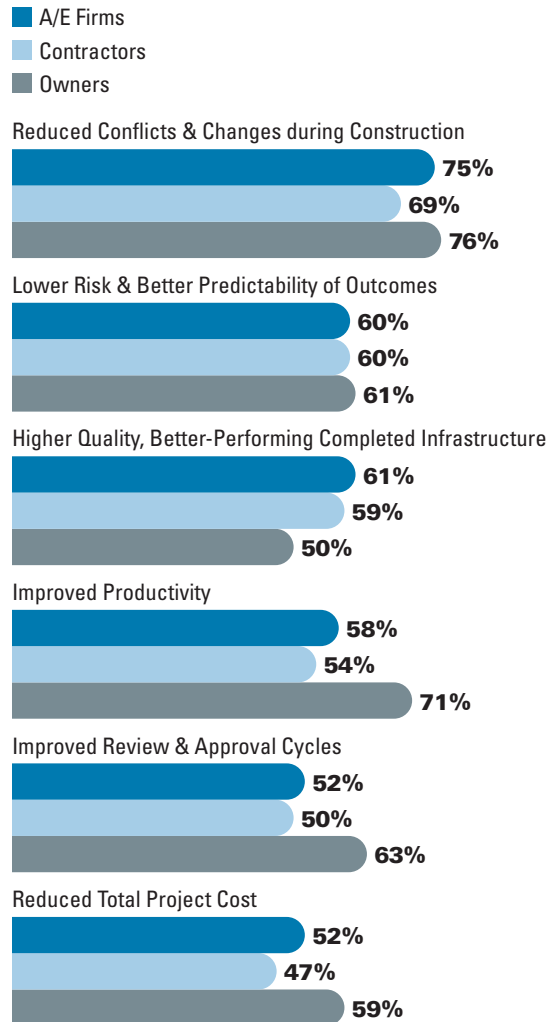
- **Lower risk and better predictability of outcomes (61%) and reduced total project cost (59%)**

The importance of these areas reinforces the owners' focus on the elements by which their performance ultimately will be measured.

Interestingly, the fewest owners place high value on the future benefit of higher-quality, better-performing completed infrastructure, which should accrue the most relative benefit to them. This may be because there currently is not enough evidence of the ability to achieve that result, and their opinion may shift once data are collected to establish that potential.

Areas of Greatest Value to BIM Practitioners for Infrastructure Projects in 5 Years

Source: McGraw-Hill Construction, 2012



Use of BIM on Dams, Canals and Levees



The Panama Canal Authority added BIM to the workflow at its ongoing \$6 billion expansion project, primarily for use by the design team; however future plans call for use of BIM in other tasks, including scheduling.

Building information modeling (BIM) is beginning to pique the interest of public entities that own, operate and maintain dams, canals and levees. Such critical infrastructure is generally expected to remain in operation for many decades, and some owners recognize the long-term benefits of creating models for ongoing analysis and improvement of facilities.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers released its BIM Roadmap in 2006, and since then it has made great strides by requiring use of the technology on its vertical building projects. Recently, the Corps started implementing 3D modeling and BIM on civil works projects as well.

Van Woods, CAD/BIM manager in the U.S. Army Corps of Engineers

Seattle District, says that unlike the “top-down” approach that the Corps used to implement BIM on vertical building projects, the adoption of BIM on civil projects is starting in the trenches. “We have engineers interested in trying to get [BIM] into the workflow, and we are helping to support that,” he says.

Woods says that a handful of districts are starting to test the technology’s applications in civil projects, including recent work on the Howard Hanson Dam through its Seattle District. Initially, engineers chose to model the dam as a way to monitor a depression that appeared on an abutment. The team used terrestrial and aerial LIDAR data to build a 3D site model.

The team has since built models on top of that data, including a BIM model of a new fish passage facility at the

dam. Woods notes that the facility had relatively complex geometries, such as a horn modeled as an elliptical curve, traction water conduit modeled as an ogee parabolic curve, and a flood control tunnel modeled as a helical horseshoe. Additionally, a pedestrian bridge comes in on an angle and has a slope.

Multiple disciplines worked on the model, including structural, mechanical, civil and geotechnical. Through its coordination efforts, the team discovered that a planned drilling location for reinforcement of the fish ladder would have clipped the existing structure. “That was an interesting exercise in cost avoidance,” Woods says.

The team was also able to pull quantities from the model, such as volume of concrete, rebar and structural steel; volume of rock and soil excavation; and vertical and horizontal surface areas.

CONTINUED

Use of BIM on Dams, Canals and Levees

Although the Corps' use of BIM on civil projects is years behind its efforts in vertical building, Steve Hutsell, geospatial section chief in the Seattle District, says it will be part of the Corps' future workflows. "You'll see more civil projects with 3D as a requirement for design and construction," he adds. "Within the Corps, there's recognition of its value in the vertical world. The question we're trying to answer is: Can we not achieve those same results in civil works?"

The Panama Canal

In recent years, the Panama Canal Authority added BIM to the workflow at its ongoing \$6 billion expansion project. Nick Pansic, deputy design manager for the project with MWH Global, has been involved with the project for more than a decade, and recently was asked by the authority to implement BIM.

Pansic says the initiative provided MWH with an entrée into BIM for civil works. "I was excited to see it requested," he says. "I knew it would challenge us to up our game and figure out a new way to design projects versus traditional delivery of something like this."

The master plan includes several dredging projects, but the BIM initiative is focused on the Third Set of Locks project. MWH is part of a design joint venture with Tetra Tech and the Dutch firm Iv-Infra. The joint venture is subcontracted under the design-build consortium Grupo Unidos por el Canal.

The authority specified the BIM platform that would be used for the project, but left the implementation plan largely up to the design consortium, Pansic says.

The team's primary focus for modeling is the reinforced concrete structures that retain the water, as well as some

earth dam components. Other modeled elements include filling and emptying components, large fixed-wheel gate valves, and 60 control buildings per lock complex. All mechanical systems and electrical controls for the complex are also modeled, as well as supporting utilities. Additional civil works and earthwork models were created by outside consultants.

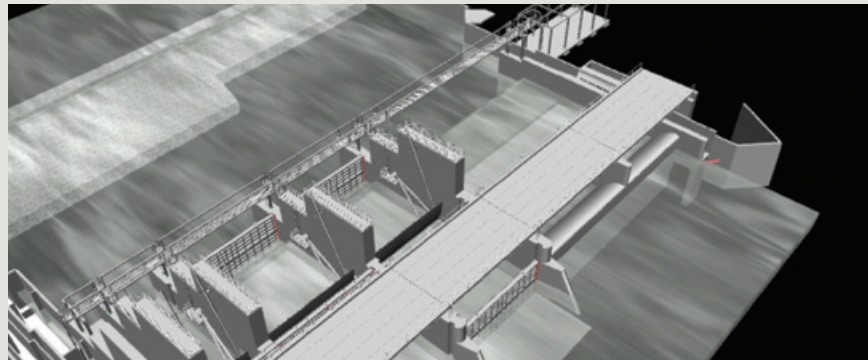
Although the authority left the implementation plan up to the consortium, Pansic says having all parties on the same platforms aided with coordination of models from the different disciplines. "We had to resolve a conflict recently with the high-mast lighting required for operation of the locks," he says. "The locations of those light poles are interfering with some access roadways needed for equipment. The BIM tool is an easy way to quickly identify where we have those conflicts and present that to the contractor and owner."

The team designed the project to Level of Development 300 standards, which enables the team to create construction documents and provide rough quantity takeoffs for estimating. Pansic says the team didn't link structural or hydraulic intelligence for analysis purposes to the model, since that would require a higher level of development.

Pansic notes that the biggest challenge has been getting up to speed on how BIM can be applied in civil projects while sticking to the project's aggressive schedule. "We are coming up the learning curve, so there have been situations where we had to go back to the conventional approach and then come back later to catch up in the BIM model. It hasn't been 100 percent according to the grand plan."

Although the project is designed in BIM, the build team is not required to use BIM. All construction documents will be provided in 2D. Still, Pansic sees greater use of BIM on the project in the future. He says the authority plans to contract a BIM consultant to develop a 4D schedule for the project. The authority may also consider using the model for facilities management in the future, but those plans have not been finalized, he says.

Beyond the benefits for the project, Pansic says MWH is gaining a critical understanding of the technology. "They have been looking for ways to introduce this technology and understand what is needed to make this a standard approach going forward," he says. "Having a real project with real challenges and lessons learned will help with other projects in the future." ■



The U.S. Army Corps of Engineers is testing the use of BIM on infrastructure projects, including a new fish ladder at Howard Hanson Dam in Washington State.

Data: Investment and ROI

THE BUSINESS VALUE OF BIM FOR INFRASTRUCTURE DATA

Top Investments in BIM for Infrastructure

Marketing BIM capability is the leading focus for both current (38%) and future (51%) investment across all respondents. This result is not surprising because A/E firms and contractors report that the ability to market new capabilities is currently one of the top benefits from BIM for infrastructure (see page 21). This also contributes to why few owners indicate that this is a focus for their BIM investments. Among the different player types, architects show a slightly greater degree of current (40%) and significantly more future (62%) commitment to a high or very high level of investment.

The next most important current and future investment for all respondents is software that supports BIM. Among the players, architects (subset of the A/E firms) have the lowest current percentage (29%) of firms investing at high or very high levels, but they appear to be the most aggressive future investors, with 57% forecasting that level five years out. Owners also predict strong growth over the period.

New or upgraded hardware required to operate BIM software scored third highest, but its importance does not increase quite as much over five years as other top investment types. This perhaps reflects a belief that near-term upgrades will suffice. In general, architects and engineers focus on this more than contractors, likely due to their high level of involvement in authoring and analyzing large model files.

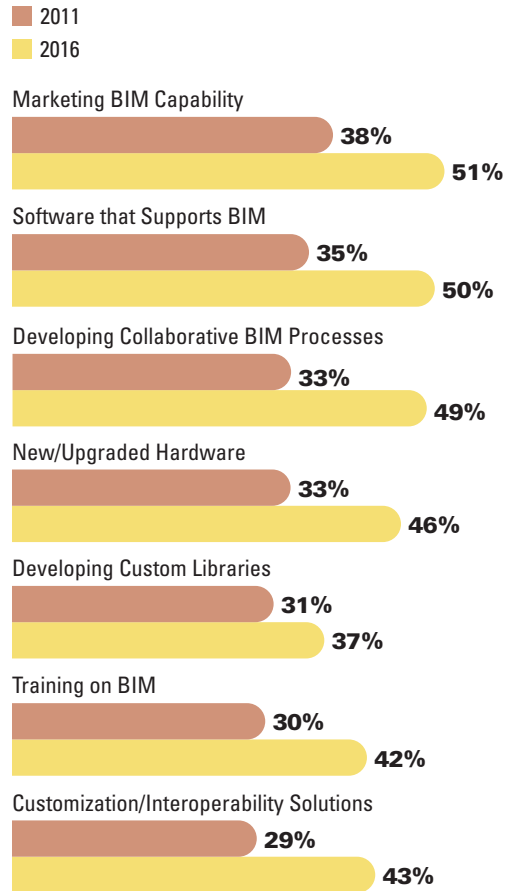
Investments with a High Percentage of Increase Expected

Developing collaborative BIM processes shows the greatest percentage increase, with the number of high and very high investors increasing dramatically during this period—from 33% in 2011 to 49% in 2016. This reflects the increasing awareness that while hardware and software are prerequisites, enhanced inter-company processes will generate the greatest value.

The numbers of organizations placing high priority on investments in training on BIM and customization/interoperability solutions, while somewhat lower currently than other categories, are expected to increase significantly. By contrast, developing custom libraries shows the least predicted growth in importance, perhaps reflecting a belief that, similar to hardware, near-term investments will reduce future needs.

Focus of BIM Infrastructure Investments (Current and Future)

Source: McGraw-Hill Construction, 2012



Return on Investments of BIM for Infrastructure

Because currently there is no widely accepted way to calculate ROI on BIM, respondents were asked to estimate their ROI in seven broad categories. **The findings demonstrate that the majority of respondents are finding that using BIM for infrastructure has value, and a significant percentage find that they are gaining significant returns from their investments in BIM.**

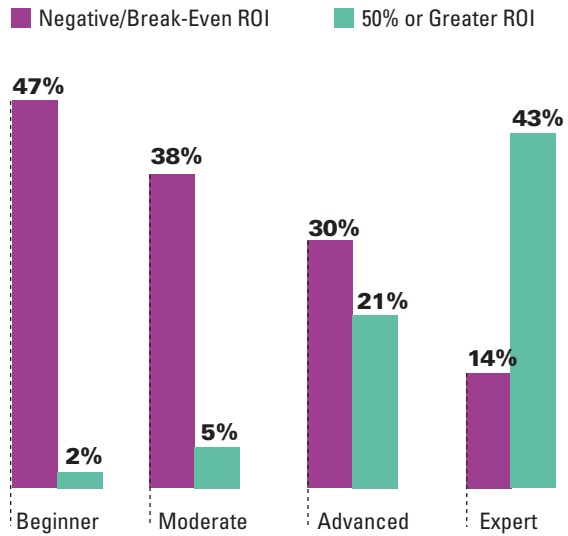
- One third of respondents currently using BIM for infrastructure work show negative or break-even ROI. Almost half (47%) of owners fall into this category, followed by A/E firms at 37%.
- More than one quarter of all respondents report ROI of 25% or better, with nearly one third of the contractors reporting that attractive level.

