SmartMarket Report

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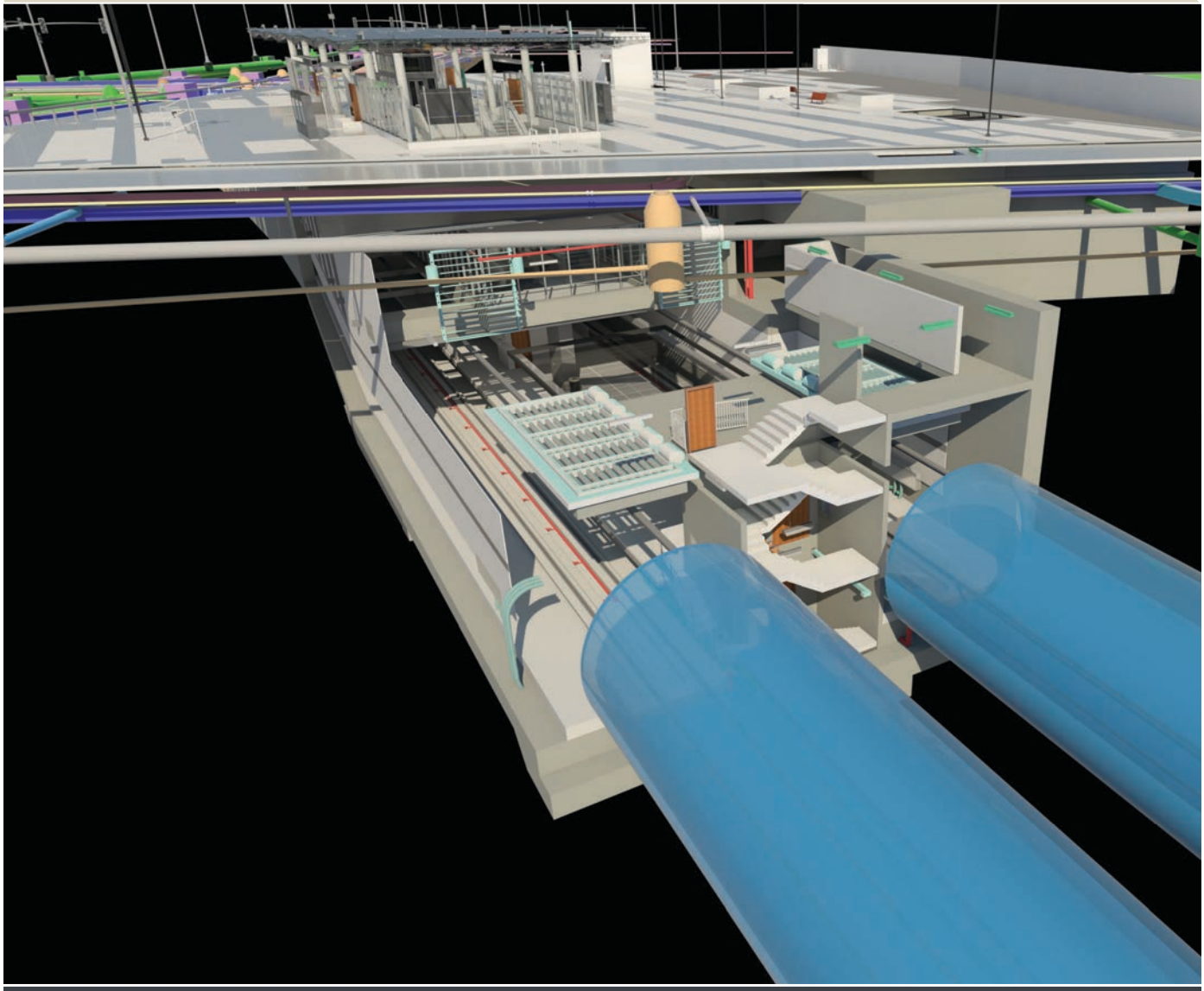

The Business Value of BIM for Infrastructure 2017

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The Business Value of BIM for Infrastructure 2017 SmartMarket Report

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About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of analytics and software-based workflow integration solutions for the construction industry. Building product manufacturers, architects, engineers, contractors, and service providers leverage Dodge to identify and pursue unseen growth opportunities and execute on those opportunities for enhanced business performance. Whether it's on a local, regional or national level, Dodge makes the hidden obvious, empowering its clients to better understand their markets, uncover key relationships, size growth opportunities and pursue those opportunities with success. The company's construction project information is the most comprehensive and verified in the industry. Dodge is leveraging its 100-year-old legacy of continuous innovation to help the industry meet the building challenges of the future.

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Introduction

In 2012, Dodge partnered with Autodesk on the publication of the first *Business Value of BIM for Infrastructure SmartMarket Report*. The most striking conclusions of that study were twofold: BIM in infrastructure appeared to lag about three years behind the building sector, but there were many positive signs that the use of BIM in this sector was poised to become more widespread.

The findings of this 2017 update on the business value of BIM for infrastructure clearly demonstrate the fulfillment of that promise. While the exact parameters of the study have changed, the evolution in the use of BIM is nonetheless quite clear. The first study was confined solely to the US construction market, and it covered a broad span of infrastructure projects. The current study is focused entirely on transportation infrastructure, the largest segment from the previous study, and it also expands in scope to include the UK, France and Germany.

Perhaps the most telling finding is the dramatic growth of BIM implementation reported by respondents from all four countries.

- **BIM users at a high level of implementation (on at least half of their projects) grew from 20% in 2015 to 52% in 2017.**
- **By 2019, 61% forecast that they will be at that high level of implementation.**
- **Between 2017 and 2019, the growth in BIM implementation is most dramatic among those deploying BIM on nearly all (75% or more) of their projects, with the percentage almost doubling from 17% to 32%.**

These levels of growth are relatively consistent in all four countries despite other differences between these markets. BIM users in the US have a longer history with using BIM for transportation infrastructure, but the European countries are rapidly achieving maturity, with the BIM mandate in the UK and the upcoming German mandate likely driving adoption in the entire region.

However, the study demonstrates that there are other compelling reasons for the embrace of BIM in the transportation sector:

- **Most BIM users (87%) report that they see positive value from their use of BIM.** Another positive sign is that most believe that they are just starting to see the full potential of BIM, a driver for wider future implementation.
- **Nearly two thirds believe that they are seeing a positive ROI from their use of BIM, with about half of those reporting an ROI of 25% or more.** Among the remaining third, well over half simply do not know what the ROI on their BIM investments is, a relatively small percentage say that they are breaking even, and less than 5% report a negative ROI.

These findings are driven by the benefits that BIM users in the transportation sector experience.

- **Most of them find that using BIM improves their processes and project outcomes most by reducing errors and providing greater cost predictability.**
- **Over half also report that BIM helps them to achieve two types of business benefits:**
  - **They can do business better** through improving younger staff's understanding of how projects go together and establishing a consistent and repeatable project delivery process.
  - **They can find more work** through increased ability to offer services and by being able to maintain business with previous clients.

We thank our partner Autodesk for their ongoing support of this critical research, and hope it inspires current users to expand their programs while encouraging others to get involved.

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

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

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

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Cover Image Courtesy of Mott MacDonald; Image on Opposite Page Courtesy of Transport Scotland and Jacobs

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Front Cover:
Mott MacDonald's isometric of the future Little Tokyo/Arts District Station on the Los Angeles County Metropolitan Transportation Authority's Regional Connector Transit Corridor Project in downtown Los Angeles.

This page:
Highways England uses models for their roadway project, like this example created by Jacobs, to improve information flow across the asset lifecycle.

Executive Summary

The degree of BIM implementation for transportation infrastructure projects has seen a big surge in the last two years, and growth is expected to continue.
In addition to their positive outlook on increasing the percentage of projects that use BIM, owners, engineers and subcontractors in France, Germany, the UK and the US also report achieving a variety of benefits from its use, which are reflected in the positive ROI they attribute to BIM for this sector.

BIM Implementation for Transportation Infrastructure

When engineers and contractors in France, Germany, the UK and the US were asked about their involvement with BIM for transportation infrastructure projects, over three quarters of respondents who use it (76%) report that they are creating their own models, and the remainder work with models authored by others. In this research study, both of these two categories are considered BIM users.

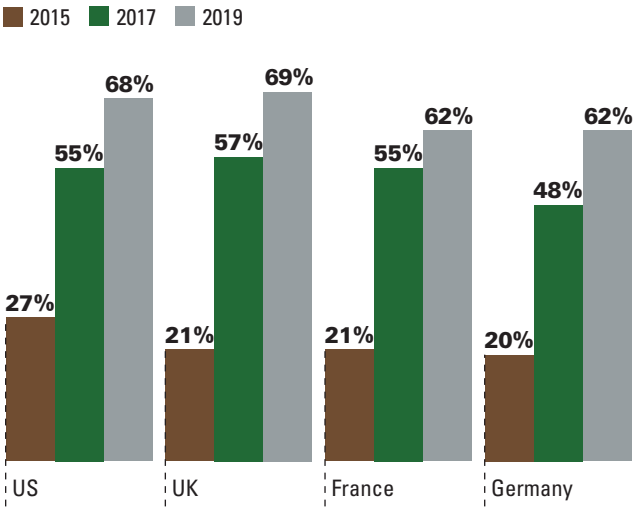
Dodge Data & Analytics measures the growth of BIM implementation (the percentage of projects on which a user deploys it) as a key indicator of the dynamics of BIM usage. The chart at right shows how many of the engineers and contractors who are currently working with BIM report they were (2015), are (2017), and expect to be (2019) using BIM on 50% or more of their transportation infrastructure projects.

- **The percentage of heavy BIM users (deploying it on half or more of their transportation infrastructure projects) powerfully surged between 2015 and 2017.**
- **While the growth of heavy users is predicted to slow somewhat over the next two years, within that group, the proportion of very heavy users (deploying it on 75% or more of their projects) will grow by 100% to 200% in the four countries studied.**

This implementation pattern reflects an evolving BIM maturity that Dodge Data & Analytics has observed in other sectors and is a positive indicator that BIM usage will continue to advance for transportation infrastructure.

Use of BIM on 50% or More Transportation Infrastructure Projects (According to Engineers and Contractors by Country)

Dodge Data & Analytics, 2017



Benefits From Using BIM

While owner demand and mandates in the UK and Germany have been important to drive BIM use for transportation infrastructure, the internal business benefits that BIM users experience, and the improvements to project processes and outcomes that BIM generates are also key drivers for adoption and implementation. **Most BIM users (87%) report positive value from their use of it,** and 73% say they have not yet receive even half of the

potential value they believe BIM can provide. This finding reinforces the forecast for additional growth in BIM implementation as users gain experience, and the tools and processes advance to address more effectively the specific needs of the transportation infrastructure sector.

TOP BUSINESS BENEFITS

All of the nine business benefits included in the study were experienced at least at a moderate level by about three quarters or more of respondents, but five in particular were experienced at a high or very high level by 50% or more. Those benefits are included in the chart at right, and they include two types of benefits:

- **Those that help companies do business better,** including improving younger staff's understanding of how projects go together, establishing a consistent and repeatable project delivery process and allowing staff to spend more time designing and less time documenting.
- **Those that help companies find more projects,** including the ability to offer services and to maintain business with past clients.

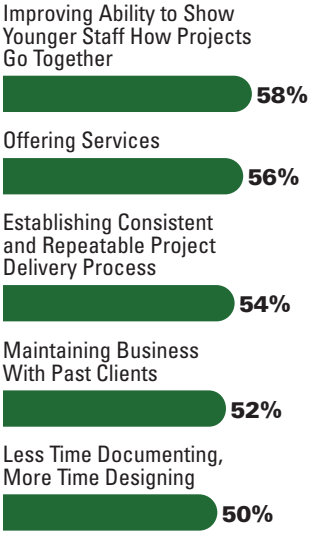
TOP WAYS BIM IMPROVES PROJECT PROCESSES AND OUTCOMES

Respondents were also asked to select the top three benefits they experience from using BIM from a list of 13 benefits. Their average responses, organized into five categories, are shown in the chart at right.

- **Fewer errors ranks highest among all respondents.** This includes benefits like:
  - Reduced conflicts/field coordination problems during construction
  - Reduced errors and omissions
- **A relatively high percentage also consider greater cost predictability and better understanding of the project among the top process and outcome benefits of BIM.**
  - Better multiparty communication and understanding from 3D visualization is a critical contribution to better project understanding.
  - Better cost predictability not only includes reduced costs but also reduced rework.
- **Also in the top five benefits are improved schedule performance and design optimization.** Nearly half (43%) of respondents have been using BIM for three years or less on transportation infrastructure projects. As they gain more experience and implement it on more projects, it is quite possible that the importance of optimizing the design (including safety performance and producing better-performing infrastructure projects) will grow.

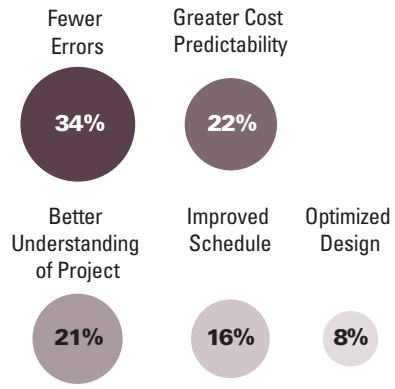
Top Business Benefits of BIM Related to Transportation Infrastructure Projects
(Rated High/Very High by All BIM Users)

Dodge Data & Analytics, 2017



Top Ways BIM Improves Process and Project Outcomes (Average of 13 Different Process and Outcome Benefits Ranked in the Top 3 by All Respondents and Assigned to 5 Categories)

Dodge Data & Analytics, 2017



BIM ROI

While many respondents are not formally measuring the return on investment they see from using BIM, **nearly two thirds (65%) perceive that they get a positive ROI from their investment in BIM.** Even more impressive, over one quarter (26%) believe that ROI is 25% or more. The US respondents lag those in other countries in the ROI they report, but they also notably lag in the percentage who are formally measuring ROI, which suggests that they may be underestimating the value they get from BIM.

BIM Investments

Respondents were asked about the top investments their company currently makes in ways to improve the value they receive from BIM, and they were also asked to rank the top priorities for investment expected in the next five years. **The findings reveal that everyone expects investments in marketing their BIM capabilities to be a higher priority than they are now,** and there are also interesting differences by country in the current versus future investment priorities:

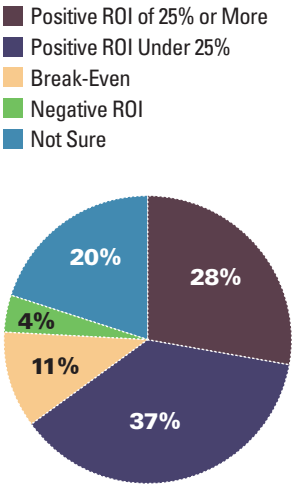
- **Future Priority Investments in France:** Developing collaborative BIM processes with external parties, strategic BIM program deployment and BIM accreditation
- **Future Priority Investments in Germany:** BIM training, new hardware and strategic BIM program deployment
- **Future Priority Investments in the UK:** BIM training, BIM accreditation, upgrading software and strategic BIM program deployment
- **Future Priority Investments in the US:** BIM training, BIM accreditation, new hardware and developing collaborative BIM processes with external parties.

Non-User Attitudes Toward BIM

Roughly one quarter of the survey respondents do not use BIM in any way for transportation infrastructure. As the chart at right reveals, however, their attitudes toward BIM are very positive, suggesting that an uptick in adoption is likely to accompany the increase expected in BIM implementation in this sector.

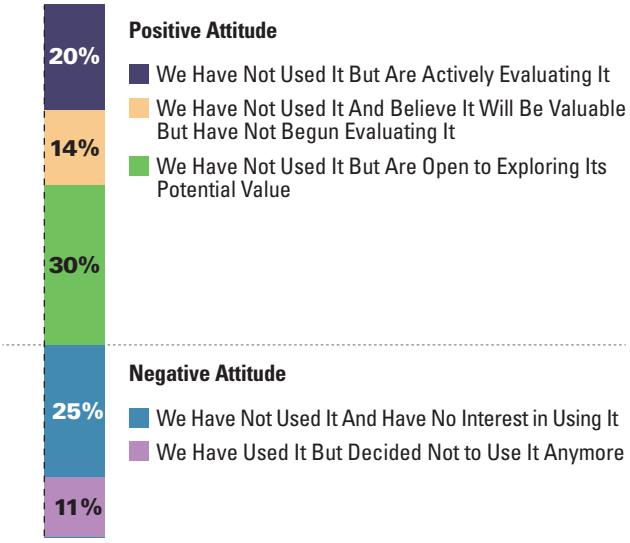
Perceived ROI on BIM for Transporatation Infrastructure (According to All BIM Users)

Dodge Data & Analytics, 2017



Non-User Attitudes Toward BIM for Transportation Infrastructure Projects

Dodge Data & Analytics, 2017



Data: Introduction

This study joins a long line of research conducted by Dodge Data & Analytics since 2006 that examines the business benefits of BIM. It is also an update of a previous study on the business value of BIM for infrastructure that was conducted in 2011 and published in 2012. That study suggested a bright future for BIM, but it revealed that infrastructure was lagging behind the vertical building market in terms of BIM adoption. Now, the current study, while different in scale and scope than the previous one, clearly demonstrates that those using BIM for infrastructure have been increasing implementation and are seeing strong benefits as a result.

This study differed from the one in 2011 in two ways:

- **The 2017 study focuses solely on transportation infrastructure, while the earlier study included many different kinds of infrastructure.**
- **The 2017 study takes an international approach, looking at responses from engineers, contractors and owners in France, Germany, the UK and the US, while the earlier study was only US-based.**

The topics covered in the 2017 study are the same as the previous one: the degree to which BIM is being used for this sector; the benefits reported by those using BIM, including both internal business benefits and project process and outcome benefits; the investments being made and those expected in the near future to enhance the value obtained from BIM; the perceived ROI of their use of BIM and the attitudes of non-users toward BIM.

In addition to the analysis of the data, the report also includes a summary of each of the four countries featured. The France, Germany and UK sections all focus on the data in the current study, but the US section also includes a comparison with the 2011 study to track notable trends.

The report as a whole demonstrates a significant advance in BIM for infrastructure since 2011. It reveals powerful benefits, and it demonstrates that most of the respondents believe that they are experiencing just a portion of the full benefits BIM can offer for this sector.

Note About the Data

The findings in this report are from an online survey of engineers/architects/planners, contractors and building owners conducted in France, Germany, the UK and the US from October 2016 to February 2017.

368 design and construction professionals responded to the survey. The following approaches are taken consistently throughout the analysis of the data from the study:

- **Since 89% of the engineer/architect/planner respondents are engineers, the group as a whole is referred to as engineers.**
- **Since the percentage of owner respondents varies widely across the four countries, all comparisons of data by country are comprised of engineer and contractor responses only.**
- **Respondents were asked to identify the size of their companies by number of employees, and comparisons based on size are made throughout the analysis on the responses from engineers and contractors.**
- **Respondents were asked about the types of transportation infrastructure projects they have experience with, including roads, bridges, rail/mass transit, tunnels and aviation, and they could select multiple options. The results of those working on different types of transportation infrastructure are compared throughout the report, but it should be noted that these comparisons are not statistically significant since the same respondent may be in multiple groups.**

A more complete description of the study and responses, including a breakdown of the number of respondents by country and by role, can be found in the Methodology on page 64.

Data: BIM Use

Use of BIM for Transportation Infrastructure

In all research on BIM, Dodge Data & Analytics asks respondents to identify whether they are using BIM at all, and if so, whether they are creating their own models or only using models created by others. This survey focused exclusively on BIM use for transportation infrastructure projects.

The bar charts at right demonstrate that **the use of BIM for transportation projects is both widespread and consistent among the organizations surveyed in the US, UK, France and Germany,** suggesting a high level of familiarity with BIM for transportation infrastructure.

- **By Sector:** A somewhat higher percentage of those who work on tunnels (86%) report using BIM than do those who do roads (76%), bridges (79%) or rail/mass transit (77%).
- **By Size of Company:** A lower percentage of small companies report using BIM for transportation infrastructure than large companies. This is true for both engineers and contractors, and is consistent with the findings of all other Dodge global studies of BIM use.
  - Engineers: 71% of companies with less than 250 employees use BIM, compared with 85% of larger companies.
  - Contractors: 54% of companies with less than 100 employees use BIM, compared with 81% of larger companies.

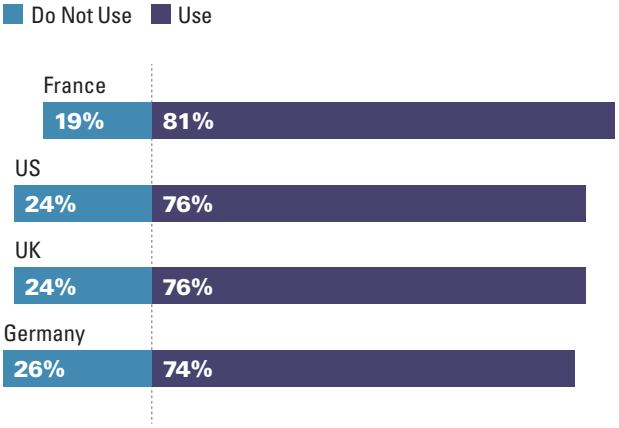
Authoring and Using Models

BIM provides value both to those who author models and those who extract value from models authored by others. Among these survey respondents, the charts at right and on the opposite page show the percentage of BIM users who author models, compared with those who do not.

- **By Country:** Just as the use of BIM is consistent in transportation infrastructure between the US, UK, France and Germany, **there is little difference by country between respondents who are authoring models and those who use models created by others.** The chart at right reveals that about three quarters of those using BIM in this sector are creating their own models in all four countries.
- **By Role:** A higher percentage of engineers author models than do contractors. This is consistent with patterns of BIM adoption in other sectors and other countries reported by Dodge, where designers are earlier adopters and more frequent modelers. However, in many cases, contractors eventually exceed designers in their use of BIM, and, therefore, this divide may narrow over time.

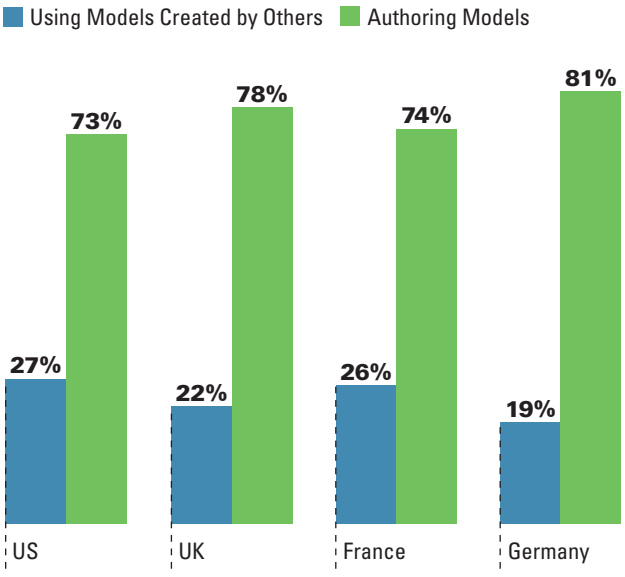
Use of BIM for Transportation Infrastructure Among the Organizations Surveyed
(By Country)

Dodge Data & Analytics, 2017



How BIM Is Used
(By Country)

Dodge Data & Analytics, 2017



Use of BIM by Those Who Do Not Author Models

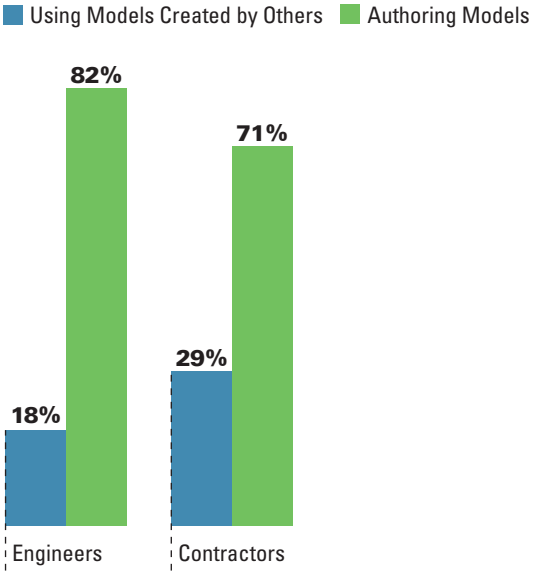
The respondents who use models created by others but do not author models themselves were asked to select their single most common use of BIM models and data for transportation infrastructure projects.

The findings demonstrate that there are a variety of ways in which models are being used by those who do not author them, with no single method selected by more than one quarter of respondents. The top three most common uses demonstrate the breadth of ways in which BIM can improve project processes and outcomes, even by those who do not model:

- **Interdisciplinary Project Collaboration:** Consistently, findings of Dodge BIM studies demonstrate that the ability to support increased collaboration on projects is a critical benefit of BIM, and this finding demonstrates that authoring models is not essential to experience this capability.
- **Deliver Design Intent to Construction:** This is another means in which BIM supports the sharing of information across the project team.
- **Aid Production of 3D Deliverables to Owners:** 3D deliverables can enhance an owner's understanding of how a project is designed, will be constructed, and, in a growing number of cases, how it will function after completion. The prevalence of this activity even among those who do not create their own models suggests that owners may be increasingly expecting these deliverables.

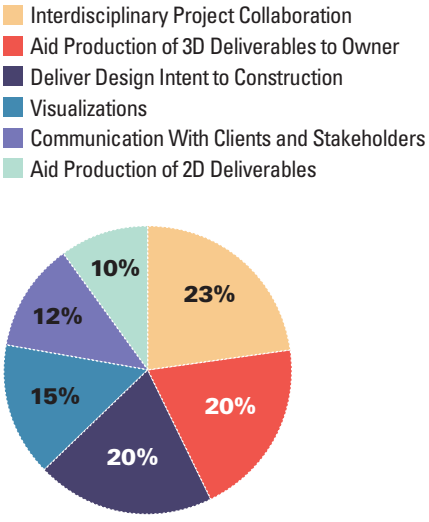
How BIM Is Used
(By Type of Company)

Dodge Data & Analytics, 2017



Most Common Use of BIM Models by Those Not Creating Them (According to Engineers and Contractors Using BIM)

Dodge Data & Analytics, 2017



BIM Implementation Levels

All respondents who use BIM were asked about the volume of transportation infrastructure projects on which they use or expect to use BIM in three time frames: two years ago, currently and two years from now. The charts at right represent those who implement BIM at a high level (on 50% or more of their projects). These responses are represented by country and by role.