Comparisons with the results reported in MHC's 2009 *Business Value of BIM SmartMarket Report* are striking. That report examined the ROI of BIM used for buildings, and the findings again are quite similar, demonstrating that BIM adoption for infrastructure is lagging behind its adoption for buildings by a few years.

In 2011, 67% report a positive ROI for BIM use on infrastructure, compared to 63% for buildings. The percentage experiencing a high ROI of more than 50%

Perceived ROI on Infrastructure BIM Investment by Expertise Level

Source: McGraw-Hill Construction, 2012

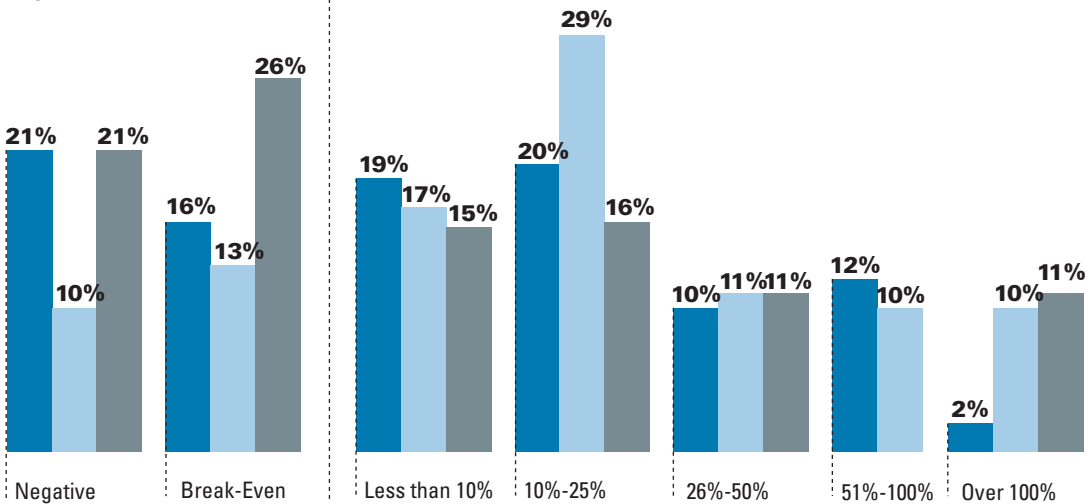


Perceived ROI on Infrastructure BIM Investment

Source: McGraw-Hill Construction, 2012

■ A/E Firms ■ Contractors ■ Owners

Negative/Break-Even 33%



is the same in both surveys—15%. The overall greater experience with BIM by the players in this survey combined with their relative lack of experience with using it for infrastructure may account for these results.

ROI Investments by Level of Expertise

There is a strong correlation between respondents’ reported ROI on BIM for infrastructure and their BIM expertise level.

- **Nearly half (47%) of BIM beginners are experiencing negative or break-even ROI in BIM for infrastructure.**

- **At the other extreme, 43% of BIM experts claim high positive ROI (50% or greater). Only 2% of beginners believe they are receiving that level of ROI.**

Comparing the results by level of expertise to the 2009 report reveals a similar pattern. Far more beginners (62%) reported negative/break-even ROI in 2009, but among the experts, the percentage in 2009 who experienced 50% or greater ROI is 39%, slightly lower than the 2011 infrastructure results. Again, this suggests that their greater overall knowledge of BIM from building projects may be impacting the ROI of those who consider themselves beginners in BIM for infrastructure.

Measuring ROI of BIM for Infrastructure

56% of all respondents engage in formal measurement of ROI for BIM on at least some portion of their infrastructure projects, compared to 46% of BIM users on buildings in MHC’s 2009 *Business Value of BIM SmartMarket Report*. This increase may be due to greater overall familiarity with BIM in the industry since 2009.

Among all the organizations that measure ROI on some portion of their projects, the largest group (28%) do so on less than 25% of them. Most of these are A/E firms and contractors, who are typically not highly experienced with calculating ROI and thus only do so on a relatively small percentage of their projects. Also, many organizations are probably assuming that the metrics for a few projects reasonably apply across all of them, and thus measuring ROI on a sample of their portfolio is adequate.

Variation by Player

A/E FIRMS AND CONTRACTORS

58% of A/E firms conduct ROI measurement on at least some of their projects, followed closely by contractors at 54%.

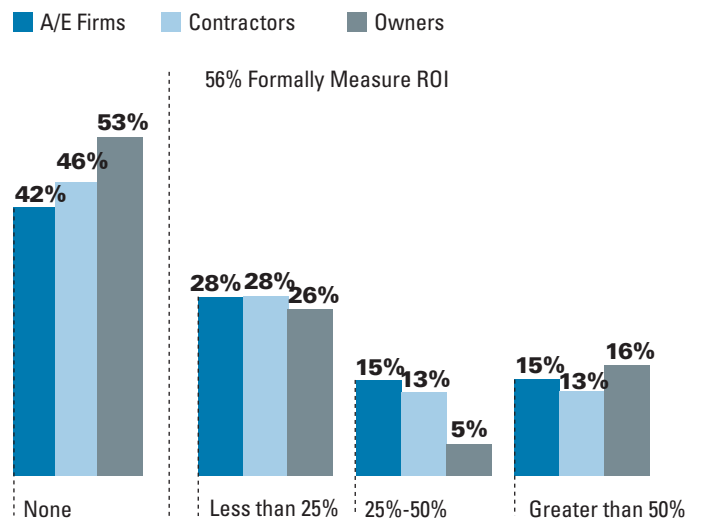
OWNERS

Taking the lead at both extremes, 53% of owners conduct no ROI measurement, while another 16% of them are measuring ROI on half or more of their projects.

In both cases, this is probably a reflection of organization-wide policies. Organizations committed to measuring ROI as a standard practice will also do so for investments

Formal Measurement of ROI on BIM for Infrastructure Projects

Source: McGraw-Hill Construction, 2012



related to their construction programs. But if ROI is not being measured as a standard practice, it is unlikely that the introduction of BIM, in and of itself, would instigate this major process change.

Length of Time Measuring ROI

About one quarter of all respondents that measure ROI for BIM on infrastructure projects report having done so for a long time (more than two years), with roughly equal proportions of the three player types falling into this category.

Variation by Player

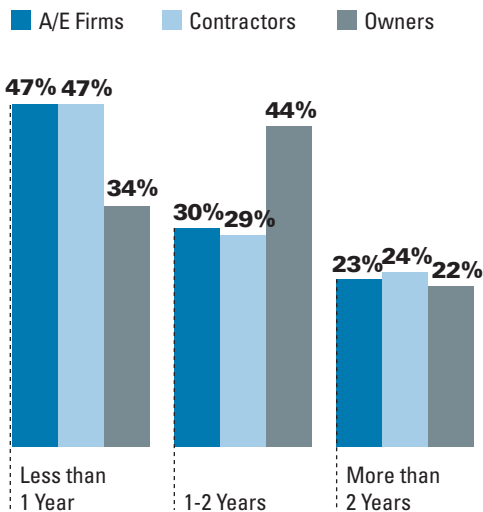
44% of owners have been formally measuring ROI for a moderate length of time (one to two years), leading that category by a significant margin. Thus, even though a relatively smaller portion of the owners engage in formal measurement, those that do have been conducting such measurements for a longer time.

This is likely due to long-standing organizational policies that require ROI measurement on a wide range of technology investments across the organization, therefore establishing it as an expectation of construction activity as well.

Almost half (47%) of the A/E firms and contractors that report measuring ROI are new to it, having done so for less than one year.

Length of Time ROI Has Been Formally Measured on BIM for Infrastructure Projects (Among those Doing Formal Measurements)

Source: McGraw-Hill Construction, 2012



Future Plans to Measure ROI

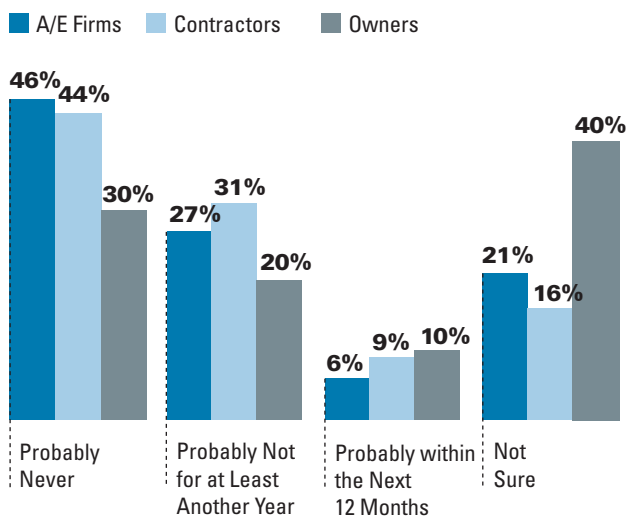
For the respondents that report using BIM for infrastructure projects but not measuring its ROI, a significant percentage are interested in measuring ROI eventually, but the data also demonstrate that they are unlikely to begin any time soon.

- Overall, 35% indicate they are likely to engage in formal measurement of ROI at some point in the future, and over 20% are not sure. This is similar to the responses in 2009 from firms using BIM for buildings, highlighting an industry-wide need that technology companies and industry organizations can address to help create more universally accepted methods for measurement.
- At just over 7%, those predicting they probably will begin formally measuring ROI within the next 12 months are the smallest group overall.

This low level of near-term commitment is likely due to the lack of well-established methods for measuring ROI, especially among A/E firms and contractors, where the practice is not widespread to begin with.

Measurement of ROI on BIM for Infrastructure Projects in the Future (Among those Not Measuring ROI)

Source: McGraw-Hill Construction, 2012



How to Improve ROI

For players that measure the ROI of BIM, the top two factors that can raise their perception of ROI are project-oriented benefits, not internally focused ones.

- At 66%, the leading factor is improved project process outcomes (such as fewer RFIs and field coordination problems). This represents an enlightened understanding that all participants benefit from smoother, more trouble-free projects. This was especially strongly felt by contractors (71%).
- Better multi-party communication, a close second at 63%, reflects the belief that the use of modeling can improve information exchange so effectively that each company will directly benefit.

These were also the top two factors selected by organizations using BIM for buildings in MHC's 2009 survey.

Six other factors considered the most important means of improving ROI by 30% to 52% of the respondents are project-based benefits, including reduced cycle time, lower project cost, positive impact of sustainability, increased prefabrication, faster plan approvals and permits, and improved job safety.

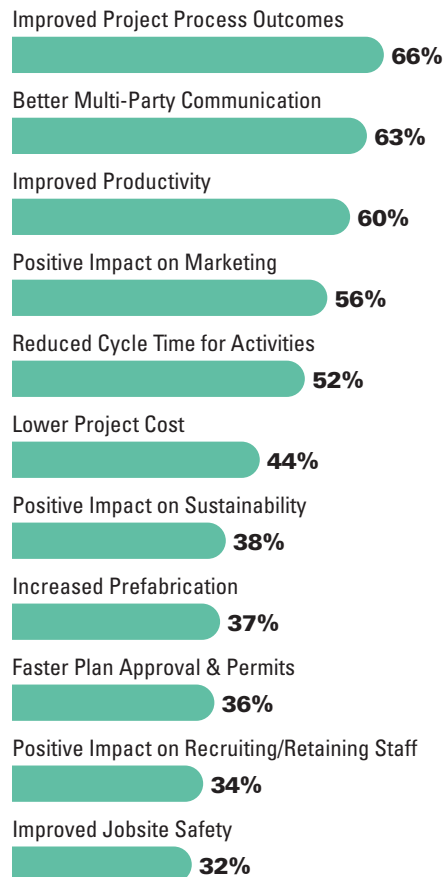
These findings support the conclusion that better project processes generate notable benefits for individual participants, benefits they believe are demonstrable in their ROI.

However, internally focused benefits are still important to the respondents, with improved productivity and positive impact on marketing scoring third and fourth in the ranking—at 60% and 56% respectively. In addition, one third find great value in the impact of BIM on recruiting and retaining staff.

Most Important Means of Improving ROI on BIM for Infrastructure Projects

(Among those Doing Formal Measurements)

Source: McGraw-Hill Construction, 2012



Green Infrastructure

38% of the firms that measure the ROI of BIM in infrastructure consider improved sustainability an important means to improve ROI. This result is consistent with rising industry interest in green infrastructure.

One major milestone for the pursuit of green infrastructure in the U.S. is the launch of the Institute for Sustainable Infrastructure's (ISI) Envision standard. This system is

the first in the U.S. to rate the sustainability level of all types of infrastructure across three dimensions: economic, social and environmental.

The Envision standard may have a broad reach since it is supported by leading infrastructure industry associations in the U.S. The founding organizations of the ISI are the American Society of Civil Engineers (ASCE), the American Council of

Engineering Companies (ACEC) and the American Public Works Association (APWA).

Government at all levels is also engaged in pursuing green infrastructure. Cities like Chicago and Philadelphia have launched major initiatives, and the federal government has begun to look at how to green the procurement of infrastructure across all agencies.

How to Improve the Value of BIM

The factors expected to improve the value of BIM by organizations that are using BIM for infrastructure but are not measuring ROI correlate with the benefits considered important by those that already measure the ROI of BIM.

- **63% of both groups cite better multi-party communication as being of high or very high importance, which indicates widespread support for the value of this collaborative project benefit.**
- **Internally focused benefits of positive impact on marketing (46%) and improved productivity (42%), rank in the top four for this group, but at distinctly lower percentages than with the group that measures ROI—56% and 60% respectively (see page 35).**

A major difference between those who measure BIM ROI and those who do not involves the level of importance assigned to improved project process outcomes. 43% of those that do not measure ROI assign top importance to this factor, versus 66% of those that do (see page 35).

The differential between the two groups again reinforces the trend found throughout the data that benefits that are more difficult to measure are less valued than those that can be more easily gauged. Thus, the respondents who measure ROI may be more willing to assign importance to elements that have established methods of measurement.

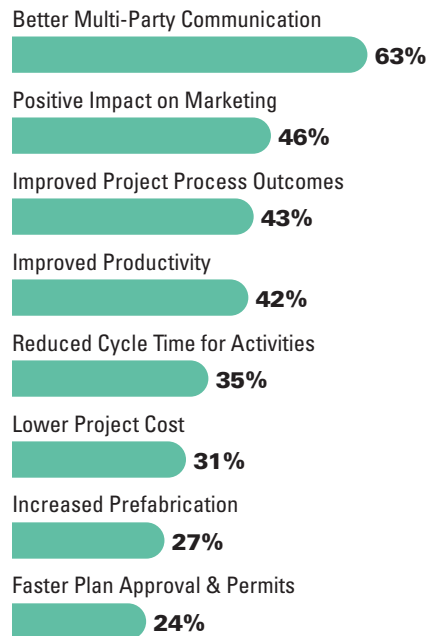
Comparison to BIM Users for Buildings in the 2009 Survey

The results of the importance of BIM benefits that improve ROI on building projects from MHC's 2009 *Business Value of BIM SmartMarket Report* were not divided between those who measure ROI and those who do not, but they still offer useful comparisons to the current results on the factors that can improve BIM's contribution to ROI on infrastructure projects.

The most striking differential is that the percentage who consider all of these factors important is significantly higher on all of the top measures, with the top five measures selected by over 70%. While the ROI benefits reported by BIM users for infrastructure in the current survey are a little stronger than those from the firms using it for buildings in 2009, there is less of a clear sense in the industry about how to continue to improve their ROI. This suggests an opportunity for further education and engagement, both by experienced BIM for infrastructure users and by software companies promoting BIM for infrastructure.

Factors Most Important to Overall Experience of Value from BIM on Infrastructure Projects (Among those Not Measuring ROI)

Source: McGraw-Hill Construction, 2012



Some interesting points of comparison include:

- **Better multi-party communication, improved project process outcomes and improved productivity are the top three factors contributing to BIM's value for buildings in 2009. These factors all clearly contribute to value regardless of project type and are central to what BIM offers its users.**
- **Positive impact on marketing ranks much higher in the overall infrastructure responses than in the building responses.**
- **Increased prefabrication ranks much lower in infrastructure, while 71% considered it important in 2009 to improve ROI on buildings. This may suggest that prefabrication companies in infrastructure need to promote the value of BIM use.**

Use of BIM on Water and Wastewater Facilities

Major design and construction firms are exploring ways to maximize models within the design-bid-build delivery system typical on water and wastewater projects. However, many see far greater benefits to using BIM in a more integrated environment. “We can model effectively on our own, but clearly BIM works best with a collaborative approach,” says John Bowen, national BIM integration manager at HDR Engineering.

Des Moines Combined Sewer Solids Separation Facility

HDR was selected by the Des Moines Wastewater Reclamation Authority for design services on a combined sewer solids separation facility in 2008. It was the authority’s first project designed in BIM. Bowen says the client was hesitant at first about the process, which involved ongoing model reviews—rather than printed documents—until around the 60% design stage.

“Early on, we showed them both 2D sketches and a 3D model and found that a few engineers couldn’t

read the 2D blueprints well, but they could read the 3D model,” he says. “They could visualize it better to tell us what changes were needed.”

Bowen says the team saved time by identifying conflicts early and being able to react quickly to changes. For example, when the design reached 90%, the team identified a change in the floodplain that resulted in a need to raise the facility by one foot. “We were able to update our construction documents and the model in less than 40 hours,” he says. “In 2D, we’d be talking 300 to 400 hours to do that.”

However, the BIM benefits ended after the design process since the contractor is not using BIM. Bowen says it is a function of the design-bid-build process that is common in public sector infrastructure work.

By comparison, on a biosolids processing facility for an industrial client in California, HDR is part of an integrated design-build team that is using BIM throughout design and construction. “We’ll see some savings on the design side, but the big savings will be in construction because of the amount of time saved,” he adds.

Arbennie Pritchett Water Reclamation Facility

Some public authorities are embracing an integrated BIM approach. The Okaloosa County Water and Sewer Department in Florida selected CDM Smith to design, construct, outfit, start up, performance test and obtain permits for the new 10 mgd Arbennie Pritchett Water Reclamation Facility. The team used BIM throughout the project lifecycle, including delivery of a model for operations and maintenance (O&M).

Through a design-build process, the team used BIM to help compress the design schedule to just over five months, reviewing models with the client throughout. The construction team was provided with an early start package generated from the model, which consisted of building foundations, plumbing and electrical underground utilities. This enabled the team to start site work 2.5 months before construction documents were complete.

The model was used to create bid packages for subcontractors, who also used it in the field to aid in construction and coordination efforts.

Upon completion, the model was connected to an electronic O&M system that helps manage data equipment, datasheets and manuals. It was also used for training staff at the new plant.

Although CDM makes effective use of BIM, William Nelson, senior vice president at CDM, says the technology has significant room for improvement. For example, he says, engineers do little to no analysis within its models, instead pulling data from the models, analyzing it and then re-inputting it.

CDM is also unable to do its process modeling, which simulates wastewater treatment behavior, within its models. “That is a major part of the puzzle that is missing,” he adds. ■



On the Arbennie Pritchett Water Reclamation Facility, CDM Smith connected its models to an O&M system that manages equipment, datasheets and manuals.

Use of BIM on Energy Projects

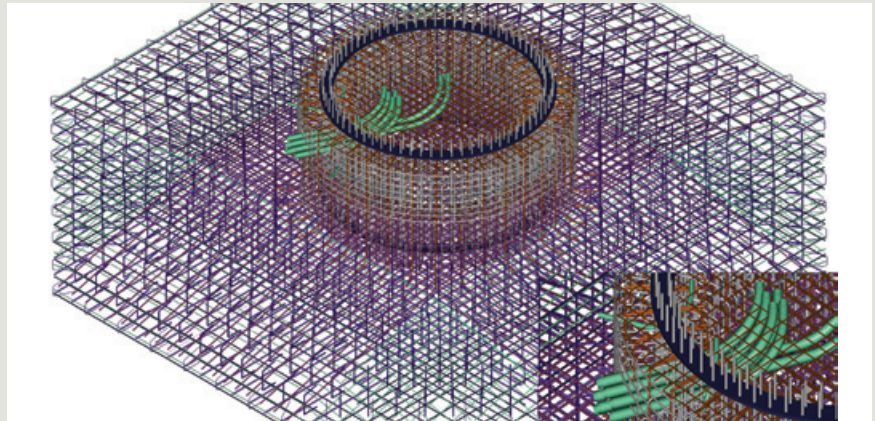
BIM is yielding powerful results on energy projects. Mortenson Construction, which was an early adopter of BIM in vertical building construction, extended that commitment into its Renewable Energy Group. “We wanted to push its limits to see what it could do,” says Sera Maloney, the group’s integrated construction manager.

Wind Farms

On its wind farm projects, Mortenson’s teams construct numerous turbines on vast sites that often have varying conditions. Heavy equipment and materials may need to cross small rural bridges, open streams or railroad tracks. Underground and overhead utilities must also be considered. Many farms are built on mountaintops, another challenge. “A blade transport truck could be up to 190 feet long with 19 axles,” she adds. “Driving that over a rural road will probably cause issues.”

Speed of construction is critical, as most farms must be delivered within one season, so Maloney says preplanning is where BIM offers the greatest benefit. The team investigates all site issues; considers where dirt needs to be moved; determines lay-down areas; and maps how equipment and materials will be moved around.

On one of its projects, about 70 towers were constructed on a U.S. Bureau of Land Management site. The team was given up to a three-acre radius per tower to work in. After modeling each stage of the process, Mortenson found it only needed to use two acres per tower. “On environmentally sensitive land, that’s a huge savings,” she adds.



Mortenson Construction uses BIM models to resolve potential conflicts between a wind tower’s electrical conduit and the structural rebar in its foundation.

Scheduling is a major component of its modeling effort. Deliveries must be carefully planned so that materials are placed in the right location and in the proper sequence. With solid planning, construction follows almost an assembly line process, as crews move from pad to pad, ideally in a near-repetitive pattern.

“We model every piece of the construction process,” she adds. “We have plan room computers located on each site, and the 4D schedule is used in our daily meetings.”

Models are also used for quantity takeoffs and systems coordination. For example, the electrical conduit for a tower, which can be 100 feet tall, typically conflicts with the significant structural rebar required in the foundations, she says.

Mortenson has also leveraged its preplanning modeling to create better proposals. “We won a recent project based on the modeling we did [as part of our proposal] because we showed that we knew the project better,” she says.

Electrical Substations

Some owners in the energy sector are also adding BIM to their workflow.

Engineers at Enmax Power Corporation, which owns and operates an electricity distribution and transmission network around Calgary, started modeling new substations in mid-2010.

“We build 3D models with intelligence,” says Lindsey Porteous, electrical construction planner at Enmax. “We create a single-line diagram of the substation that shows the equipment. Then, we can click on a device, such as a circuit breaker, and navigate to that on the 3D model of that station. You can click on it and get the part number, the manufacturer and the cost. You can also create accessory parts for each device, so you can include things like the connector bolts.”

Porteous says modeling saved time and reduced errors. The software automatically creates wiring diagrams, which he notes are prone to errors using traditional design methods. The team also generates bills of materials and estimates costs from its models.

Some suppliers provide his team with models of devices. “Instead of taking a week to build a model of a circuit breaker, it takes 10 minutes,” he adds. ■

Data: Non-Users

THE BUSINESS VALUE OF BIM FOR INFRASTRUCTURE DATA

Non-User Profile: Organization Type

54% of respondents report that they do not currently use BIM on infrastructure projects.

The player type data reveal a trend that runs through the non-user profile—exposure to BIM use on vertical projects increases the likelihood of using BIM for infrastructure as well.

Owners have the highest percentage of non-users (74%), probably due to the slower pace of BIM adoption in the infrastructure sector compared to the vertical (building) market. Infrastructure owners are less likely to do a large number of vertical projects that might expose them to using BIM. 14% of owners also indicate that they do not understand what BIM is, compared to only 2% of architects and 4% of engineers.

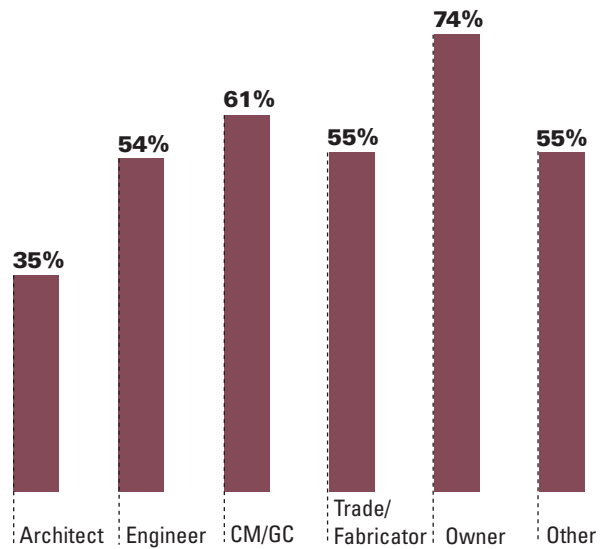
In contrast, architects have the lowest percentage of non-users (35%). Many architects may also practice in a variety of vertical project types. Thus, they are more likely to use BIM elsewhere in their firms and can apply the knowledge of its benefits to their infrastructure work.

The involvement of different types of engineers with BIM for infrastructure also supports this correlation:

- **Nearly two-thirds of MEP engineers (represented in the “Other Engineers” pie chart below) use BIM on infrastructure projects.**
- **Structural engineers are evenly divided.**
- **Two thirds of civil engineers are non-users. These engineers are less likely to be involved with vertical projects compared with the other disciplines.**

Non-User Profile: Company Type

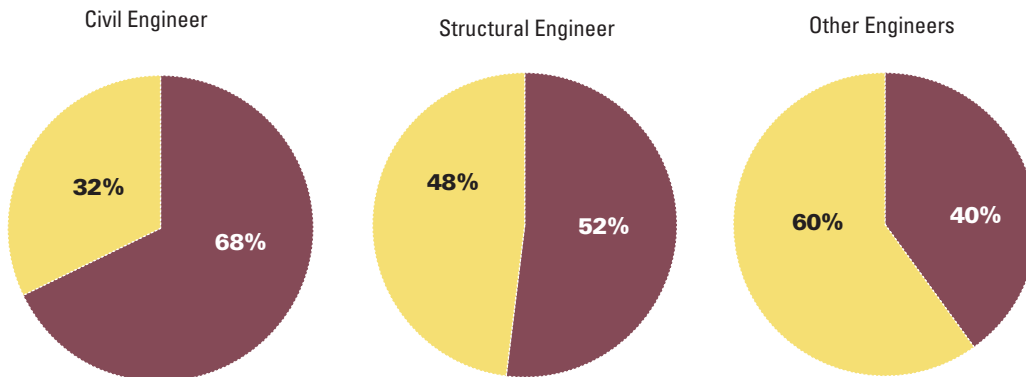
Source: McGraw-Hill Construction, 2012



Non-User Profile: Engineers by Discipline

Source: McGraw-Hill Construction, 2012

■ Users ■ Non-Users



Comments by Users:

Converting Non-Users to Adopt BIM for Infrastructure

Every organization currently using BIM on its infrastructure projects was, at some point, a non-user and made the transition to become a user. Although the specific triggers for how this happens at each organization are unique, there are three general paths to conversion.