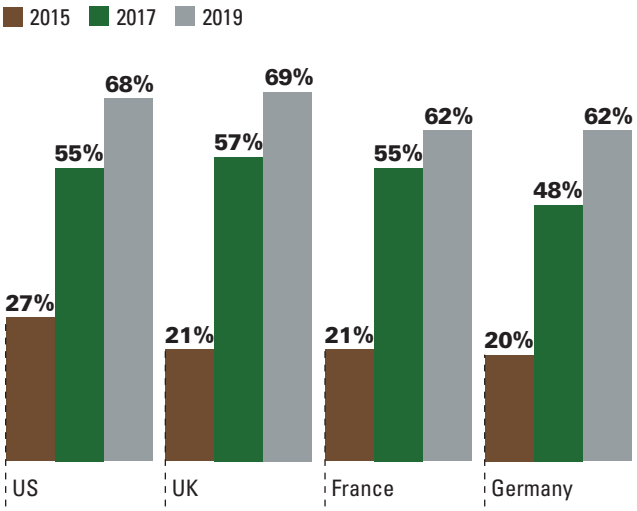
- **By Country: Implementation more than doubled in all countries over the last two years.** The US led in 2015, but UK and France have now achieved parity, and Germany is close behind. Growth is expected to modulate a little in the next two years, but remains strong in all four countries.
- **By Role:** In 2015, engineers and contractors report roughly the same level of BIM implementation on their projects, but **by 2017, contractors are experiencing much higher implementation levels than engineers,** with a 13 percentage point gap between the two. However, that gap is expected to decrease again to a nominal level in the next two years by 2019. This pattern for BIM implementation is different from that observed for building construction in other Dodge studies around the globe, where designers are usually earlier adopters, and it may suggest that contractors are gaining experience with BIM in other sectors of construction and thus are able to more rapidly ramp up their use of BIM.

Other interesting differences include:

- 62% of those doing aviation projects report that they currently use BIM on the majority of their projects, a much higher percentage than those doing roads (51%), bridges (52%), rail/mass transit (52%) or tunnels (49%).
- 69% of large contractors report now using BIM on most of their projects versus only 53% of smaller ones. Firm size does not impact engineers' implementation.

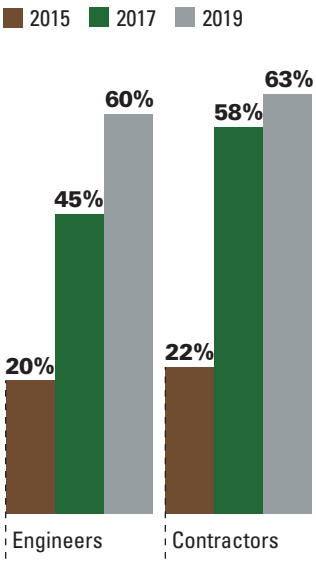
Use of BIM on 50% or More of Projects
(By Country)

Dodge Data & Analytics, 2017



Use of BIM on 50% or More Projects
(According to Engineers and Contractors)

Dodge Data & Analytics, 2017



Years of Experience Using BIM

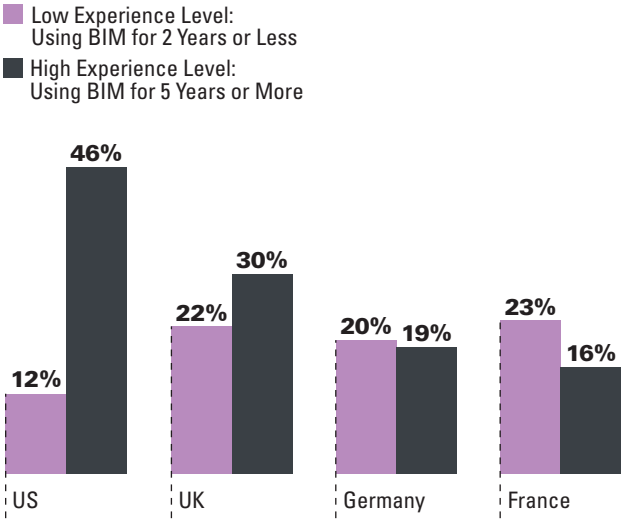
One way to gauge the level of experience with BIM is by how many years respondents have been using it. The chart at right represents by country the percentages of engineers and contractors who have a relatively low level of experience (using BIM for 2 years or less) and those who have a relatively high level of experience (using BIM for five years or more).

The US currently has the most practitioners with five or more years of BIM experience on transportation infrastructure. Nearly half (46%) of US respondents have used BIM for five years or more, far more than those in the UK (30%), Germany (19%) or France (16%). This is particularly surprising given the similarity in implementation levels (see page 10). In the UK, the BIM mandate currently in place helps drive increased implementation, and France and Germany appear to also see strong increases despite a relatively immature BIM market compared with the US.

There are no notable differences by sector or role in the years of BIM experience reported.

Years of Experience Using BIM for Transportation Infrastructure (Percentage of Those With Low and High Levels of BIM Experience Based on Number of Years Using It)

Dodge Data & Analytics, 2017



BIM Expertise Levels

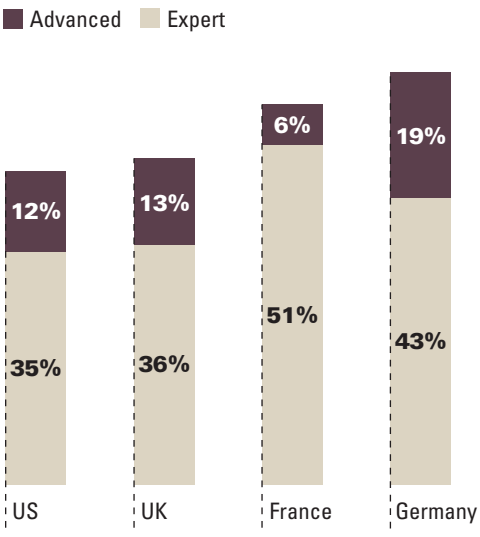
There is currently no objective means of measuring BIM expertise levels, but as a point of comparison, Dodge studies on BIM have included a question asking respondents to self-evaluate the level of BIM expertise at their companies (Basic, Moderate, Advanced or Expert).

In previous studies, the findings have often aligned with the years of experience using BIM, but the transportation infrastructure respondents do not. Instead, more engineers and contractors from Germany (19%) consider themselves at expert levels than those in the US (12%), UK (13%) or especially France (6%). This is despite more years of experience with BIM in the US and UK than in Germany and close to the same level of experience in France.

The reasons for this disconnect are unclear. It could be due to a cultural difference in terms of self-assessment, but it could also be due to wider BIM experience by German companies in other sectors than transportation infrastructure.

Level of BIM Expertise at Company (Percentage of Engineers and Contractors by Country Who Find That Their Company Is at an Advanced or Expert Level)

Dodge Data & Analytics, 2017



Owners Requesting BIM Use on Transportation Projects

Engineers and contractors were asked how frequently potential clients are requesting BIM in new business solicitations. **Overall, these respondents report that they see owner requests for BIM on roughly one third (35% average) of their projects.** The findings clearly suggest that owners are helping to drive the use of BIM in the transportation infrastructure sector:

- 80% or more of the engineers and contractors in each country report that owners are requesting BIM on at least some of their business opportunities.
- In France in particular, owners are encouraging the use of BIM, with one third of engineers and contractors (33%) reporting that owners request BIM on the majority of their projects.

Variation by Size of Company

Large companies are also more likely to see these requests than smaller ones.

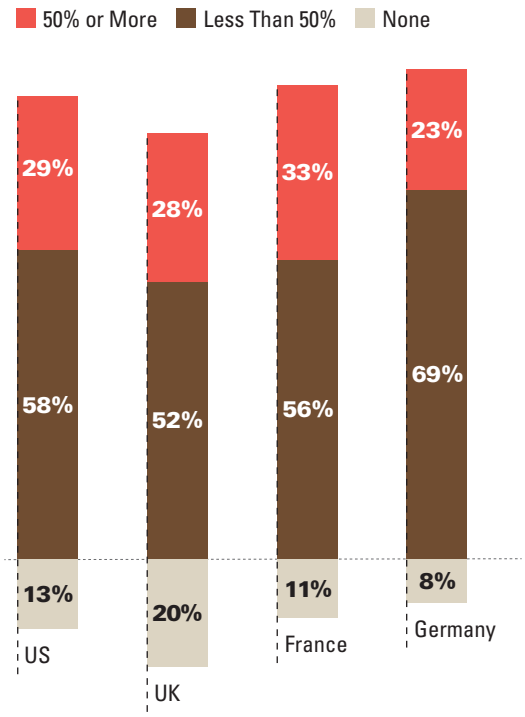
- Engineering firms with more than 1,000 employees see these on average in 41% of their new business requests, compared with 28% of project opportunities coming in for those working for firms with less than 250 employees.
- Likewise, contractors working for companies with more than 1,000 employees report that owners request BIM on about 45% of their projects, compared with 26% of projects reported by those working for companies with less than 100 employees.

Variation by BIM Use

Unlike most of the questions in this study, this was asked of BIM users and non-users alike. The influence of owner requests is clearly evident in their responses, with only 3% of the BIM users reporting that they do not see any owner requests for BIM, compared with nearly half (42%) of non-users. However, continuing demand from owners should help to accelerate adoption among non-users.

Owners Requesting BIM Use on Transportation Projects (Engineers and Contractors Reporting Percentage of Projects on Which Owners Request BIM Use)

Dodge Data & Analytics, 2017

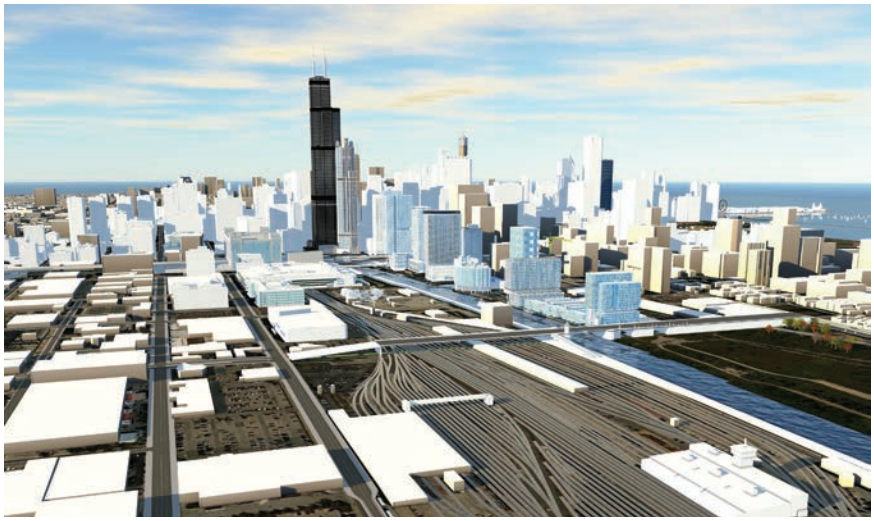


BIM for Planning

The Chicago Urban River Edges Ideas Lab

The City of Chicago is modeling its existing conditions to create a virtual city that will help it make smarter planning decisions for the next generation of transformation for the city's riverfront.

The ability to envision a place completely transformed may come easily to design and development professionals, but members of the public often struggle to imagine what is being proposed. "As planners, we run lots of community meetings where we have people looking at two-dimensional maps," says Josh Ellis, vice president at the Metropolitan Planning Council (MPC), a Chicago-based nonprofit organization. "It's hard for them to figure out where things are, and it's a couple of levels removed from feeling like they're weighing in on reality." For communities seeking meaningful input into public processes, that's a problem.



A BIM model of Chicago is supporting planning and public engagement for the future of the city's river edges.

Envisioning Chicago's River Edges

The Chicago Urban River Edges Ideas Lab, a visioning project funded by The Richard H. Driehaus Foundation and Comcast, and led by MPC in collaboration with the Chicago Department of Planning and Development (CDPD), is making a concerted effort to improve how options for Chicago's next wave of riverfront transformations are communicated. In addition to physical displays, the River Edges Ideas Lab will include innovative digital components.

The primary design medium for the Lab is a BIM model, developed by WSP USA in partnership with Autodesk, which depicts 600 acres of the city of Chicago. "When combined with technologies such as the Chicago Data Portal, big data and the internet of things," says Tom Coleman, manager of technology integration at WSP USA, "[it provides] the opportunity to develop a data rich model to help transform development along the South Branch of the Chicago River."

Innovations in Communication

Each of the nine architecture firms participating in the Lab will be issued a portion of the BIM model to enable them to explore typical and problematic conditions in 3D. The goal is to develop design solutions that will lead to a unified aesthetic for the riverfront. Final designs will be submitted in model form for insertion back into the master model.

The teams will also use the BIM model as a basis for developing panoramic renderings so that, using augmented and virtual reality, members of the public will be able to hold up their phones or peer into an Owlized viewfinder at specific locations, and see an overlay of what's proposed for a site, with opportunities to provide feedback. The concepts will also be displayed at the Chicago Architectural Biennial.