Starting With Vertical BIM

In some cases the organization was already successfully engaged with BIM on its vertical work, then discovered some specific, tangible application of it to a unique aspect of an infrastructure project, and subsequently started the adoption process.

This happened with Sundt Construction of Tempe AZ, where president Doug Pruitt championed the firm's adoption of BIM in 2006 by forming an internal group called SIMCON, which provides BIM services to its project teams. From there its use grew steadily on Sundt's vertical projects, especially with the self-perform concrete group.

In 2009 the firm found the right opportunity to apply BIM to Phase II of a light rail project, the first phase of which Sundt had built conventionally. Coordination of underground utilities had been a major challenge on Phase I, and by modeling underground data from 700 locations on Phase II, they discovered over 1,000 issues that would have created field problems.

This successful proof-of-concept led to a more ambitious application of BIM involving laser scanning and modeling of dangerously deteriorating civil and structural conditions on a complex and time-critical bridge replacement. Establishing BIM's clear value in that instance, SIMCON placed a permanent BIM engineer in Sundt's self-performing heavy

civil group in 2010, where the firm continues to innovate in applying BIM technologies and processes to infrastructure projects.

Growing BIM Organically

Organizations that specialize in infrastructure typically have not had the chance to build BIM expertise on vertical work and have had to adopt BIM for infrastructure more organically.

Infrastructure engineering powerhouse Parsons Brinckerhoff (PB) provides an example of this approach, where some business units started leveraging 3D for visualization in the early 1990s, including detailed rebar models and computational fluid dynamics in addition to 3D representations of proposed dams, bridges and highways for client presentations. "Our culture at PB has always been very supportive of innovation," says Jay Mezher, manager of virtual design and construction in PB's New York City office and part of the global technology team of parent company Balfour Beatty, which has mandated an all-BIM policy by 2014. "Visualization of complex engineering solutions is so critical," he continues, "that at this point every group in PB is modeling."

Owner-Driven Adoption

Much infrastructure work is government related, and many organizations are brought into using

BIM by an owner requirement. This is taking place at all levels from local airport authorities, to state departments of transportation, to large federal agencies such as the U.S. Army Corps of Engineers. Robert Bank, Chief of the Civil Works Branch, Engineering & Construction of the Corps sees BIM as a fundamental part of the Corps' approach of "solutioneering, basically finding creative and collaborative solutions to problems. As the projects get more complex, our smart A/E industry partners are going to respond to the challenge."

It is most effective when an owner is committed to BIM from the very beginning of a project and will, as George Pontikes, CEO of contractor Satterfield & Pontikes, puts it, "drive the BIM train," ensuring that all team members understand the importance of compliance. Such committed owners are critical for driving industry-wide adoption. ■

Non-User Profile: Organization Size and Location

The size of an organization has a clear correlation with BIM usage for infrastructure projects. Of the organizations that are not using BIM for infrastructure projects, almost three quarters (73%) are small or small to medium sized. (Refer to Methodology on page 60 for organization size definitions.) Only 16% of the non-users are large organizations.

This may be due in part to the resources available for larger organizations that make the original investment in BIM technology and training more manageable. However, findings from the organizations that use BIM suggest that once small organizations adopt it, they more quickly achieve a high level of BIM implementation than larger organizations, demonstrating BIM’s applicability for these groups. (See page 13 for more information on BIM implementation by organization size.)

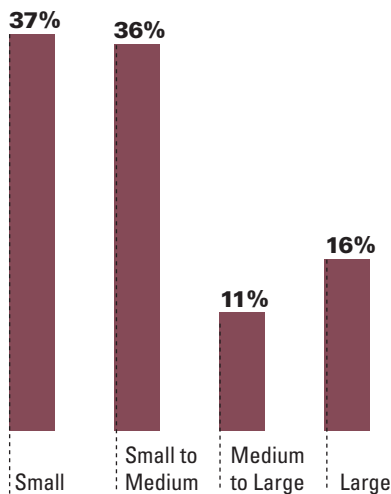
Variation by Region

An organization’s location within North America seems to influence whether they have adopted BIM for infrastructure.

- The highest percentage (30%) of non-users are located the Southern U.S.
- The Northeastern U.S. (17%) and Canada (9%) have the lowest percentages of non-users.

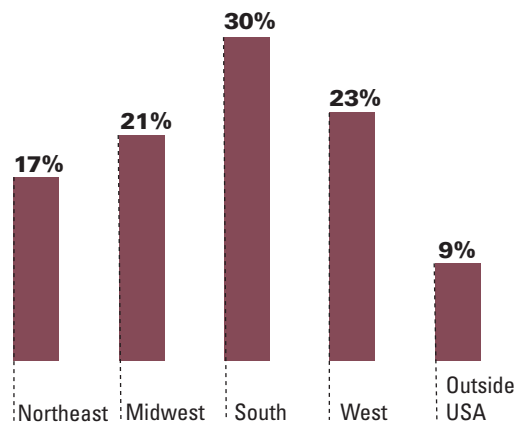
Non-User Profile: Organization Size

Source: McGraw-Hill Construction, 2012



Non-User Profile: Location

Source: McGraw-Hill Construction, 2012



Non-User Profile: Project Type

There are clear correlations between the types of infrastructure projects undertaken by organizations and the percentage of those organizations that have begun using BIM. Again, these results support the general trend that organizations that do a combination of infrastructure and vertical (building) construction are more likely to use BIM for infrastructure than organizations that do little vertical construction.

Water Projects

Projects involving water supply, treatment and recovery are the most commonly reported infrastructure project type. They are almost equally divided between users and non-users. Water treatment and recovery projects typically involve some minor building work in addition to horizontal infrastructure work.

Roads, Highways and Bridges

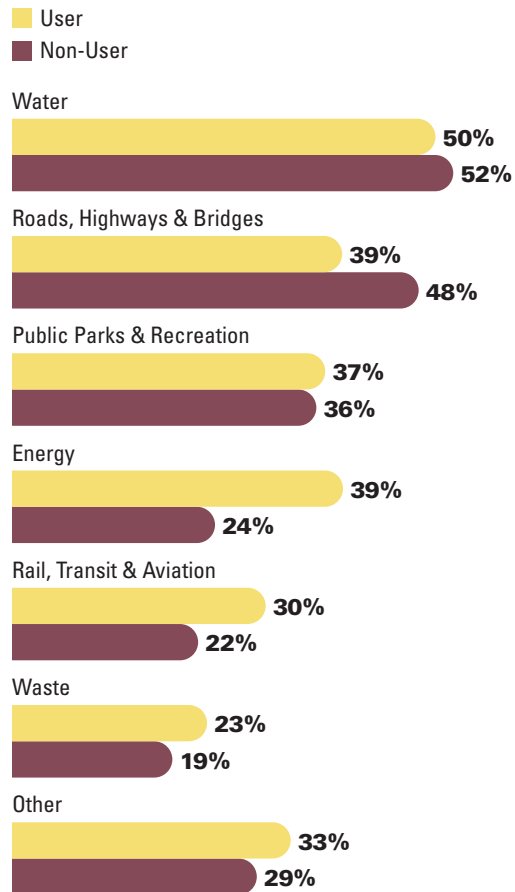
These projects were also done by a large percentage of respondents, but they have the greatest proportion of non-users. A/E firms and contractors that specialize in this type of construction typically do not do very much vertical work.

Other Project Types

Energy, aviation and rail/transit projects show the largest proportion of BIM users, and again, these projects are more typically handled by organizations that also do vertical construction.

Non-User Profile: Project Type

Source: McGraw-Hill Construction, 2012



Non-User Attitude Toward BIM for Infrastructure

Despite not currently using BIM for infrastructure, non-users' attitudes towards BIM are predominantly positive (79%). Firms that have rejected BIM after experience with comprise a very small fraction of the total (5% of A/E firms and 3% of contractors). A few more have not tried it and are just not interested in using it, but by far the majority indicate that they are interested in exploring BIM adoption in the future, with well over 10% currently in the process of actively evaluating it.

These results are roughly equivalent, if slightly less positive, than those of the non-users of BIM for buildings in MHC's 2009 *Business Value of BIM SmartMarket Report*, where almost one quarter of respondents were already evaluating it and 11% reported having no interest in using it. Infrastructure has historically been a very traditional segment of the construction industry, and slightly more skepticism is not surprising.

Variation by Player

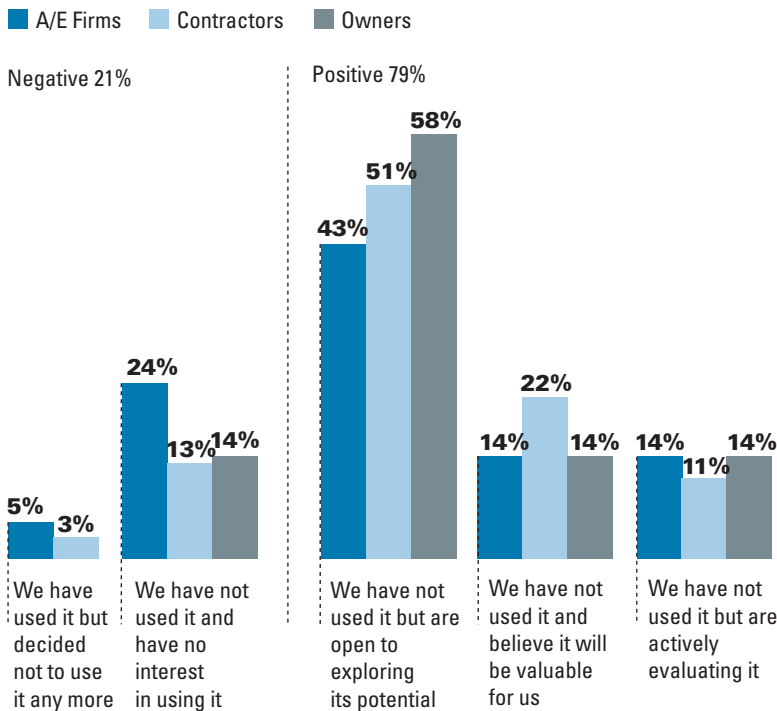
Among non-users, contractors and owners are the most engaged with the possibility of using BIM, with A/E firms comprising the largest percentage of non-users that are simply not interested in using it.

This may be because many of the top benefits reported by contractors and owners, such as reduced conflicts and changes during construction and prefabrication of larger, complex parts, are typically more tangible, measurable and visible than those enjoyed by A/E firms during the design phase, such as improved review and approval cycles.

Also, the majority of North American A/E firms are small, and their resource limitations may reduce their interest in adoption. This conclusion is supported by two of the top reasons that A/E firms cite for delaying adoption—the cost required and the view that BIM is less efficient for smaller projects (see page 48).

Non-User Attitude Toward BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



Non-User Forecast: Importance of BIM to the Infrastructure Industry in Five Years

The generally positive forecast of the importance of BIM to the infrastructure industry in five years by current non-users is another leading indicator of increased adoption of BIM for infrastructure projects. Only 4% of all non-users believe it will have no importance in five years. Even more promising, 25% believe it will have high or very high importance.

Even with this optimistic forecast, infrastructure respondents are more conservative than their building counterparts in the 2009 survey, where 81% expected BIM to be very important in the next five years. Again, this may be a cultural difference between infrastructure and building organizations.

Variation by Player

OWNERS

Owner non-users place the highest value on the importance of BIM in the future, with 43% of the owners indicating that BIM will have high or very high importance and 78% expecting it to have at least moderate importance.

The positive perception of the future importance of BIM for infrastructure by owner non-users signals an impending increase in demand from that sector, which will have a major impact on driving adoption by other players.

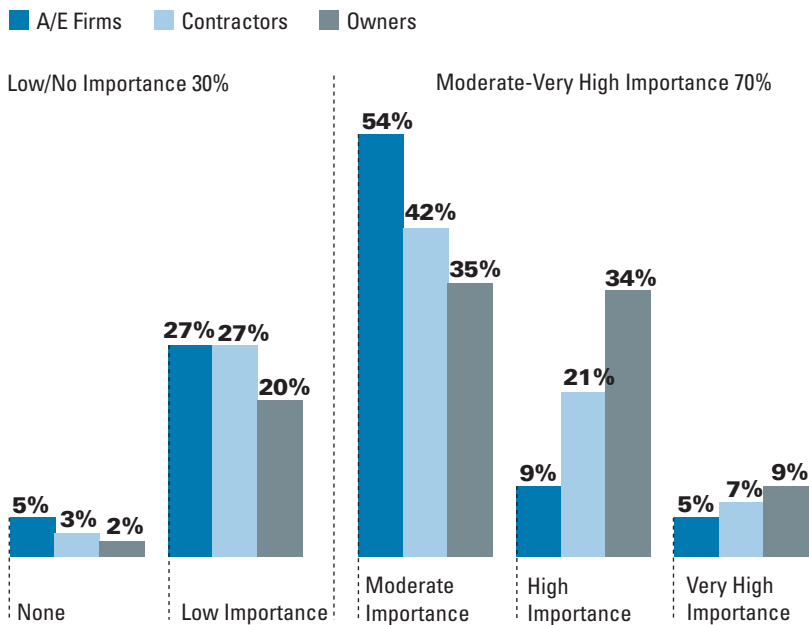
Other findings in this study bear out the importance of owner demand in increasing adoption, including the fact that nearly half of the A/E and contractor non-users believe that owner demand for BIM will drive non-user adoption, and that well over half of the A/E and contractor non-users (67% of A/E firms and 57% of contractors) believe that lack of demand is the biggest factor influencing the decision to not use BIM. (See pages 50 and 49 for more information.)