"The planning field is just starting to figure out how to use these technologies," says Ellis. "If this kind of experience makes a meaningful difference in the level of engagement and the kind of feedback we get from the public, then that will provide proof of concept." The input collected from residents will inform CDPD's update of the city's riverfront design guidelines, which will be released in 2018. ■

Image Courtesy of WSP USA

Capitalizing on BIM Across the Roadway Lifecycle

The Smart Motorways Programme in the UK seeks to provide models for new construction projects that not only improve project delivery during design and construction but can be leveraged during operations as well.

Highways England is addressing congestion concerns through its Smart Motorways Programme, a technology-driven effort to relieve congestion and improve capacity. Congestion levels can be monitored and analyzed to determine if speed limits should be adjusted to smooth traffic flow. Through warning signage, motorists can also be alerted about road hazards and traffic jams.

Supporting Collaboration

In delivering the program, the team is also looking for a smart approach to its design, construction and future operations. "The program is all about collaboration," says Liam Gallagher, director of information management for the UK transportation and process teams at Jacobs. "The approach here is a full-lifecycle model."

Jacobs is a member of the program management team for the £5 billion effort, which will deliver roughly 50 projects in the next few years.

The Smart Motorways Programme, which is divided into multiple tranches, was already underway when the UK government mandated that BIM needed to be used. The program is one of the first in the UK to require BIM Level 2, which calls for a collaborative BIM environment, where team members can exchange information within a common data environment [CDE]. Through an employer's information request [EIR], 3D geometrical and non-graphical data requirements are outlined. The design and construction team then responds to that request through a BIM execution plan.

Section of roadway from the A96I-N VRM

Images Courtesy of Transport Scotland and Jacobs

Improving the Flow of Data Throughout the Project Lifecycle

As an emerging approach for delivery of roadways, Gallagher says the team is developing ways it can best leverage the value of BIM on the program. With efforts currently focused on design, the team is exploring ways data can seamlessly flow from design to construction and on to facilities management. "Key things like roadway alignment can be extremely valuable," he says. "Going forward, the next time they want to do some work on a piece of infrastructure, wouldn't it be great if they didn't have to redesign the alignment?"

Streamlining Design Options and Using Modularization

Through modeling, Gallagher says the team plans to streamline and simplify its design options. For example, roadways will require numerous gantries, but Gallagher says he wants to use BIM to design a limited number of common gantries that can be used across the program.

"We'd like to have five choices, not 50," he says. "We're building a digital component library, so that we're not reinventing the wheel every time we have to build a gantry. We will make them parametric in the future as well, so you can just pull them down and resize them."

Gallagher also expects to use BIM to leverage modularization of roadway components. Gantries with

Section of roadway from the A96I-N VRM

electronic displays could potentially be built as multi-trade modular units. Road components could also be simplified.

In addition, as part of the Smart Motorways Programme concept, hard shoulders could be used for traffic at peak times or even permanently. To address safety needs, teams will instead construct numerous "emergency refuge areas" along the alignment, where cars can pull off following a breakdown. Each area has an emergency telephone that connects to regional control centers and pinpoints the location of the vehicle. Gallagher says the team is looking into designing these refuge areas as complete modular components. "We want to be able to pull up a truck, drop [the refuge area] in place and go," he says.

Gallagher adds that the team is also looking into componentizing foundations.

Future Uses of BIM Under Consideration

Looking ahead, Gallagher says the team is exploring some more cutting-edge uses of BIM. As part of using BIM data to help guide machinery in the field, the team is considering the use of robotics to dig trenches.

The team is also looking at its models to see if they can be used to create virtual reality (VR) scenarios. "We can train people in VR and be there before we go there," he says.

Overall, Gallagher says the level of collaboration possible through BIM offers the greatest value. "We're seeing designers talking to contractors, but we're also seeing contractors talking to maintenance people earlier than usual," he says. "Further down the line the focus will be the assets, asset management and asset data. Asset management is king here. We need the ability to deliver clean and validated asset information into the client's asset information systems that can then be reused to make informed decisions. If we build up that asset library as we go, eventually maintenance will have the information it needs at its fingertips." ■

Data: BIM Benefits

Experience of Overall Business Value From BIM

Adoption, implementation and evolving maturity with the use of BIM are elements of an overall BIM journey, and different users will go through a variety of stages as they progress. To assess the overall status of a geographic market in this respect, Dodge Data & Analytics frequently asks users about the degree to which they find that they are experiencing the full value that BIM offers to them (ranging from no value at all through 25% intervals up to 100% value). **87% of all BIM users in the four countries included in the study report that they are experiencing value from BIM.**

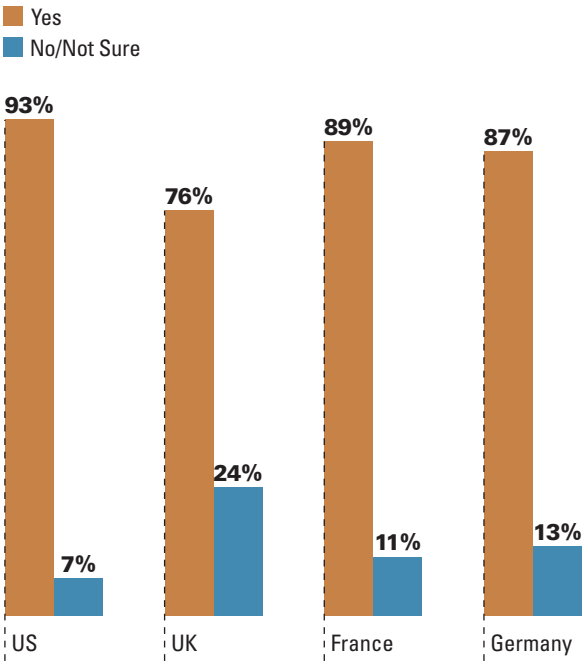
The first chart at right shows the combined responses of engineers and contractors from the four countries who experience at least some level of value from BIM. The chart that follows looks just at those experiencing value and shows the degree of value they have achieved, compared with the overall value they believe BIM can deliver.

When compared in combination, the findings are telling.

- **The US has the highest percentage who report experiencing any value (93%), but they also have the highest percentage who report experiencing 25% or less of the total value BIM has to offer (43%).** Given the relatively high level of BIM experience in the US (see page 11), this may suggest the need for more research about why so many feel that they are just experiencing a small percentage of the value of BIM.
- **Around half of those experiencing value in the UK (45%) and Germany (52%) believe that they are getting between one quarter and one half of the full value that BIM offers.** This finding bodes well for increased use in these markets, since this suggests that they are seeing sufficient value to justify their investments but still have a great deal to gain from wider BIM use.
- **France is split between those seeing low, medium and high levels of value,** which may be related to the relatively few years of BIM experience and relatively low self-reported levels of BIM expertise in France (see page 11).

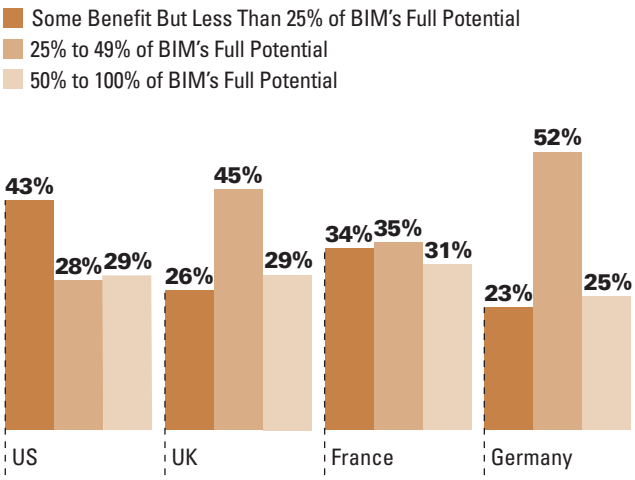
Experience of Overall Business Value From BIM (Engineers and Contractors by Country Using BIM Who Experience Value)

Dodge Data & Analytics, 2017



Degree of Value Experienced From BIM (According to BIM Users by Country Who Find Value in Using BIM)

Dodge Data & Analytics, 2017



Internal Business Benefits From BIM

While BIM provides numerous benefits to the projects on which it is deployed, there are also critical benefits that the users' companies can derive by adopting and implementing BIM. For this study, BIM users were asked to rate the degree to which BIM generates nine business benefits related to transportation infrastructure projects on a scale of one to five (none, low, medium, high, very high). The chart at right represents the percentage of BIM users who find that they experience these benefits to a medium, high or very high degree.

Overall, **the findings reveal that a wide range of business benefits are experienced by companies doing transportation infrastructure due to their use of BIM.** Only a 15 percentage point gap exists between the top benefit and the lowest one, despite the high number of benefits. This clearly demonstrates that BIM users experience many business benefits and that these benefits are substantial and impactful.

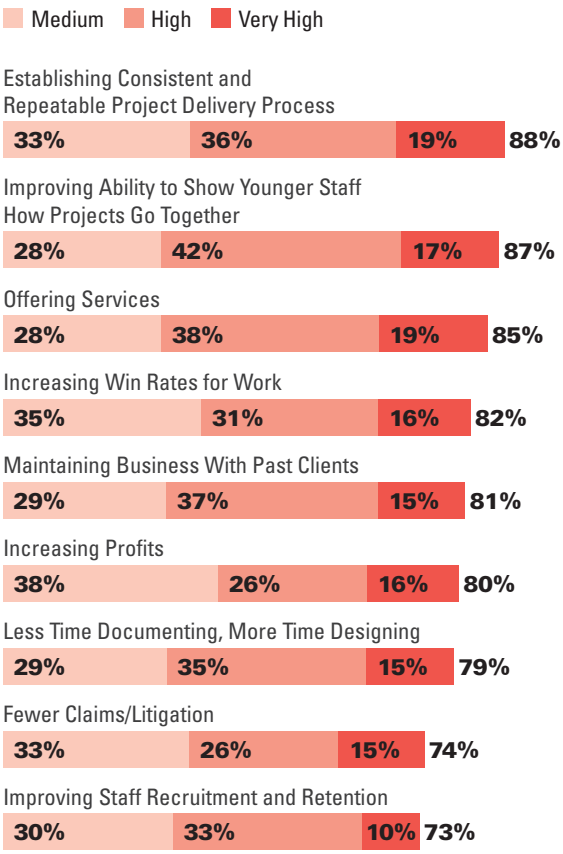
Improving Staff Effectiveness

Many of the business benefits measured in the study help companies improve the effectiveness of their staff.

- **BIM's impact on improving a company's ability to show younger staff how projects go together is the top benefit, rated high/very high by 59%.** This helps address concerns currently experienced across the design and construction industry about the loss of institutional knowledge as older professionals retire.
- **Half of BIM users (50%) experience a high/very high benefit from BIM's ability to allow their staff to spend less time documenting and more time designing,** adding value to their contributions on projects.
- **A notable percentage (43%) also see BIM being highly effective in helping them to recruit and retain staff.** The competition for top talent is a global challenge in design and construction, and this is an important benefit to be addressed by companies committed to BIM.

Business Benefits of BIM (Rated High/Very High by BIM Users)

Dodge Data & Analytics, 2017



Internal Business Benefits From BIM CONTINUED

Increasing Business and Profitability

Companies need to be able to expand their service offering opportunities as well as maintaining and nurturing relationships with previous clients. BIM is a valuable tool for all these activities in the infrastructure market.

- **Many see a high/very high influence from BIM on their ability to offer services (57%) and increase their win rates for new work (47%).** This combination helps to increase the possible projects they are eligible to pursue, along with their success rate of winning that new business.
- **They also see a high/very high impact from BIM on their ability to maintain business with past clients (52%), along with the ability to establish a consistent and repeatable project delivery process (55%) and reducing claims and litigation (41%).** Each of these benefits can have a positive impact on a company's bottom line, and they can also improve their reputation and standing within the industry.
- **42% also see a high/very high impact from BIM on their ability to generate increased profits,** which, in turn, is a compelling reason to expand their implementation of BIM.

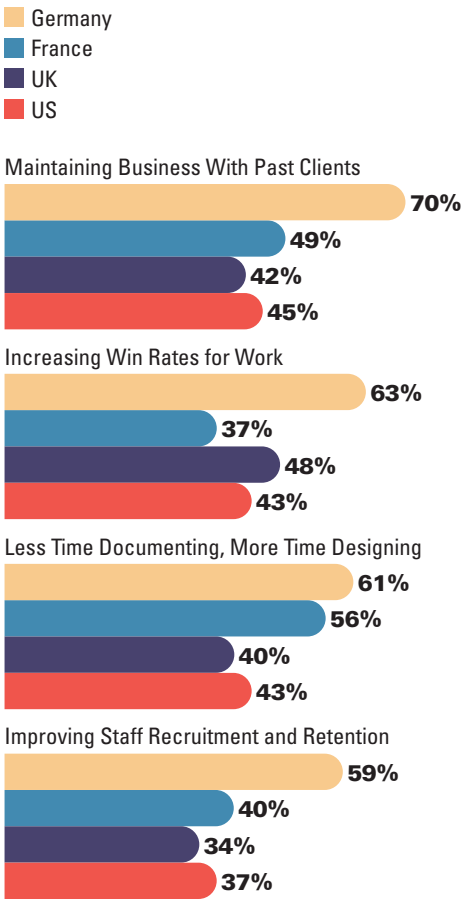
Variation by Country

The chart at right shows the benefits for which there is a statistically significant difference by country in the percentages reporting that they are generated by BIM at a high/very high level.