A/E FIRMS

In contrast, A/E firms appear to be the most skeptical of BIM's value for infrastructure. They represent the highest proportion of those who expect that BIM will have no or low importance and the lowest proportion of those who believe it will have high or very high importance.

Non-User Forecast: Importance of BIM to Infrastructure Industry in 5 Years

Source: McGraw-Hill Construction, 2012



AEC Perception: BIM Usage for Infrastructure by Competitors

When asked about their awareness of BIM usage in their markets, 71% of the A/E and contractor non-users indicate that they believe their competitors are using BIM. Strong perception of use by competitors could be a factor in the high level of interest in BIM adoption (see page 43 for the breakdown of non-users that express interest in BIM).

Even though most of these non-users believe BIM is being used by their competitors, they do not think that the level of implementation is very high. **Most non-users (55% on average) perceive that a low level (<15% of projects) of BIM use for infrastructure is taking place.**

These results are strikingly similar to the perception of competitor use of BIM for buildings reported in MHC's 2009 *Business Value of BIM SmartMarket Report*, with almost every category within a few percentage points of the 2009 non-users. This suggests that, despite their more conservative estimates about the importance of BIM, non-users may feel competitive pressure to begin exploring it, which will expose them to the benefits already reported by those using BIM for infrastructure.

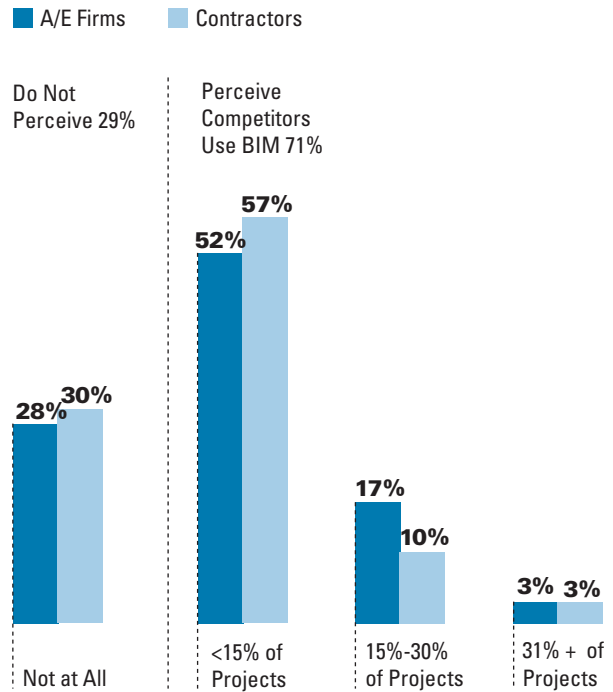
Variation by Player

While 28% of the A/E firms perceive no competitive BIM use, that percentage shrinks to 11% when considering architects alone. In addition, while the percentage is small (3%), architects are the only firm type that believes that competitors are using BIM on more than 30% of their projects. Given the higher adoption levels by A/E firms involved in infrastructure evident in this survey, this estimation is consistent with the industry.

In contrast, 37% of specialty contractors and 31% of engineers do not perceive any BIM use by their competitors, far more than the architect respondents.

Non-User Perception of Competitors' Use of BIM (A/E Firms and Contractors)

Source: McGraw-Hill Construction, 2012



AEC Perception: BIM Usage for Infrastructure by Clients

78% of A/E and contractor non-users believe that their clients use BIM. While the overall pattern echoes the perceptions of competitor use (see page 45), there are some important variations, both in the expectations of overall use and by firm type.

One critical difference is that client use is perceived to be more widespread and more intensive than competitor use.

- **A higher percentage of non-users believe that their clients are using BIM than believe that their competitors are.**
- **20% of non-users believe their clients are using BIM on more than 15% of their projects, compared to 16% who perceive a similarly high level of use among their competitors.**

These results are in striking contrast the level of client usage expected by non-users of BIM for buildings in the 2009 survey. Only 66% of them believed their clients were using BIM, and only 13% believed that the owners were using BIM on 15% or more of their projects. This suggests that in infrastructure, the expectation that owners are using BIM may be a more significant factor in BIM adoption rates than it was for buildings in 2009.

Variation by Player

Like their perception of competitor use, more speciality contractors and engineers believe that clients are using no BIM compared to architects. However, the percentage that think there is no use is much lower.

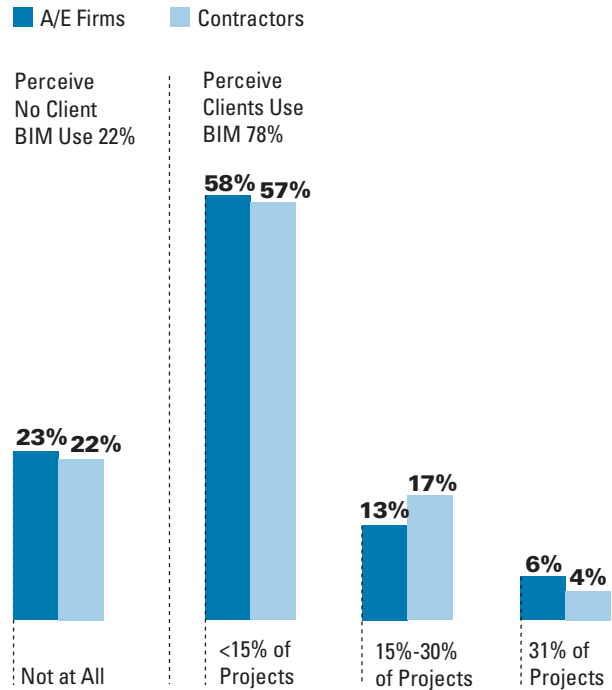
- **Engineers:** 23% perceive no BIM use by their clients, compared to 31% by their competitors.
- **Contractors:** 26% perceive no BIM use by their clients, compared to 37% by their competitors.

Only a small fraction (5%) of firms believe that clients are using BIM on more than 30% of their projects, a similar result to the evaluation of competitors' BIM use. However, in this case, the few non-users perceiving these high levels of BIM implementation include architects, engineers and contractors, whereas only architects perceived high implementation levels among their competitors.

The percentage of architects that expect a high level of implementation among their clients is also greater than those that have similar expectations of their competitors—11% compared to only 3%.

Non-User Perception of Clients' Use of BIM (A/E Firms and Contractors)

Source: McGraw-Hill Construction, 2012



Owner Perceptions of BIM Usage for Infrastructure

BIM Use by Design and Construction Firms

73% of non-user owners believe that A/E firms and contractors are using BIM. This is very similar to the estimation the non-user A/E firms and contractors have for BIM use for infrastructure among their competitors.

In addition, non-user owners perceive the levels of implementation comparable to those reported by the other player types.

- **54% believe that A/E firms and contractors use BIM on less than 15% of infrastructure projects.**
- **19% believe that A/E firms and contractors use BIM on 15% or more of infrastructure projects, with a very small percentage believing BIM use on more than 30% of projects.**

BIM Usage by Other Owners

Owners that do not use BIM for infrastructure are also similar in the estimation of the overall use of BIM by their peers to non-user A/E firms and contractor—23% perceive no BIM use by other owners.

On the other hand, the owners that do expect some level of BIM use in their peers perceive a much higher level of used compared to the perceptions of the other players—**35% believe that other owners are using BIM on 15% or more of their projects.**

The level of BIM use that infrastructure owners perceive among their peers is notably higher than the level of use that building owners perceived among their peers in the 2009 BIM study, in which only 23% believed that other owners were using BIM on 15% or more of their projects.

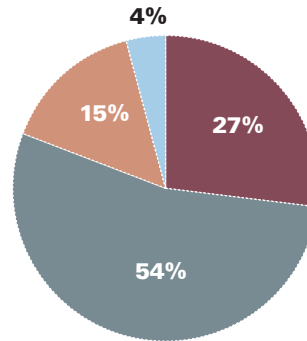
This more optimistic view of other owners' use of BIM is interesting, especially since owners currently are the lowest-usage group. The perception may stem from broad publicity related to comprehensive BIM programs being undertaken by large infrastructure owners such as the U.S. Army Corps of Engineers.

Perception of Industry Use of BIM (According to Owners)

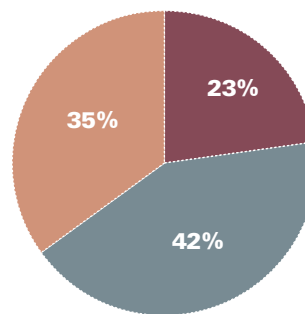
Source: McGraw-Hill Construction, 2012

- None
- Low (less than 15% of Projects)
- Medium (15%-30% of Projects)
- High (31% or More of Projects)

Perceived A/E Firm and Contractor Use of BIM



Perceived Use of BIM by Other Owners



Why BIM is Not Being Adopted for Infrastructure

All of the top five reasons for delaying the adoption of BIM for infrastructure were selected by over 40% of the non-user respondents. This demonstrates that several issues may need to be addressed to encourage non-users to begin using BIM.

The leading reason for delaying adoption among all three types of non-user respondents is the belief that it is less efficient for smaller projects. This correlates with the lower rate of adoption among small and small to medium sized organizations, whose projects would generally be smaller. (See the Methodology section on page 60 for a breakdown of the size of the participants.)

Variation by Player

A/E FIRMS

While important to all three groups, A/E firms are especially concerned about training time for BIM. This is not surprising considering that dedicated time for staff training is not generally as high a priority in A/E firms as in construction companies and owner organizations.

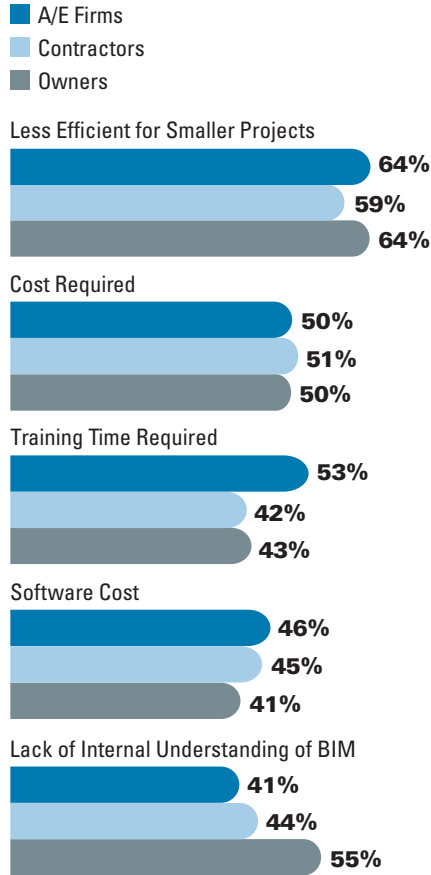
OWNERS

Owners find a lack of internal understanding of BIM to be the second most important reason to delay adoption, and significantly more of them are concerned about this issue compared to other players.

Given the critical role that owner adoption can play in encouraging the industry at large to adopt BIM, this finding indicates an important gap that software companies and industry organizations should address.

Top Reasons for Delaying the Adoption of BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



Factors Influencing Lack of BIM Adoption for Infrastructure

When non-users were asked to rate the importance of factors that impact their decisions not to use BIM for infrastructure projects, the overwhelmingly dominant influence against adoption for A/E firms and contractors is the lack of demand by customers. This is most keenly felt by A/E firms. This finding also echoes the findings of MHC's 2009 *SmartMarket Report* on BIM adoption for buildings, revealing the importance of owner influence in all project sectors to encourage BIM adoption.

The impact of most other influences varied by player type, which demonstrates the importance of targeting the approach for BIM adoption to specific players. However, a couple of categories have roughly equal impact across all respondents. Insufficient time to evaluate the adoption of BIM appears to be a problem for all involved. This indicates a need that software companies and industry organizations should address.

On the other hand, few of the respondents from all three players cite insurance or liability concerns as having an influence on their not adopting BIM for infrastructure.

Variation by Player

A/E FIRMS

- While the cost for both software and hardware is an important issue across the board, more A/E firms report it as important.
- More A/E firms, compared to other players, feel that BIM processes do not apply well to what they do and that their current methods are better. This probably relates directly to the concern among this group that BIM is less efficient for smaller projects.
- Because they are responsible for authoring design models and documents, more A/E firms are concerned about poor interoperability with CAD and the difficulty of using BIM compared to contractors or owners.