- **German respondents are highly enthusiastic about several benefits, often exceeding other countries by wide margins.**
- **The top benefit for Germany is maintaining business with past clients, with 70% considering this a strong benefit of BIM.**
- **The top benefit in France (63%) and the US (57%) is how BIM improves the ability to show younger staff how projects go together, but this ranks a distant fourth in the UK.**
- **The top benefit in the UK is the ability to establish consistent and repeatable project delivery processes (56%).**

Differences in Business Benefits of BIM Experienced by Country (According to Engineers and Contractors Who Rate Them High/Very High)

Dodge Data & Analytics, 2017



Project Process and Outcome Benefits From BIM

BIM has been demonstrated in numerous studies by Dodge Data & Analytics to have a positive impact on project processes and outcomes, including the previous *BIM for Infrastructure* study published in 2012. To identify the most impactful project process and outcome benefits related to BIM use on transportation infrastructure projects, respondents in this study were asked to identify just their top three from a list of 13 potential ones. The benefits selected by 20% or more of the respondents are shown in the chart at right.

The benefit most frequently ranked in the top three is reduced conflicts, field coordination problems and changes during construction. However, the findings on this top benefit vary notably by role and by country.

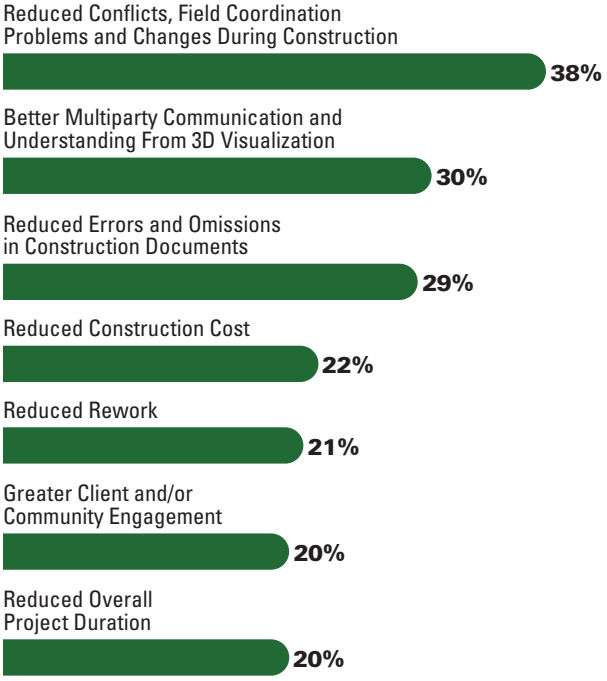
- **By Role: A higher percentage of contractors (41%) rank this among their top three process and outcome benefits than do engineers (29%).** In addition, more contractors working for large companies (1,000 or more employees) rank this highly (54%) than do those working for smaller companies (34%) by a large percentage, perhaps due to the nature of projects typically undertaken by larger companies.
- **By Country: More US respondents (54%) rank this as a top benefit than their counterparts in the UK (39%), France (32%) or Germany (22%).** No other process or outcome benefit is selected by more than 50% of respondents from any other country, demonstrating how important this benefit is in the US.

Two benefits nearly tie as the next most important for all BIM users: better multiparty communication and understanding from 3D visualization, and reduced errors and omissions in construction documents. For both, engineers and contractors agree on their importance, as do the respondents from the four different countries.

- **Better multiparty communication and understanding from 3D visualization is a benefit particularly noted by owners, with 46% selecting it among their top three.** This aspect of BIM can be particularly valuable for owners to understand projects from early concept stages and be able to provide meaningful input and direction to the design and construction teams.
- **It is worth noting that nearly the same percentage of engineers (28%) and contractors (29%) see reduced errors and omissions in construction documents as a top benefit of BIM,** demonstrating the way in which this benefit cascades through the project lifecycle from design to construction.

Top Project Process and Outcome Benefits From BIM (Selected Among Their Top 3 by 20% or More of BIM Users)

Dodge Data & Analytics, 2017



Among the final four benefits ranked in the top three by 20% or more of BIM users, three involve improving metrics that are frequently tracked to gauge improved project performance: reduced construction cost, reduced rework and reduced overall project duration.

The fourth benefit reflected in the chart, greater client and/or community engagement, is of particular importance in the transportation infrastructure sector, in which large projects often need to obtain approval across multiple stakeholders.

Emerging benefits that are not yet ranked by at least 20% of respondents in their top three include:

- Increased Ability to Do Prefabrication
- Faster Plan Approval and Permits
- Reduced Number of RFIs
- Better Performing Completed Transportation Infrastructure
- Reduced Cycle Time of Specific Workflows
- Improved Safety Performance

Most Important Ways BIM Improves

Transportation Infrastructure Projects

After responding to a number of multiple choice questions about BIM value, BIM users were asked two open questions about the most important ways that BIM improves transportation infrastructure projects.

- What is the single most important way BIM is saving time and/or money on transportation infrastructure projects?
- What is the single most important way other than saving time/money that BIM is improving your organization's delivery of transportation infrastructure projects?

Their responses reveal insights into top-of-mind benefits of BIM. Though the question was optional, over half of the BIM users volunteered an answer to both, indicating a strong desire to express their beliefs.

Most Important Ways BIM Saves Time and/or Money

Most of the responses fell into five top categories:

- **Improved Performance/Efficiency/Competence:** The highest percentage believes that BIM saves time or money because it improves the efficiency, performance and basic competence of their staff.
- **Planning/Programming:** Previous studies by Dodge Data & Analytics on BIM have demonstrated that improvements due to the use of BIM in the programming or planning stages of a project tend to cascade down and save time and money during construction.
- **Faster Coordination/Better Communication:** Improved coordination and communication are consistently cited in other Dodge Data & Analytics studies as a top benefit of BIM, but these responses make clear that those who experience improvements in these areas believe they save time and money as a result.
- **Speed of Design/Installation:** While the most effective use of BIM may involve more time in the beginning of design to set up a BIM execution plan, this top-of-mind benefit suggests that spending time upfront on BIM results in shorter overall design/installation schedules.
- **Improved Organization/Simplified Procedures:** The process improvements that BIM users experience (see page 19) are also perceived to result in improved organization and simplified procedures, which are also seen as opportunities to save time and money.

A few respondents also felt that improved visualization and producing higher quality projects help save time and money on projects.

Most Important Ways That BIM Improves Project Delivery Other Than Money/Time Savings

Responses to this question cover a wide spectrum of beneficial contributions from BIM. Among them, **the only category that encompasses more than 10% of the responses is that BIM improves cooperation across the project team and enhances teamwork and communication.** This finding corresponds to other Dodge studies in which the ability of BIM to enhance collaboration is frequently cited as a top benefit.

A few of the other responses that emerged to this question included the following:

- Streamlining/Simplified Procedures
- Transparency/Clarity/Better Understanding
- Visualization
- Improved Accuracy
- Being Able to Create Advanced Designs
- Better Organization/Structure

All of these findings, both in terms of how BIM saves time and money and how it improves project delivery, support the importance of the benefits reported by respondents on pages 17 to 19.

Project Stage at Which BIM Provides the Greatest Value

The level of value that users derive from BIM varies across the lifecycle of a project based on their role and how they are leveraging it. In this study, BIM users were asked to select the stage at which they see the greatest value from their use of BIM. The table shows the responses of engineers and contractors. It is worth noting that the questions were phrased differently for the US respondents than they were for the others, due to different standard nomenclatures in the North American design and construction market compared with Europe, and the table designates the terminology used for each.

By far, the largest percentage of respondents across all four countries consider BIM to provide the greatest value during design development (US)/developed design (UK, France, Germany). A few factors may influence this finding. First, for some respondents such as contractors, this may be the first point at which they engage in the project. In addition, previous BIM studies by Dodge Data & Analytics reveal that the early benefits of using BIM during design—including increased accuracy, improved visualization and enhanced collaboration—often cascade down to benefit the construction phase as well.

However, differences are also evident in the responses by country.

- The second most frequently selected stage in the UK is the concept stage.
- In Germany, the concept stage ranks third, but it is exceeded by the production stage by just a few percentage points.
- In France, the production stage ranks second, and by a wide margin above any other stage.
- In the US, the construction phase ranks quite high. While it appears on first glance to vastly exceed its European counterparts, there is no separate US equivalent for the production stage, and the combination of the production and installation stages for the UK, France and Germany puts them all on par with the US construction phase percentages.
- Very few respondents select the maintenance/use phase. While the table only represents engineer and contractor responses, owner responses are not notably different: Only one owner out of the 24 BIM-using owners included in the study selected this stage. This may suggest that currently most transportation infrastructure owners see BIM as a tool to improve design and construction, but that they do not yet see its potential to improve how they manage operation of their assets.

Project Stage at Which BIM Provides the Greatest Value (According to Engineers and Contractors)

	US	UK	France	Germany
Before Design Begins				
Preplanning (US)/Brief (UK, France, Germany)	7%	0%	4%	2%
Predesign (US)/Concept (UK, France, Germany)	15%	22%	10%	19%
During Design				
Design Development (US)/Developed Design (UK, France, Germany)	36%	49%	49%	44%
Construction Documentation (US Only)	11%			
Bidding/Construction/Installation				
Bid Letting (US)	1%			
Production (UK, France, Germany)		13%	20%	22%
Construction (US)/Installation (UK, France, Germany)	28%	7%	3%	13%
Post-Construction				
Project Closeout (US)/As Constructed (UK, France, Germany)	0%	7%	12%	0%
Maintenance (US)/Use (UK, France, Germany)	0%	2%	1%	0%

Value Experienced From Specific BIM Activities

Engineers and contractors who use BIM were asked to rate the value of 10 specific BIM activities on a scale of one to five (no, low, medium, high, very high). The chart represents those who found that they were experiencing a high/very high value from each activity. The activities are divided into three groups for easier comparisons.

It is notable that German respondents more frequently consider each of these activities to be of high value than the respondents from the US, UK or France. This finding is consistent with an enthusiastic German response to other questions throughout the study.

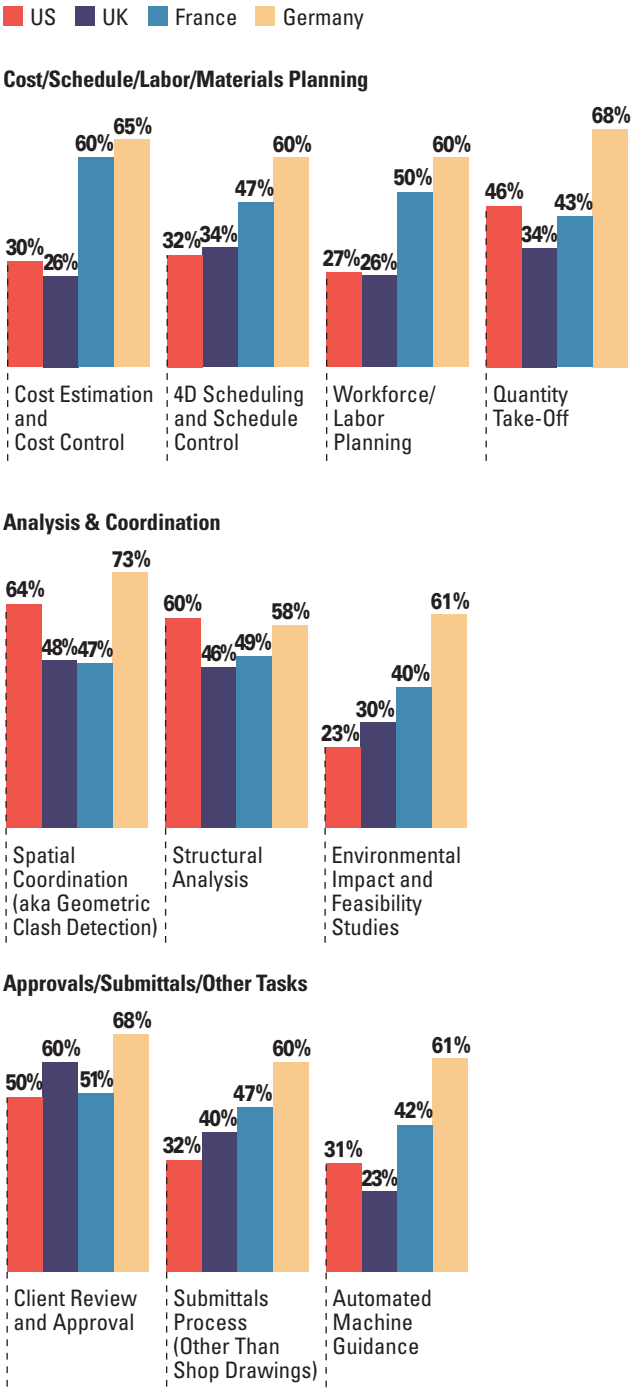
Cost, Schedule, Labor and Materials Planning

BIM can support improved planning and tracking of cost, schedule, labor and materials on transportation infrastructure projects. However, the value of these activities was not experienced uniformly by respondents from different countries.

- **French and German respondents experience greater value from cost estimation and cost control, 4D scheduling and schedule control, and workforce and labor planning than their counterparts in the US and UK.** This may suggest wider use of BIM for these functions in continental Europe.
- **German respondents are also experiencing high value from quantity take-offs, more so than even those in France.**
- **More respondents doing work on tunnels (56%) report experiencing a high value from 4D scheduling and schedule controls than those doing road or rail/ mass transit projects.** The challenges of working underground may make tunnels particularly benefit from this use of BIM.
- **More engineers (51%) report seeing high value from cost estimation and cost controls than contractors (41%).** This result may seem surprising, given the importance of cost control for contractors typically. The high-profile nature of infrastructure work may contribute to the value placed on this by engineers, who may find their reputations built, in part, on being able to deliver the public assets they design within a well-publicized budget.