CONTRACTORS

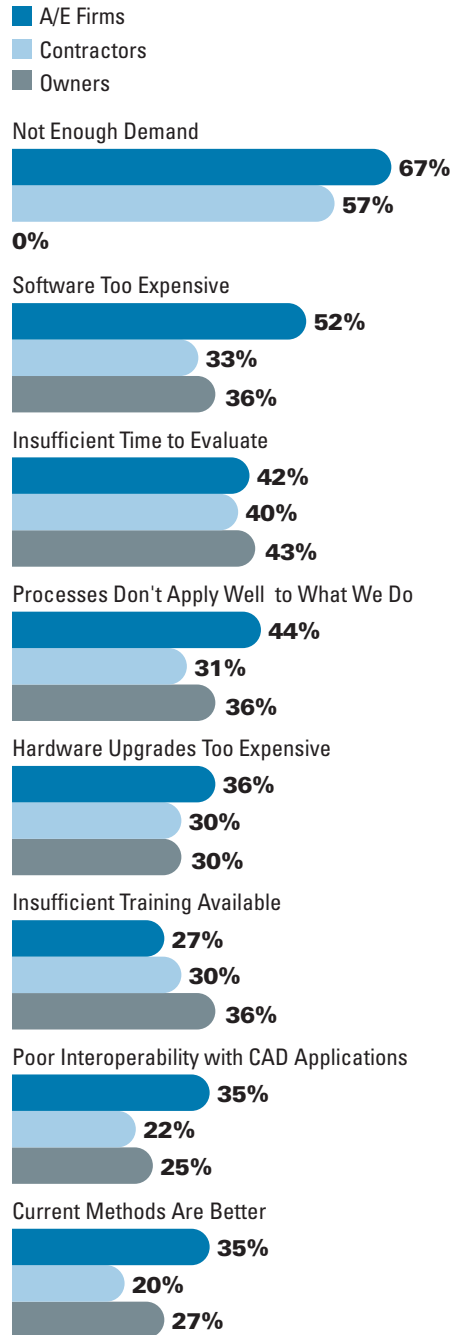
Contractors show the least concern with interoperability issues related to existing authoring tools.

OWNERS

Lack of sufficient training is a particular concern of owners (36%), which aligns with their reported lack of internal understanding of BIM.

Top Influences on the Decision to Not Use BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



Benefits that Would Encourage BIM Adoption for Infrastructure

Even more than the factors that prevent BIM adoption, the top factors that drive BIM adoption vary strongly by player type. This is due to the different ways that these organizations typically use BIM, and again strongly suggests that the approach to encouraging BIM adoption needs to vary strongly by player. In particular, the greatest differences are between owners and the other two groups.

More accurate construction documents and improved communications were considered important factors to drive non-user adoption for buildings in the 2009 BIM *SmartMarket Report*. However, reduced construction costs and schedule is selected as important by more infrastructure respondents in the current survey than building respondents in 2009.

Variation by Player

A/E FIRMS AND CONTRACTORS

Since not enough demand is the top reason influencing non-adoption among A/E firms and contractors, it is not surprising that they name owner demand as a top factor encouraging BIM adoption.

Another important benefit to these firm types is the ability to offer new services.

■ A/E Firms

A/E firms want proof that BIM will lead to less time drafting and more time designing.

■ Contractors

Contractors find the improved ability to do digital fabrication to be a compelling benefit. MHC's 2011 *Prefabrication and Modularization SmartMarket Report* revealed the importance of BIM to encourage prefabrication in vertical construction, and the same principle clearly applies in infrastructure for contractors.

OWNERS

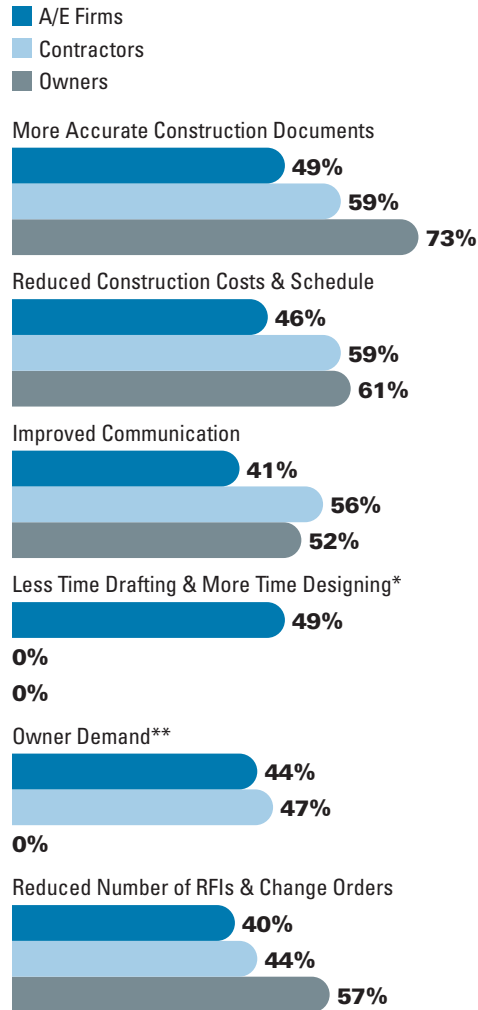
Owners feel most strongly about benefits that would accrue directly to projects, likely due to the fact that project outcomes are the main way that they measure performance.

- More Accurate Construction Documents: 73%
- Reduced Construction Cost and Schedule: 61%
- Reduced Number of RFIs and Change Orders: 57%

Owners are also interested in seeing evidence that BIM will improve operations and maintenance (O&M), as well as their ability to do sustainable construction. In

Top Factors That Can Drive Non-User Adoption of BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



* Asked of A/E Firms Only

** Asked of A/E Firms and Contractors Only

MHC's 2010 *Green BIM SmartMarket Report*, industry practitioners who use BIM for green projects reported significant benefits in conducting energy modeling and improving building performance, and they indicated the value that greater use of BIM to monitor building performance for greener O&M would provide.

Use of BIM on Park and Recreation Projects

Complex park projects, particularly those in urban areas, can face a myriad of civil, structural and hydrological challenges. As with vertical buildings, multiple overlapping systems create ample reasons for some designers and contractors to model park projects.

Scioto Riverfront

A \$44 million transformation of the Scioto Riverfront in Columbus, Ohio, into grand public spaces spurred the first use of BIM for underground modeling on a public project in Ohio. The five-acre project, which broke ground in 2009, features a promenade, a plaza, numerous green spaces and the 15,000 square foot signature Scioto Mile Fountain. The fountain features five stainless steel halos that reach up to 24 feet in height and support more than 1,000 nozzles. An additional 1,000 ground-level jets can propel water up to 70 feet in the air.

Due to the complexity of the fountain, the team chose to model the project's five miles of underground plumbing and electrical conduit. Piping was as large as 14 inches in diameter and was stacked up to 7 pipes deep.

"The fountain work was the most complicated part," says Jeff Ruschau, project executive at Messer Construction. "We didn't have any opportunities to make mistakes."

Seven different entities on the project, including the fountain contractor, were involved in modeling the site. The architect provided the team with DWG [drawing] files. Messer modeled some architectural features, structural, topography, some civil elements and the existing utilities in-house. The electrical contractor modeled its own elements, and the civil contractor modeled storm-sewer and water lines.

"We knew we had a one-time shot at this," Ruschau says. "We needed everyone to weigh in about everything going into the ground."

Large concrete and stone architectural features were built above much of the piping on the site. The granite was prefabricated and shipped to the site, so piping had to align perfectly with the nozzle openings. The stainless steel features were also in the model, including how they were bolted down.

Among the team's early discoveries was a 12-foot-wide by 7-foot-high stormwater outfall that would have interfered with the fountain's foundation and piping design.

Undulation on the site created challenges with grade changes. "We modeled the [topography] and found that some of the pipe came up into the frost line, so we had to move that," says Mike Kaiser, virtual construction modeler at Messer.

The team also held regular model reviews with the owner. "They were able to visualize the piping," Kaiser says. "They had concerns about access around the pumps and head clearance, which they were able to identify in the model."

Additional design changes were made to the fountains while the project was underway, which caused changes in the piping. "Without a model, it would have been a real challenge to figure out if we could accommodate these changes," Ruschau says.

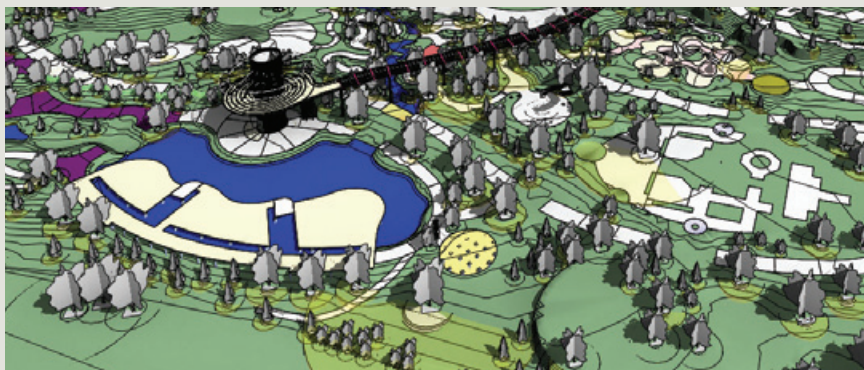
The coordination effort paid off. No underground rework was required. Kaiser estimates that between the model coordination and streamlined redesign process, the team saved roughly half the time that would have been required for those tasks on a traditional project. Overall, the project came in five months ahead of schedule and under budget.

The owner was also provided with a 3D model for future facilities management.

Rory Meyers Children's Adventure Garden

A myriad of potential underground conflicts led the team on the \$50 million Rory Meyers Children's Adventure Garden addition to the Dallas Arboretum to create detailed 3D models.

Subgrade utilities run throughout the seven-acre site, which is being topped with numerous landscape features that will require hundreds of piers. In



At the Dallas Arboretum, subgrade utilities, structural piers and setbacks around each of the park's hundreds of trees were modeled for coordination.

Use of BIM on Park and Recreation Projects

addition, crews have to be cautious because of the delicate root systems around the hundreds of trees on site.

The project, which was in planning for a decade, was designed in 2D. The Beck Group brought in Ikerd Consulting to model the site for coordination. "This was the most progressive use of BIM for a public park and recreation area we have seen," says Will Ikerd, principal of Ikerd Consulting.

Ikerd says the project's numerous man-made landscape features were "driven by the landscape architect's decisions, not the civil engineer, so all dimensional control was very artistic."

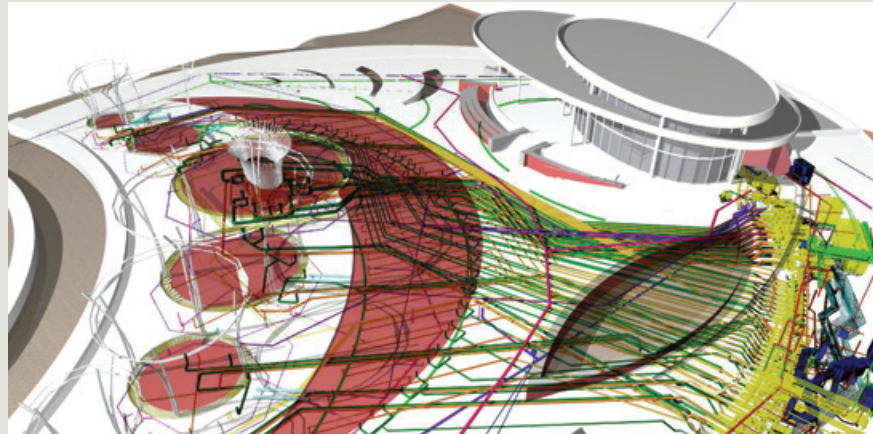
Because of construction sequencing, utilities were installed on the site first. The team then had to coordinate the existing and newly placed utilities with the landscape features. Ikerd modeled subgrade utilities and structural piers, as well as setbacks around each of the park's hundreds of trees, using data provided by the project arborist.

"The utilities and the structural piers supporting these landscape features are scattered throughout like a minefield," Ikerd says. "Based on the original design, we found several piers that were stabbing those utilities. Had [crew members] gone and drilled piers, they would have hit utilities that had been installed."

In addition to saving time and reducing errors through coordination, the team used BIM to help make critical value-engineering decisions. Ikerd says the model was set up for quantity takeoffs and that schedule could be tied to the model for look-aheads. "I don't know how this job could have been done effectively in 2D," he adds.

Saw Mill River

Modeling played a critical role in restoring public access to the Saw



Due to the complexity of the Scioto Mile Fountain, the project's five miles of underground plumbing and electrical conduit were modeled.

Mill River in Yonkers, New York. In the 1920s, the U.S. Army Corps of Engineers diverted the river, which was heavily polluted by local mills, into a flume that carried it under portions of the city. Officials recently restored the river, "daylighting" it and creating inviting public spaces around the city's Larkin Plaza.

However, the river experiences a wide range of water flows that could threaten to flood portions of the city once exposed. The river has a long-reach watershed upstream and tidal issues created downstream by the Hudson River.

"Understanding the flow regime through modeling was critical," says Joseph Fleming, executive vice president at design firm Paulus, Sokolowski & Sartor (PS&S). "Especially since this was not just a straight-line Corps of Engineers-type channel. We wanted to undulate this thing and give it some feel and some character."

The river was designed to curve gently through the plaza, featuring a new public park along its banks and a pedestrian bridge crossing. Adjacent water mains, sanitary sewer and

storm sewers were also improved as part of the project.

Through the model, Fleming says, PS&S was effectively able to carry out hydraulic and storm-water runoff analysis.

PS&S adjusted and validated the 100-year flood flows from 1,600 cubic feet per second [as previously estimated] to 2,000 cubic feet per second. Fleming says its analysis also ensured that the city wouldn't "overbuild" the system. "The city suggested raising everything by a foot," he adds. "By having accurate models, it gave us confidence in addressing the city's concerns. As a consultant, you can expect to be second guessed on every decision, so that added confidence helped us through the design process."

The team was able to test its analysis in a 100-year flood event when Hurricane Irene hit the state in 2011. "I was able to stand over and watch at the diversion chamber and see the force of this system pouring in," Fleming recalls. "Our assumptions proved out, and everything survived." ■

Data: Looking Ahead

BIM Value for Infrastructure Projects in the Future

Determining the most important drivers of value in the future is important since these drivers will encourage wider adoption, accelerate user implementation and ultimately establish BIM as the industry standard approach to infrastructure projects.