High Value BIM Activities (Percentage of BIM Users Rating Each Activity as Having a High/Very High Value)

Dodge Data & Analytics, 2017



Value Experienced From Specific BIM Activities CONTINUED

Analysis and Coordination

BIM supports access to analysis and coordination tools that enable informed design and construction decisions, and the high degree of value noted for spatial coordination (58% of all respondents) and structural analysis (53% of all respondents) reflects the degree to which the industry recognizes and takes advantage of these capabilities.

- **Spatial coordination and structural analysis are particularly important among US respondents,** where they rank at least nine percentage points above any other activity for those respondents.
- **More engineers (45%) than contractors (33%) place a high value on environmental impact and feasibility studies.** Contractors were not asked about structural analysis, and the difference in the percentage who consider spatial coordination a high value activity is nominal, with contractors (60%) slightly leading engineers (56%).
- **A higher percentage of respondents who do tunnel projects (51%) consider environmental impact and feasibility studies to be valuable than those doing roads (41%), bridges (40%) or aviation projects (37%).**

Approvals, Submittals and Other Tasks

BIM can assist the project team in gaining client approvals through improved visualization tools, and, therefore, it is not surprising that **client review and approval is widely considered valuable (selected as having a high/very high value by 58% overall)**.

However, varying submittal requirements across different projects may cause the relatively low value ratings for that activity, with 45% overall who believe this activity provides a high/very high value. Very few respondents in the US (32%) consider this of value, but a very high percentage in Germany (60%) do, possibly due to differing requirements.

Automated machine guidance, described by the US Federal Highway Administration as "using a 3D model to guide construction equipment during earth work and paving operations," is an emerging activity. Recognition of its value by contractors overall is relatively low (39%), despite the higher degree of response in Germany (61%). The findings are also consistent across the different types of civil construction projects included in the report, including roads, bridges, rail/mass transit, tunnels and aviation.

Project Factors That Increase Ability to

Experience Value From BIM

Dodge Data & Analytics' research has consistently shown that the nature of the projects on which users are deploying BIM and a number of factors related to the broader industry environment in which BIM users operate have a profound impact on their ability to experience value from BIM.

In this study, BIM users were asked to select the top three project factors from a list of 11 possible ones that increase their ability to experience value from BIM. The chart lists the top findings ranked by more than 20% of respondents in their top three. The top factors fall into two categories: the scale of the project proposed, and the levels of BIM skill/familiarity among the project team members.

Scale of Project

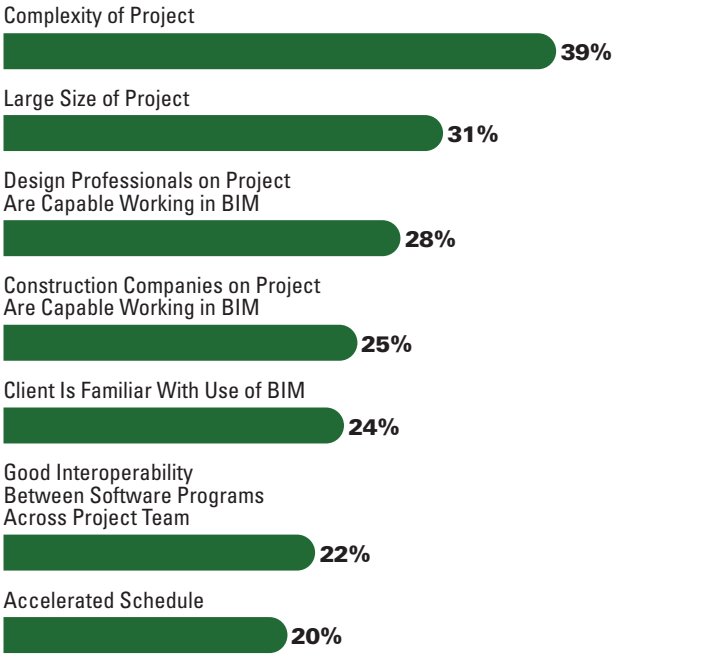
Project complexity is ranked by the highest percentage of overall respondents (39%) as contributing to the value received from using BIM, with large projects ranking second overall (31%). In fact, complexity is believed to impact the value of BIM by nearly twice as many respondents as having an accelerated schedule (20%) or a tight budget (16%).

A few differences are evident in the responses when analyzed by country, role or sector of work.

- **Complexity:**
  - Complexity ranks first in the US, with 60% selecting this among their top three factors.
  - It ranks second in the UK and France, but the percentage that rank it in the top three is around half of those in the US (31% and 29%, respectively).
  - While 28% in Germany consider complexity a top three factor, the more even spread of German respondents across many different factors reduces this to a fourth place ranking in that country.
  - Nearly three quarters of owners find that project complexity contributes to the value they receive from BIM.
- **Large Size:**
  - The size of the project ranks first in France (34%) and second in the US (36%), but size is less of a factor for UK (25%) or German (22%) respondents.
  - Project size is ranked in the top three by a smaller percentage of respondents in the aviation sector (26%) than by those working on bridge (35%), rail/mass transit (37%) or tunnel (34%) projects.

Top Project Factors That Increase Ability to Experience Value From BIM (According to BIM Users)

Dodge Data & Analytics, 2017



Project Factors That Increase Ability to Experience Value From BIM CONTINUED

Level of BIM Skill/Familiarity Among Project Team Members

Other studies of BIM in the building sector reveal that it is most effective when models are shared across the project team, and that finding is clearly evident for transportation infrastructure as well.

- Having design professionals on the project who are capable of working with BIM is the third most popular factor in the US (33%), UK (29%) and Germany (30%).
- Client familiarity with BIM is the most frequently selected project factor that contributes to BIM value in France, with 32% placing this in their top three.
- This factor is also very important in Germany, ranked in the top three by the second highest percentage of respondents (31%).
- About one quarter rank construction companies familiar with BIM in their top three in the US (29%), Germany (27%) and the UK (25%), but only 19% do so in France, where clients are bigger factors in the ability to experience value from BIM than other team members.
- In Germany, the top factor associated with value for using BIM is good interoperability between software programs among project team members (34%). This also supports the importance of using BIM as a means to share project information across the team. However, those in the UK consider interoperability less of an issue, with only 8% ranking it among their top options. The standards for BIM use laid out in the UK BIM mandate may make this a less critical factor in that country.
- 23% of UK respondents rank contracts that support collaboration as a top factor increasing the value of BIM, but that is in sharp contrast to US respondents, where only 9% select this as a top factor.

Additional Factors

Additional factors selected by only a few respondents that support team coordination include companies having previous experience working together (12%) and a place for physical collocation and collaboration for companies on the project (10%).

BIM Benefits of Greatest Importance in Five Years

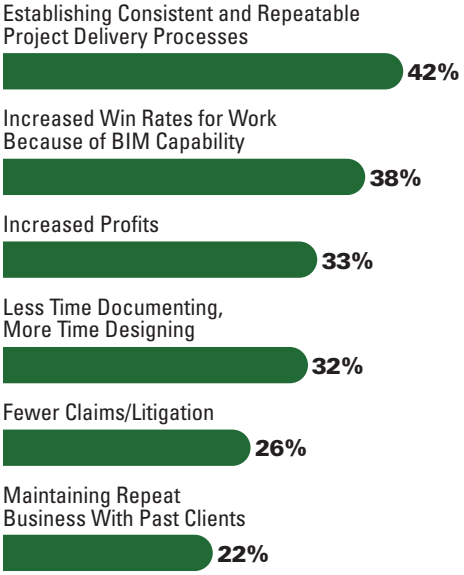
BIM users were provided with the same list of nine benefits discussed on page 17 and were asked to select the top three that will be most important to their company in five years. Understanding the benefits that are considered most important in the future can help in gathering the right performance improvement data to encourage increased implementation. The chart at right shows all of the benefits that were selected by more than 20% of BIM users. Meanwhile, the chart below shows the significant differences between engineers and contractors by country, demonstrating that certain benefits may be more influential in some countries than others.

The top factor is establishing consistent and repeatable project delivery processes, ranked in the top three by nearly half of all BIM users (42%). This finding demonstrates the expectation that BIM will support the transformation of fundamental construction processes. For the most part, there was general agreement on the importance of this factor, although there were a couple of notable differences.

- Engineers and contractors in the US (50%) significantly exceed those in France (30%) in their belief in this benefit's future importance.
- Nearly two thirds of owners (63%) rank this factor in their top three, compared with only 36% of engineers and 44% of contractors.

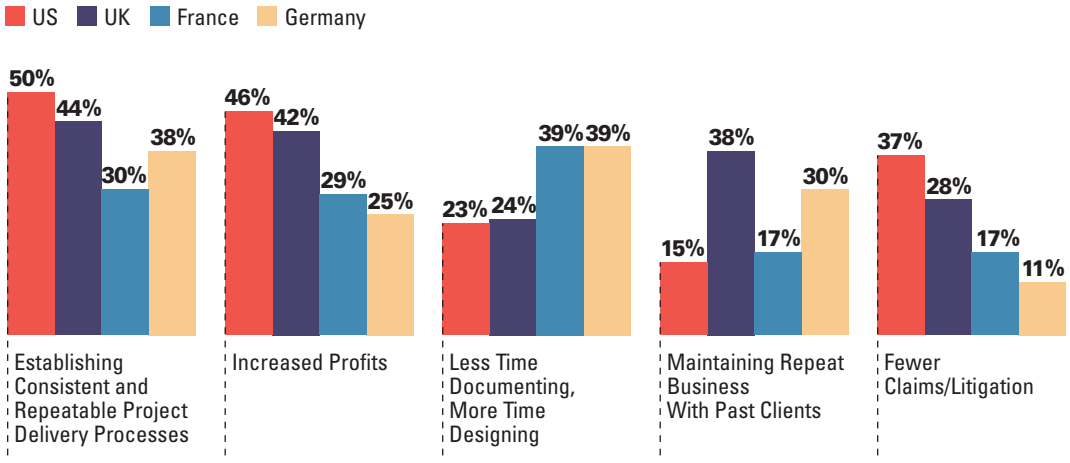
Top BIM Business Benefits of Greatest Importance in Five Years (Selected in Top Three by More Than 20% of BIM Users)

Dodge Data & Analytics, 2017



BIM Business Benefits of Greatest Importance in Five Years (Those With the Most Significant Difference Reported by Country)

Dodge Data & Analytics, 2017



BIM Benefits of Greatest Importance in Five Years CONTINUED

Another benefit widely expected to be important in five years is the ability to increase win rates for work because of BIM capability (38%). This is also one of the top benefits currently reported by respondents (see page 17), and it is not only compelling in terms of obtaining more work, but also for increasing the productivity of the resources that companies deploy to pursue new work. This may explain why this option is equally popular across all four countries included in the study, and why owners (17%) are far less interested in it as a future benefit than are engineers (40%) and contractors (41%).

One third of respondents (33%) believe increased profits are important. The strong performance of this metric demonstrates the importance of formal tracking of how BIM impacts profitability to demonstrate its importance to the user's organization.

- Not surprisingly, this is far more important for engineers (30%) and contractors (39%) than for owners (4%).
- Increased profits are also ranked more frequently as an important benefit for the future by engineers and contractors in the US (46%) and UK (42%) than by those in France (29%) or Germany (25%).

Nearly one third (32%) also rank the ability to spend less time documenting and more time designing as an important future benefit of BIM.

- As might be expected, engineers (38%) are more likely to rank this benefit in their top three than contractors (26%).
- Engineers and contractors in the US (23%) and UK (24%) are less enthusiastic about this benefit than those in France and Germany (39% for both).

Fewer claims and litigation has a notable percentage overall (26%) who select it as an important future benefit, but more engineers and contractors in the US (37%) and UK (28%) rank it in their top three than those in France (17%) and Germany (11%). This is also a benefit that appeals particularly to owners, with over half (54%) ranking it in the top three, more than double the percentage of engineers (21%) and contractors (26%).

Rounding out the list of top benefits is maintaining repeat business with past clients, which is particularly popular among engineers and contractors in the UK (38%) and Germany (30%).

Factors With a Positive Impact on

Increasing Company's Experience of BIM Benefits

In addition to understanding the benefits most important in the future (see page 26), understanding the factors that companies believe will increase their ability to experience benefits from BIM on future transportation infrastructure projects is also essential to encourage wider BIM implementation across the industry.

BIM users were asked to select the top three factors out of a list of 14 possible options. The first chart shows the top seven selected by all BIM users. The second shows the major differences in responses from engineers and contractors by country.

Two factors rank higher than the rest, and in combination, they tell an interesting story. **What the industry thinks would best help them get a positive impact from BIM on future projects is having more internal staff with BIM skills and more owners asking for BIM.** In other words, they want to see more demand for the use of BIM and be able to meet that demand with their own internal workforce. This is far more important to the survey respondents than improved functionality of the software or reduced costs. This suggests a general belief that current BIM functionality is sufficient, and that it is the larger industry that needs to catch up.

In addition to that broader conclusion, there are also interesting variations by country:

- **The need for more internal staff with BIM skills is largely being driven by engineers and contractors from the US, with 41% stating this is a top factor.** It is also the top factor in Germany, but selected by a much lower percentage of respondents (28%). In addition, while not the most important factor in the UK or France, it is still ranked in the top three by a relatively high percentage

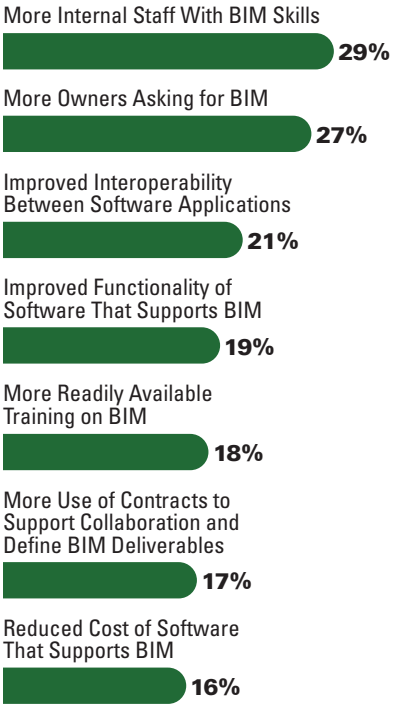
Factors With a Positive Impact on Increasing Company's Experience of BIM Benefits CONTINUED

from both of those countries. All of this contributes to its overall high ranking across the study.

- **The influence of more owners asking for BIM would be particularly strong in the US and UK.** German respondents, on the other hand, see this as far less influential on their ability to benefit from BIM in the future. They are more concerned about the availability of national or international standards, and thus see greater benefit in making BIM use more uniform than in driving the market.
- **A high percentage of UK respondents (30%) believe they would benefit from more use of contracts to support collaboration and define BIM deliverables.** In fact, the percentage of respondents in the UK who rank this among their top three factors is more than double those in France (10%) or Germany (13%). However, the focus in Germany on national or international standards does suggest that they recognize a benefit from having all BIM users apply the same standard, which is another means to support greater collaboration.
- **More respondents from the UK (18%) and Germany (19%) consider hard data demonstrating the business value of BIM critical to being able to experience BIM benefits of future transportation infrastructure projects than those in the US (7%) or France (10%).**

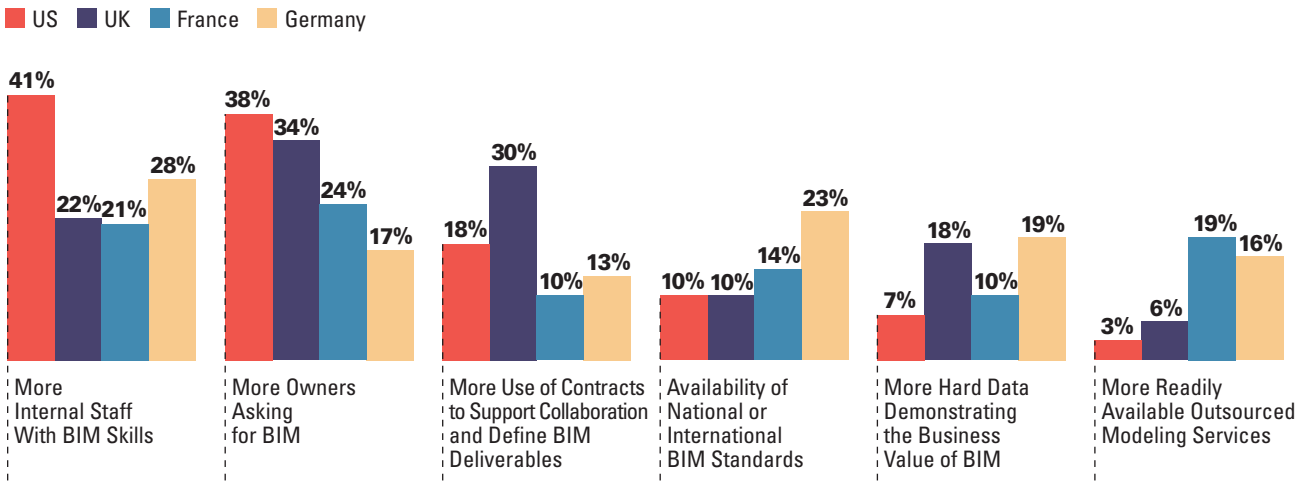
Top Seven Factors With the Greatest Positive Impact on Increasing the Ability to Experience BIM Benefits on Future Transportation Projects

Dodge Data & Analytics, 2017



Industry Factors With the Greatest Positive Impact on Increasing the Ability to Experience BIM Benefits on Future Transportation Projects (Differences by Country)

Dodge Data & Analytics, 2017



Interview: Thought Leader

Jason Fairchild, CAD/BIM Community of Practice Leader, US Army Corps of Engineers (USACE)

Jason is responsible for USACE BIM policy and guidance, with over 25 years of experience with USACE. He supported their Civil Works design construction mission for both the Vicksburg District and Mississippi Valley Division prior to joining Headquarters in 2011.

How has the use of BIM for infrastructure changed in the last five years?

FAIRCHILD: We have expanded our policy to include not only vertical construction, but we've also expanded our BIM requirements to include horizontal construction. We were hesitant to do so before, but with technology and adoption changing, we are starting to see [people within our organization and the AE firms we work with] take the expertise they've built up with BIM for buildings and start to apply that [to infrastructure]. There is more of an understanding that BIM as a process has become our de facto method of operation... We still have issues with people who are ingrained with 20-plus years experience of doing things a certain way, but we are starting to see training requests coming from our field offices and to see a grassroots, bottom-up driven change with technology adoption, so we don't have to push quite as hard from the top.

How has BIM impacted project delivery at your organization?

FAIRCHILD: We've seen a shift away from people asking for some of our traditional deliverables. The owners are starting to see more value in having the model and a handful of representative CAD files to do master planning or to see how their structure fits within the site work. We are starting to see more flexibility in what they will accept as far as equipment schedules. They don't have to rely on transcribing from CAD drawings; they can get the data straight out of the BIM model through Excel or some other translation matrix into a target format ... People are starting to expect information on the civil works side [to the same degree that they see it in vertical construction], even to the point of being able to electronically transmit [models] that can be used directly for fabrication of some of the [elements of projects like gate pieces on locks and dams], whereas in the past, it was a two- or three-generation move from a design CAD drawing to an actual fabrication drawing.

What challenges do you see for the use of BIM in infrastructure, and what are the best ways to overcome those challenges?

FAIRCHILD: From our perspective, when we look at infrastructure, we look at large waterways and projects that have been ongoing for decades. We have so much legacy data [and people used to working with that data] that a cultural change still has to happen to be able to make that jump. It is also a funding limitation on our part to bring all that information and workflow and rework it into a more BIM-centric workflow ... For the entire Mississippi River program, for instance, there is no real way to bring up all the pieces at once, so you end up with a bit of a mishmash where you have to rely on interoperability between the CAD and BIM worlds to be able to effectively leverage that stuff.

What changes do you see on the operational side regarding the use of BIM?

FAIRCHILD: There is a shift starting into true asset management, not just for equipment but also for real property ... Our perspective is to start with the right hand side of the lifecycle and to move back to the left. So first, what we try to do now is ask 'What does the owner/operator need? And how can construction meet that?' And then take it one step further back and say, 'How can design enable construction to meet that owner need?'

What does the future hold for BIM for infrastructure?

FAIRCHILD: We are looking at BIM as a component of advanced modeling ... We have to start being able to do geospatial queries on information from a portal and being able to drive down until you eventually are getting information that you originally defined and populated through BIM. As you develop that, you can get into things like using real-time monitoring, smart meters and remote control. We have tried to do remote operations but it has never been integrated with the target deliverable from the construction process ... It feels like infrastructure has lagged [about five years] behind buildings, but that gap is shrinking. ■

Using BIM on Airport Projects

Airport projects are often massive undertakings, and many teams are turning to BIM to navigate their design complexities, construction logistics and future operations needs. Two airport projects provide examples of how companies are leveraging BIM on their airport projects.

Orlando International Airport Terminal C

Big projects require big teams. Dozens of firms are engaged on the $1.8 billion South Terminal C, Phase 1 project at Orlando International Airport. Although the team used colocation offices onsite to help speed approvals, it is impossible for everyone engaged on the project to be onsite, says Ryan Borszich, BIM manager at HNTB, the architect of record. The project, which recently completed design development, had six different architectural firms spread across offices in four different states, all of which shared scope on the landside and airside terminals. The project currently has more than 30 consultants with more than 200 users working on BIM models. "People are located all over the U.S.," he says. "The biggest issue for us has been wrangling all of these users into a collaborative environment."

To address the issue, the team used a cloud-based solution to host nearly 100 shared models. "This has allowed people to jump into any one of those models at any given time as if it lived on my server," Borszich says. "At any given point of the day, just in my model—not accounting for the linked models—if I check the dashboard, I can see 15 to 18 people in the model. Without this solution, there would be no way to do this."

Borszich says the team uses a shared drive that behaves like a local drive, so people can link files directly from it. "Rather than posting the models each week, they post to that drive, and it syncs to everyone else's drive automatically," he says. "That's taken out a huge amount of work. I worked on sports projects where I was managing eight models, and it felt like a full-time job managing those uploads and downloads. We've essentially eliminated that on this job."

It's been particularly helpful when trying to work around some models that are specific to airports, such as baggage handling. "That's like trying to coordinate around a mechanical system that's on steroids," Borszich says. "It has a huge footprint everywhere it goes, and it's a massive design constraint trying to work around that. It's a moving target. Every time we change something, the baggage-handling model changes."

The solution isn't without its challenges. For example, sometimes users will accidentally delete files or folders. "This is a full trust environment," he says. "If I give someone full access and I want them to be productive, it's all in or all out. That's an adjustment for everyone." Part of the concern is that it is difficult to track which users made which changes.

As the project begins construction, however, Borszich says the construction team does not have live real-time access to the design team's models. Instead, they will get access to periodic updates. "The contractors build their models in parallel to ours," he says. "Ours is a point of reference for them to refer to and note changes and use it to gauge what's going on. Our model is for reference only."

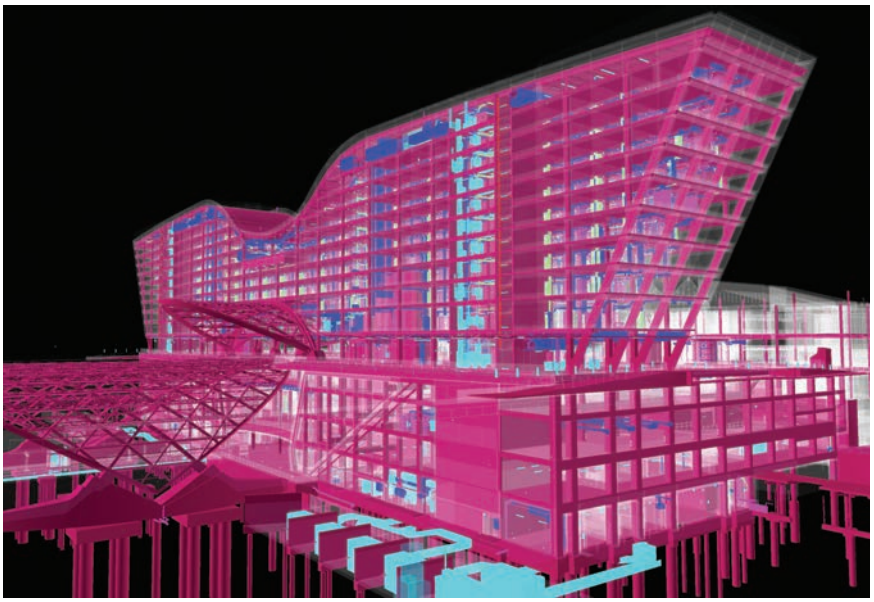
Denver International Airport

For airport authorities, the prospect of leveraging BIM data for facilities management is alluring. In 2014, Denver International Airport (DIA) rolled out a new facility management program that uses building information modeling to combine multiple databases that contain facility data into a central location. The system allows personnel access to information on when an item was purchased, the cost, the item's specific location, when it was installed, the routine maintenance schedule for the item and other information important to maintaining airport facilities.

Brendan Dillon, BIM manager at DIA, says personnel are able to push and pull data from the asset management program, fulfilling data requests on an almost daily basis from everyone from Denver Police and fire departments to event planning, space management and conceptual project exploration.

"There are a lot of benefits within design and construction, but really the biggest value of BIM as a process is within facilities management," he says. "Project construction lasts two to four years and then we maintain the facility for up to 50 years or even

Images Courtesy of Denver International Airport



DIA is using data from models, like the one created for the Hotel and Transit Center (on left and under construction above), for facilities management.

longer. Knowing exactly what we're getting in the facility and being able to use that for future renovations and reconstructions is really critical."

DIA first implemented the BIM integration on its Hotel and Transit Center program, which includes a 519-room hotel, an open-air plaza and a transit center with rail and bus access.

Since BIM was still an emerging technology when the hotel and transit center project started, Dillon says there was some initial uncertainty about the best way to leverage BIM data for facilities management.

"The airport was trying to figure out exactly what they were going to do with the models," he recalls. "Our asset management program hadn't been set up yet. So there was a lot of figuring out what could be possible... The airport at that time wasn't entirely sure what information we needed. Because we weren't entirely sure, our requirements weren't as specific as they could have been."