To determine these drivers, current users were asked to rate the importance of thirteen factors based on how much it will impact their organization's future ability to experience business benefits from BIM on infrastructure projects. Seven of the thirteen factors received high or very high ratings from at least half of the respondents.

The most important driver overall is more owners asking for BIM, with a total average of 64%. Interestingly, more owners (71%) rate this as important compared to other players. Owner adoption is clearly considered critical across the industry to drive more value.

In addition, a relatively comparable number of A/E firms, contractors and owners express a shared belief that the willingness of authorities having jurisdiction to accept models will increase BIM value.

Variation by Player

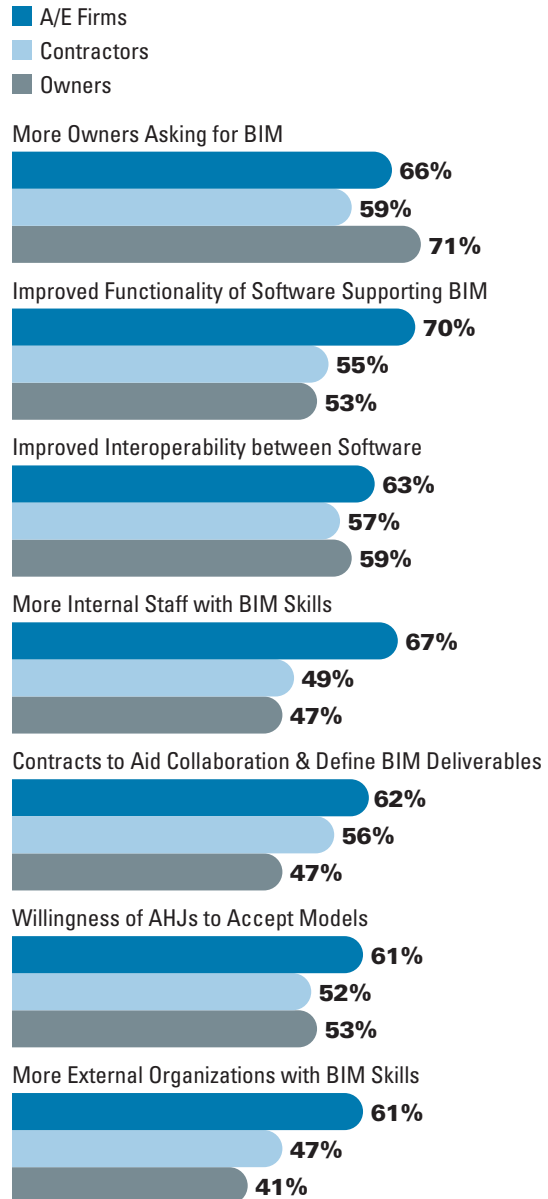
A/E FIRMS

A greater number of A/E firms (range of 60%–70%) consider six other top-rated factors important, compared to the number of owners or contractors reporting the same.

- **70% of A/E firms rate improved functionality of software supporting BIM to be an important factor increasing BIM value. This correlates with their focus on authoring and analyzing models.**
- **Over two thirds (67%) highly value having more internal staff with BIM skills as a way to increase BIM's value for infrastructure. Less than half of the other respondents rate this as being important, again reflecting A/E firms' need to generate models.**
- **63% find improved interoperability between software programs to be highly important. The relatively comparable number of other players reporting the same reflects an industry-wide need.**
- **67% of A/E firms assign value to more external organizations with BIM skills, significantly higher than the other players. This reinforces the importance A/E firms place on working with BIM-knowledgeable firms (see page 26).**

Most Important Factors for Increasing BIM Value on Infrastructure Projects

Source: McGraw-Hill Construction, 2012



OWNERS

Only 47% of owners forecast high impact from improving contracts to aid collaboration and define BIM deliverables, which is surprising given the importance of team formation for owners.

Where Help Is Needed

When current users were asked to identify the areas where they need help in order to increase their implementation of BIM for infrastructure, a significant number request help with all the issues raised. This finding loudly signals the need for industry-wide education, targeted consulting services, broadly accepted standards for practices and procedures, and active involvement by the full range of professional associations that serve our industry.

Several individual issues were also considered important by respondents.

- The need for assistance with issues related to software interoperability garnered the most unanimity among all players.
- Challenges related to project management on work that involves BIM also attracted roughly equal proportions of the three players, highlighting an opportunity for industry associations to meet a broadly held need.

Variation by Player

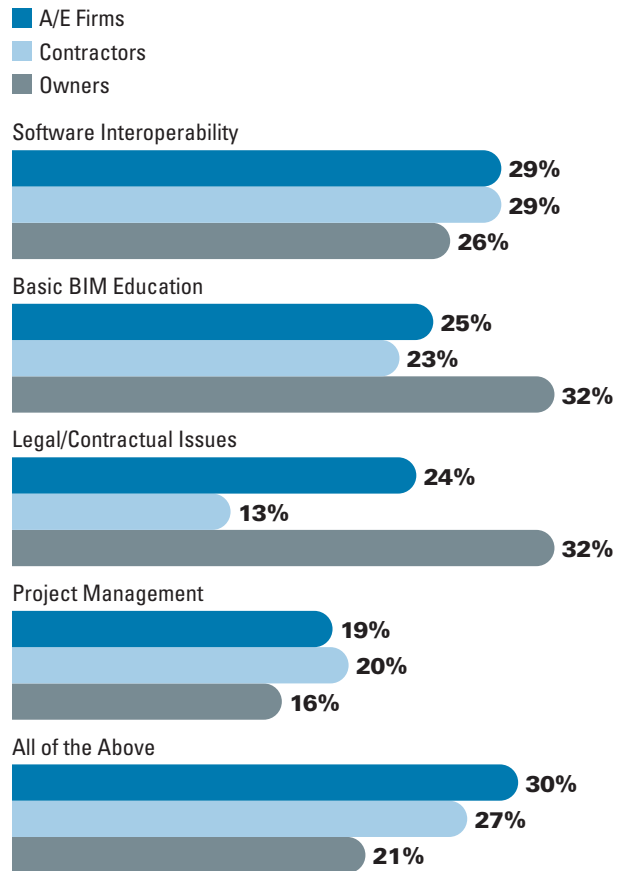
OWNERS

Owners are most concerned with basic BIM education, reinforcing the finding reported previously that the lack of internal understanding of BIM is a top reason that non-users in this group are delaying adoption (see page 48 for more information).

Although relatively fewer owners ascribe future importance to contracts to aid collaboration and define BIM deliverables when predicting drivers of BIM value in the future (see page 53), one third report the need for help with legal/contractual issues. This may indicate a belief that if these issues can be ironed out in the near term, they will exert less influence in the future.

Areas Requiring Assistance in Implementing BIM for Infrastructure

Source: McGraw-Hill Construction, 2012



Interview: Thought Leaders



Robert A. Bank, P.E., F.ASCE
The Owner Perspective on BIM Infrastructure

**Chief, Civil Works Branch, Engineering & Construction,
U.S. Army Corps of Engineers**

Bob Bank is responsible for policy development and supervision of agency technical leaders and communities of practice in the broad disciplines related to civil works in USACE, engineering and construction information technology (IT) systems, and life-safety programs.

BIM adoption for infrastructure lags behind adoption on vertical building projects. What's your perspective on that?

BANK: I think that a lot of it is perception. People see buildings as complex systems where BIM is helpful because of advanced mechanical, structural, energy analysis and architecture tools. Those tools have been out there so people associate that with BIM. But I think infrastructure BIM is getting there, and as people continue to see how BIM improves vertical construction, I think it's going to keep expanding into horizontal construction. We have to do it with small steps, keeping it simple and getting people to make incremental moves in that direction.

Are there benefits of BIM that are unique to infrastructure projects?

BANK: Absolutely. The main reason BIM has caught on for buildings is because of systems. Well, infrastructure is systems also. The real opportunity is how infrastructure is closely linked and connected to

“Several years ago, when we talked about BIM, everyone would say, ‘How much does it cost?’ And now, it’s: ‘How much does it cost to not use BIM?’”

the natural environment, which is constantly changing. Infrastructure is getting more and more complex to adapt to those changes. More complex tools can integrate all the information and data analysis, to better design, better plan and better operate these projects.

What are the unique cultural issues related to using BIM on infrastructure work?

BANK: One of the challenges today is attracting kids to engineering, so we need to keep engineering fun and relevant. Younger people were raised on video games incorporating virtual reality, basically virtual walk-throughs of scenarios, towns and buildings. So kids can relate to horizontal construction and BIM; they're already there. The cultural shift is for the older folks. We need to partner older, more experienced engineers and technical people with younger technology-savvy people who can adopt those technologies more quickly and be comfortable in them. That's one of the big cultural opportunities that we have.

How do you get companies on a project team to use BIM in the ways that you want them to?

BANK: We first created [models] for a series of standard facilities in our military transformation program by having a contractual requirement for BIM deliverables. Several years ago, when we talked about BIM, everyone would say, “How much does it cost?” And now, it's “How much does it cost to not use BIM?” The Corps already pushed a little bit by having some specific requirements. Now some companies have caught on.

What are your thoughts about the future of BIM for infrastructure?

BANK: GIS [geographic information systems] and BIM linked together. We do a lot of environmental analysis of conditions in the field which is GIS-based and need to pull that together into an integrated design. Also [we are incorporating] real-time data from monitoring sensors linked to our operating projects. We are prioritizing our repair investments by risk. We're doing that on our dam safety program, analyzing which projects present the most risk to public safety, and dealing with those first. Einstein said that we cannot solve today's problems at the same level of thinking as when we created them. That's really what this is about. ■

Interview: Thought Leaders



Richard Humphrey, ASCE, LEED AP
The Technology Industry Perspective

**Director, Industry Strategy & Development
Engineering, Natural Resources & Infrastructure Industry (ENI)
Autodesk, Inc.**

Richard Humphrey has worked with leaders in the building and infrastructure industries to drive sustainable design, technology innovation and BIM. He is responsible for directing and driving the success of Autodesk's business in the transportation, land, water, oil and gas, mining, engineering and heavy construction segments.

BIM adoption for infrastructure lags behind adoption on vertical building projects. What's your perspective on that?

HUMPHREY: There's a lot of evangelism around BIM with building information modeling, so it took a while for the rest of the AEC industry, particularly infrastructure and engineering, to realize BIM wasn't just in the context of buildings. They started to understand that it was a process and that they can leverage the learning from the building industry and the success that happened there. That's why we see adoption really accelerating now.

Are there benefits of BIM that are unique to infrastructure projects?

HUMPHREY: They're very, very large, complex public projects. Owners and consultants have a significant challenge to get through the public approval process and engage the public more. We see BIM as a great process to help do this. One of the outputs is realistic

"Once (engineers) start getting used to the new methods, new tools and processes, then the question is, 'How come you didn't give this to me sooner?'"

3D visualization. [That visualization] conveys the design intent of the infrastructure asset in the context of the real world in a much different way than reviewing construction plans, which I would say nine out of 10 people really don't understand. That's huge.

What are the unique cultural issues related to using BIM on infrastructure work?

HUMPHREY: BIM does require a new way of thinking. In the past, a civil road designer just carried out the alignment in the road design. When he got to a bridge, he just let the bridge designer do their thing. It would be more beneficial to have the bridge engineer, the civil, geotech and utilities people all working together along the same database. Once the rest of the organization sees the success and the benefits [of BIM], then it becomes viral and everyone wants to leverage the technology instead of complaining that you're trying to make them do something new. Once they start getting used to the new methods, new tools and processes, then the question is, "How come you didn't give this to me sooner?"

How do you see the industry adopting BIM for infrastructure?

HUMPHREY: You're seeing pockets of acceptance and mandates of BIM policies, and I think that's going to accelerate. There's a lot of awareness around BIM as a potential tool and process to ensure that the predictability and risk is well understood for large projects. So I would say that you're probably going to see some policy setting that includes BIM process or BIM deliverables in the infrastructure space. You're already seeing it at the state and local agency level, whether it's Caltrans [California Department of Transportation], Wisconsin [Department of Transportation] or other state agencies that are beginning to adopt BIM.

What are your thoughts about the future of BIM for infrastructure?

HUMPHREY: A lot of the work that happens in the industry is out in the field. The more we can leverage technology to bring field-mobility-type tools to the industry, the better off we can be. We also need to attract new engineers by putting engineering back into a real-world context through technology. ■

Interview: Thought Leaders



Dana Kennish "Deke" Smith, FAIA
The Industry Association Perspective
on BIM Infrastructure

**Executive Director, Building Seismic Safety Council and
buildingSMART alliance, National Institute of Building Sciences**

Deke Smith was instrumental in the beginnings of the NIBS Construction Criteria Base, now the Whole Building Design Guide (WBDG).

BIM adoption for infrastructure is behind adoption on vertical building projects. What's your perspective on that?

SMITH: I think the name, building information modeling, has been a big issue. People who are into virtual design and construction—VDC—don't even identify with BIM. We spent a lot of time early in the whole process trying to decide if there was a better name, but there was enough groundswell with the use of the word BIM that it is probably easier to go with it and let people know that it has greater meaning than just buildings. There are all kinds of words that you can substitute for [the] B [Building] to include all the different pieces that we see going into BIM.

Are there benefits of BIM that are unique to infrastructure projects?

SMITH: A lot of the benefits of BIM for buildings are also true with infrastructure. I think the bigger issue is that we haven't taken advantage of a lot of them yet in any project type. We're still so much in the infancy of this whole effort that most people probably really haven't grasped the full opportunity that's out there.

"...the growing relationship between GIS and BIM will help civil engineers to get engaged because GIS is already widely accepted with the infrastructure side of the community ."

What are the unique cultural issues related to using BIM on infrastructure work?

SMITH: It is very much a cultural change issue. I remember the transition to CAD and how significant the impact was. It was really only automating an existing process, drafting, and only affected design, but you would have thought we were changing the world! BIM affects every aspect of the industry and every practitioner. It's more disruptive than CAD ever was, but I'm not sure that most people recognize that BIM even applies to infrastructure yet. This report should help that, but a lot of culture change still has to occur.

What do you think is the key to driving BIM adoption?

SMITH: Education. How do we gear the next generation to come out and really hit the ground at full speed? At the buildingSMART alliance we've been focusing on colleges and universities. Last year we had 25 at our event talking about how they're changing the curriculum to teach BIM. But we can't just keep putting more courses into the curriculum;

we have to come up with a whole new way of teaching. We also are working with TAP [Technology in Architectural Practice] on the AIA [American Institute of Architects] side, with AGC [the Associated General Contractors of America] and with IFMA [the International Facility Management Association] trying to put together some programs.

What are your thoughts about the future of BIM for infrastructure?

SMITH: IFCs [Industry Foundation Classes] have come of age—that is our future. IFC for infrastructure is a huge step in the right direction. It started with CSTB [the Computer Science and Telecommunications Board] in France and we're building on what was already done. IFCs enable Open BIM, which is about how the vendors can all work together in order for us to have basic interoperability. Also, the growing relationship between GIS [geographic information system] and BIM will help civil engineers to get engaged because GIS is already widely accepted with the infrastructure side of the community. ■

Interview: Thought Leaders



Cory Dippold

The Engineer Perspective on BIM Infrastructure

Professional Engineer and Associate, Hatch Mott MacDonald

Cory Dippold has over ten years of structural design and project management experience. At HMM, he championed the implementation of BIM technology, and he now serves as the BIM director for their North American operations.

BIM adoption for infrastructure lags behind adoption on vertical building projects. What's your perspective on that?

DIPPOLD: BIM as most people think of it was originally conceived around the architectural field as a more effective and collaborative way to produce project data for new architectural projects. The building environment is a finite world that computers deal with very well. Working with existing conditions on infrastructure projects, there's a lot of interpolation that goes on. You can set the center line elevation and crossfall for a new road, but at some point you need to tie it into infrastructure that already exists and work around things like utilities or pipes in your way. That's hard for a computer to understand. That interpolation or "fiddle factor," which is traditionally handled in the field, is something we need to work through as an industry.

Are there benefits of BIM that are unique to infrastructure projects?

DIPPOLD: Definitely. Water infrastructure is a good example because there are a lot of finite aspects

"...we don't look at BIM as a 3-D model. We look at BIM as the future of our project delivery protocol... We intend to deliver digital models and stand behind the data."

to it. We built an internal content library of all the pipes, fittings, valves, pumps and equipment that we need, to design any wet infrastructure, and the benefits we're receiving are enormous. Now our process engineers, structural engineers and designers are in the same room working on the same model, and we can lay out a complete facility, with better tolerances on lay lengths and fittings, much more quickly and accurately than ever before.

What are the unique cultural issues related to using BIM on infrastructure work?

DIPPOLD: The cultural challenges are probably the most significant part of moving from a traditional project delivery approach to a BIM project delivery approach. And to be clear, we don't look at BIM as a 3D model. We look at BIM as the future of our project delivery protocol. It's not "Let's build a model and create a drawing." It is about using this integrated technology to combine our analytical systems with our production systems, with our project context evaluation, with our reporting systems, with our risk identification and beyond. Getting people to work in that integrated environment can be a challenge, but we're finding that our younger staff

are rapidly picking it up.

How do you get other firms on a project team to use BIM in the ways that you want them to?

DIPPOLD: Right now firms have widely varying degrees of proficiency across project types. One might be extremely proficient in tunneling BIM work, but have no ability to do bridge work. We are trying to do our due diligence up front to make sure we partner with compatible firms on a given project that can actively engage with us and add value to the team.

What are your thoughts about the future of BIM for infrastructure?

DIPPOLD: The concept of the drawing—as we've come to know it—is going the way of the dodo. It is only a matter of time. On some of our design-build highway work, we don't deliver drawings to the contractor; they simply prefer electronic deliverables. We still make record drawings for the owner, but I see the trend of model deliverables getting stronger. We intend to deliver digital models and stand behind the data. Although infrastructure lags behind commercial work, it is absolutely coming. ■

Interview: Thought Leaders



Joseph H. Jarboe

The General Contractor Perspective
on BIM Infrastructure

**President, AGC of America and
Senior Vice President, Clark Construction Group LLC**

Joe Jarboe has been with Clark since 1982. He has headed corporate estimating/preconstruction activities and evaluated potential opportunities nationwide for more than 20 years.

BIM adoption for infrastructure is behind adoption on vertical building projects. What's your perspective on that?

JARBOE: It's a somewhat natural progression. With buildings, some of the biggest benefits are clash detection and spatial coordination of very complex systems in close proximity to each other, which are very difficult to accurately coordinate with traditional 2D drawings. This gave a lot of people very early incentive to begin using BIM to avoid problems. Then mechanical and structural subcontractors found they could fabricate directly from the model, which improved their quality and cost. It also expedited the schedule. And now we have CIM, civil information modeling.

Are there benefits of BIM that are unique to infrastructure projects?

JARBOE: Yes, there are several, actually. CIM offers many of the same conflict identification attributes, such as identifying and resolving utility conflicts or other unknown underground conditions. These are important because they have a significant impact on traffic movements helping resolve issues once construction has begun. It's

"One issue that has to be dealt with is the willingness of the owners and designers to share their electronic designs."

also useful information downstream for both quantity analysis and work sequencing. And once you have that, uploading that data into your field equipment will lend itself to GPS surveying and automated machine data systems to increase your field efficiency and reduce potential safety issues.

What are the unique cultural issues related to using BIM on infrastructure work?

JARBOE: One issue that has to be dealt with is the willingness of the owners and designers to share their electronic designs. Liability concerns are the biggest impediment in this area. We went through that on the building side too, but it's an issue that needs to be resolved. Also, contracts are design-bid-build in many of these types of projects, and they really haven't started to use alternative procurement. There hasn't been the incentive yet. These are cultural changes on the procurement side. Once you do that, and people start to use it and see the benefit of it, they'll become adopters.

How do you get other companies on a project team to use BIM in the ways that you want them to?

JARBOE: It's a bit simpler on the civil side because you don't have as

many trade contractors. You've got a lot of self-perform people who do all of their own work with their own equipment. It's not like the building side where a significant portion is subcontracted.

What are your thoughts about the future of BIM for infrastructure?

JARBOE: I'll give you an example. A contractor I know is using state-standard details they've entered into their computer. When a job requires a retaining wall, they draw two dots and a straight line, and the computer generates that wall based on the design criteria and the state standard details. They add in the grades, and it makes the wall smaller or larger, whatever is required. It also generates all the quantities. The same thing is true with trenching. There's also modeling of bridges where you locate the post-tension strands and elevations for your embeds. In all these areas, things will really start to speed up. ■

Methodology:

Infrastructure Building Information Modeling Research

McGraw-Hill Construction (MHC) conducted the 2011 Infrastructure Building Information Modeling Study to assess the overall incidence of the use of BIM on infrastructure projects and gauge the value that organizations perceive they are receiving by implementing BIM on such projects. The research was conducted through an Internet survey industry professionals between October 25 and November 22, 2011. The 466 respondents sample size benchmarks at a 95% confidence interval with a margin of error of less than 5%.

The sample for the study was provided by five associations plus players in MHC's proprietary databases. The respondents were screened based on their involvement in infrastructure projects. All respondents were required to have worked on infrastructure projects

in the past year to be considered valid.

The following are the types of infrastructure projects conducted by the respondents, by the percentage of responses for each type:

- Roads and Bridges: 24%
- Water (Drinking/Waste/Stormwater): 21%
- Other Transportation (Aviation, Rail, Transit): 17%
- Public Parks and Recreation: 10%
- Energy: 9%
- Dams, Levees, Inland Waterways: 8%
- Hazardous/Solid Waste: 7%
- Other: 4%

In the data analysis, respondents are classified as BIM users or non-users based on their use of BIM on infrastructure projects.

- Non-Users: State that they are "not using BIM" or "don't understand BIM."
- Users: State that they are "creating models," "using but not creating models," or "creating and analyzing models."

In the analysis, the respondents were grouped into three categories:

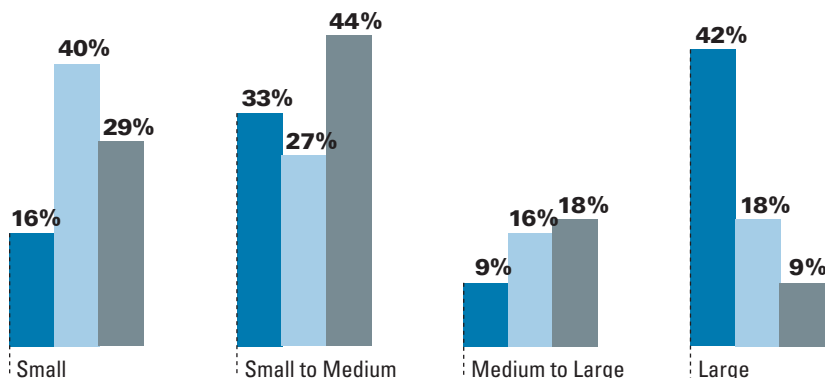
- A/E Firms: All respondents who work at architecture, engineering or A/E firms (Note that at times responses from architects and engineers are analyzed individually.)
- Contractors: Construction managers, general contractors, speciality contractors and fabricators
- Owners: Owners and all remaining respondents, such as consultants and educators ■

Distribution by Size of Organization

Source: McGraw-Hill Construction, 2012

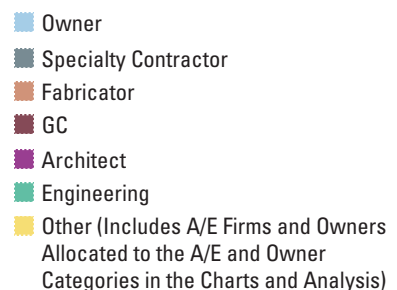
Organization Size	A/E Firm Billings	Contractor/Owner Organization Revenue
Small Organization	< \$500,000	< \$25 Million
Small to Medium	\$500,000 to < \$5 Million	\$25 Million to < \$100 Million
Medium to Large	\$5 Million to < \$10 Million	\$100 Million to < \$500 Million
Large Organization	\$10 Million and Over	\$500 Million and Over

■ A/E ■ Contractors ■ Owners



Respondents by Firm Type

Source: McGraw-Hill Construction, 2012



Resources

Organizations, websites and publications that can help you get smarter about using BIM for infrastructure projects.

McGraw Hill CONSTRUCTION

McGraw Hill Construction

Main Website: construction.com

Research & Analytics:

construction.com/market_research

Engineering News-Record: enr.com

Architectural Record: archrecord.com

GreenSource: greensourcemag.com

Sweets: sweets.com

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We would also like to thank Jay Mezher of Parsons Brinckerhoff and Eric Cylwik of Sundt Construction for their insight and expertise. We appreciate the participation of Robert Bank of U.S. Army Corps of Engineers; Cory Dippold of Hatch Mott MacDonald; Richard Humphrey of Autodesk; Joseph Jarboe of Clark Construction; and Deke Smith of the National Institute of Building Sciences who agreed to be interviewed and offered their insights. Finally, we would also like to thank the firms that provided information about their infrastructure projects and use of BIM in the case studies, as well as for their assistance in helping us secure images to supplement their project information.

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American Society of Civil Engineers (ASCE)

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Partners

buildingSMART Alliance: buildingsmartalliance.org

American Institute of Steel Construction: aisc.org

American Road & Transportation

Builders Association: artba.org

Design-Build Institute of America: dbia.org

American Public Works Association: apwa.net

Other Resources

Associated Builders & Contractors: abc.org

The Associated General Contractors
of America: agc.org

Construction Users Roundtable: curt.org

BIMForum: bimforum.org

Lean Construction Forum: agcleanforum.org

Lean Construction Institute: leanconstruction.org

National Institute of Building Sciences: nibs.org

U.S. Army Corps of Engineers: www.usace.army.mil

U.S. Department of Transportation Federal

Highway Administration: fhwa.dot.gov

■ Design and Construction Intelligence

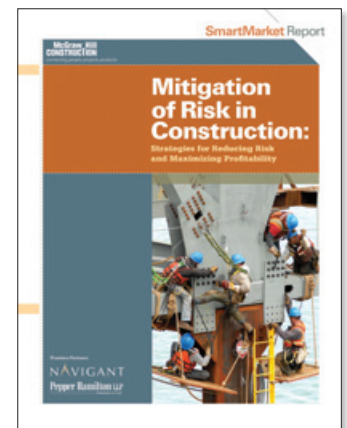
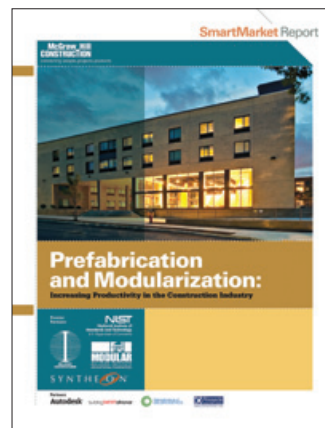
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