As part of the initiative, DIA undertook an internal model reconciliation process, comparing the design models against the construction models. "We had initially envisioned a larger scope for reconciliation, but the airport soon recognized that we didn't need everything moved into the design model," Dillon says. "It was a matter of identifying what was important, what was not important and making sure we got the important stuff."

Prior to the hotel and transit center project, the DIA asset management system captured an average of one asset per 1,000 sq ft of facilities. For the hotel and transit center project, the team captured 3.3 assets per 1,000 sq ft of facilities. On each of those assets, the average number of attributes populated per record nearly doubled from 6.5 attributes to 12.5 attributes.

Although the model reconciliation was successful, Dillon sees room for improvement. While the team can easily work with established BIM design tools, construction tools are varied and can have limited interoperability.

"Down the line, what we're hoping is that the software tools that the design teams and construction teams are working with will communicate better," he says. "The construction model will be able to be imported into the platform the designer is using. We will get that construction information in a genuinely federated model delivery."

Based on the success of the first project, DIA has since required BIM data for facilities management on several subsequent projects. "The biggest take away for me was: Be specific," he says. "While being specific might seem overly prescriptive, it's what we need to do in order to get the information we need to maintain our facilities the way we want." ■

Data: BIM Investments

BIM Investments

Companies typically need to make a wide variety of investments to ensure that they optimize their use of BIM. These investments include not just technology, but training, process improvements and creating libraries of materials, among others. Understanding BIM users' investment plans can reveal a great deal about how they use it and what their priorities are.

To capture this information, engineers and contractors using BIM were asked to select their current top three investments and those that they expect to be their top three investments in the next five years.

Training

The top investment, both now and in the next five years, is training on BIM. In fact, the percentage who expect to invest in training grows by a few percentage points in the future. This finding, along with the emphasis on having more internal staff trained in BIM to achieve BIM benefits in the future (see pages 27 and 28), demonstrates that the industry still needs more people with BIM skills.

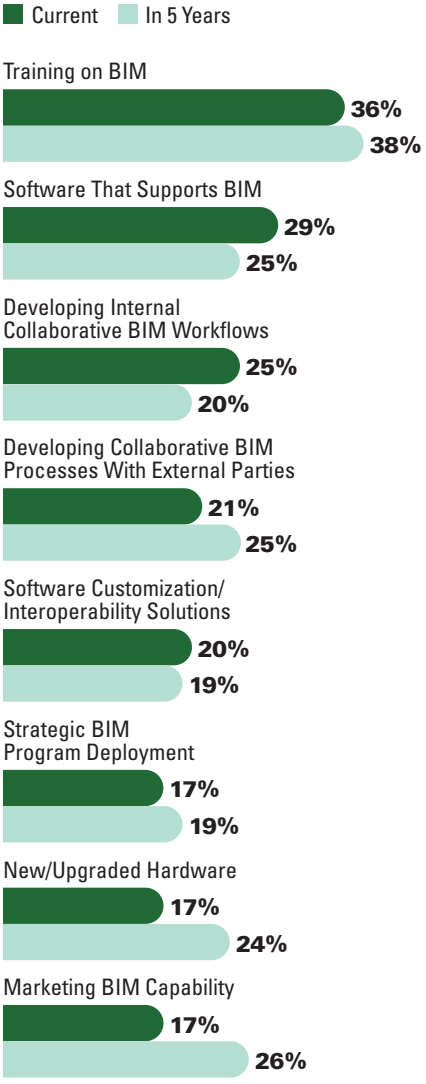
- **By Country:** There is also a greater emphasis on training in the future from respondents from the US (43%) and UK (48%) than in France (34%) or Germany (27%).
- **By Role and Size:** While there is no significant difference between engineers (36%) and contractors (39%) in terms of their investment in training in the next five years, there is a difference by size for engineers. Nearly half (48%) of smaller engineering firms (those with less than 250 employees) rank investments in training among their top three for the next five years, compared with 29% of larger companies. Typically, BIM is first adopted by larger firms in most segments, and this may suggest increasing maturity for BIM for infrastructure as smaller firms seek to catch up on BIM skills.

Technology

Software investments currently rank second, with 29% reporting that this is one of the top three investments in BIM made by their company. A slightly lower percentage (25%) consider investments in software a priority in the future. On the other hand, while upgrading hardware is currently a relatively low current priority (17%), those intending to make those investments in the next five years grow to 24%, nearly equaling those expecting to invest in software.

Top Investments Related To BIM (Selected as a Top 3 Current Investment and Top 3 Investment in Five Years by BIM Users)

Dodge Data & Analytics, 2017



BIM Investments CONTINUED

Another category of technology investment is software customization/interoperability solutions. A moderate percentage consider that a priority now (20%) with only a nominal drop in the future (19%), suggesting steady interest in this area.

- **By Country:** The only difference by country in current investments is that a relatively high percentage of German respondents (31%) are investing in software customization/interoperability improvements. However, in the next five years, many BIM users in the UK (36%) expect their company to invest in software that supports BIM, and many US respondents (34%) report that their company expects to invest in new/upgraded hardware, far more than those in the UK (14%) or France (21%).
- **By Project Type:** 31% of those doing rail/mass transit projects believe that software that supports BIM will be a top investment in the next five years, compared with 21% doing tunnels, 24% doing bridges and 25% doing roads.

Processes and Collaboration

Several of the top investments currently involve processes that enhance the use of BIM and encourage collaboration. Currently 25% of respondents report that investments in developing internal collaborative BIM workflows are among their top three, but within five years, that shrinks to 20% and the focus shifts to developing collaborative workflows with external parties, which grows from 21% who prioritize it now to 25% in the future. This may suggest the growing maturation of BIM in the transportation infrastructure sector, as more companies use BIM and the opportunities for more external collaboration grows.

Another investment considered moderately important both now (selected in the top three by 17%) and in five years (selected in the top three by 19%) is the strategic BIM program deployment. This is also evidence of firms expecting greater implementation in the near future.

- **By Country:** A higher percentage of German respondents rank developing internal collaborative BIM workflows as a top investment now (36%) and in the next five years (31%) than in the other three countries, which average 23%.
- **By Role and Size:** More contractors are currently investing in developing collaborative BIM processes with external parties (25%) than engineers (16%), with the investment largely driven by contracting firms with 100 or more employees. However, that pattern shifts in five years, with 28% of engineers ranking this investment in their top three compared with 23% of contractors. On the other hand, more contractors (23%) plan to invest in strategic BIM program deployment in five years than do engineers (15%). These differences may be directly related to the wider implementation of BIM currently by contractors and the high expectations of expanding BIM implementation in the near future among engineers (see page 10).
- **By Project Type:** More respondents working on bridges (30%) and aviation projects (36%) are planning to prioritize investments in developing collaborative BIM processes with external parties than those doing roads (25%), rail/mass transit (23%) or tunnels (24%).

Marketing

As BIM implementation grows in the infrastructure sector, so too does the intention of users to invest in marketing of their BIM capabilities. The percentage of those who plan to prioritize this investment in the future is 9 percentage points above those prioritizing it now, the largest leap among the investments studied.

US respondents are most engaged with marketing investments in the future, with 32% seeing this as a top priority, and respondents in the UK are the least interested, with only 16% ranking it in their top three.

Other Investments

The three investments that attracted the fewest respondents for their top three currently or in the future are:

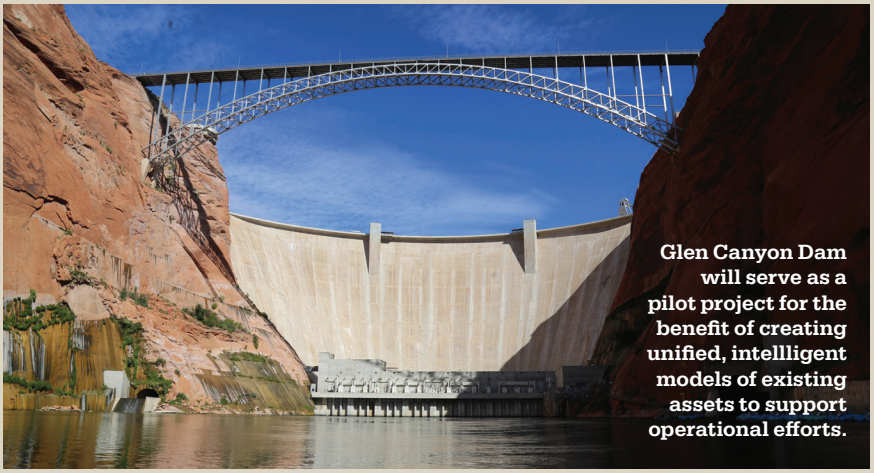
- BIM Certification With an Accreditation Agency
- Developing Custom Libraries of Content for BIM
- Implementing National BIM Standards

case study

BIM Goes Big: Modeling Glen Canyon Dam

Glen Canyon Dam

PAGE, ARIZONA



Glen Canyon Dam will serve as a pilot project for the benefit of creating unified, intellligent models of existing assets to support operational efforts.

At 710 feet high, with a predicted useful life between 700 and 1,000 years, and holding back up to 26.2 million acre-feet of water, Glen Canyon Dam, the second-tallest concrete-arch dam in the United States, is no ordinary piece of infrastructure. However, it will serve as a pilot project at the Bureau of Reclamation that will demonstrate the advantages of BIM for existing infrastructure assets.

From Fragmented to Integrated

Glen Canyon Dam, built across the Colorado River near Page, Arizona, was completed in 1964 to help meet the water and electricity needs of the West's increasing millions. Glen Canyon is one of some 340 dams, 50 power plants and other water infrastructure constructed by Reclamation since 1902, each of which is described by its own set of hundreds, if not thousands, of drawings. To date, some 10,000 drawings describe the design, construction, operation and maintenance of Glen Canyon alone.

"Each one of these drawings is just a small piece of the whole," says David Winslow, a civil engineer with the bureau's Upper Colorado Regional Office. "Important as they are, they don't provide a good understanding of the breadth and depth of this facility or the components surrounding the ones a particular drawing shows."

Cooling system pipes, for example, move both horizontally and vertically through Glen Canyon's power plant, along with associated systems, such as fire protection and potable water. But each two-dimensional drawing describes only one level and one system: Understanding what happens when a pipe moves up or down a level requires locating it on another drawing; and getting more than a diagrammatic understanding of relationships with associated systems is even harder. The same applies to the facility's electrical systems. And with both systems needing regular replacement—piping every 50 years, and electrical systems every 10 to 15 years—Reclamation is looking for ways to improve the interface.

"This is not a building that's going to last for 50 or 100 years and then be taken down," says Winslow. "We have to maintain it and show how we've changed it over hundreds, if not thousands, of years." So in 2016, Reclamation initiated a study in partnership with Autodesk, with Winslow as principal investigator, to determine whether a unified intelligent model of Glen Canyon Dam and power plant could foster enhanced facility management.

Building the Glen Canyon BIM

Although Reclamation has experience with many of the applications being used to build the Glen Canyon model, the combination of applications on a facility at this scale is something new. This project is intended to serve as a proof of concept, and to develop Reclamation's expertise, identify best practices, and establish guidelines and procedures for the completion of similar projects throughout Reclamation facilities.

The data for building the BIM model comes from multiple sources, including a point cloud, laser scanners and hundreds of photos. A helicopter allowed them to capture bird's-eye video and stills of the dam, power plant and surrounding area. Inside the power plant, an unmanned aerial system (UAS) was able to take photos in the large, high spaces of the main generating rooms from perspectives that would not have been possible any other way.

With scanning finished last fall, the models are now under construction, and two of four levels of the power plant are complete. Recognizing that not all user groups have the need or

CONTINUED

Images Courtesy of Autodesk, Inc.

Glen Canyon Dam

PAGE, ARIZONA

ability to interact with the full BIM model, the project will generate several different types of models to support multiple user groups. "We're really looking at this to revolutionize the way our crews here work on and manage this facility," says Winslow.

A Multi-Modal Model

One of the first design uses of the model will be to keep out Quagga mussels. An invasive species known for clogging the intake filters of pumping stations and power plants, as well as for impacting biosystems, Quagga mussels are now showing up at Glen Canyon, necessitating the addition of new screening components. An integrated model showing all of the facility's systems in three dimensions will help engineers see more clearly where they have room to push apart existing components and insert the additional screening.

Monitoring leaks is another example of work the model is expected to support from an operations perspective. Like any concrete structure, the dam has developed cracks, and the tremendous hydrostatic pressure on the structure means water inevitably seeps through them. This seepage is designed for, collected, measured and released downstream, with trends and issues monitored and mitigated as necessary. Tying all of this information into the BIM model will facilitate this work.

Maintenance staff will be able to use information exported to a desktop or tablet model that will allow them to see through the concrete to what is above or below them, as well as to access user manuals, operating instructions and maintenance reports. Similarly, security staff and emergency responders will be able to use information from the model to anticipate where they need to go, what types of conditions they'll face when they get there and how best to prioritize their objectives.

A security-approved model will enable Reclamation's public affairs department to support STEM curricula in schools: to demonstrate the operations and maintenance of a dam for elementary school students, or to provide college students with the opportunity to actually get in and use the model.

In the dam's visitors center, a version of the model may be used to generate a fly-through of the generator, demonstrating what is inside and how it works—something very few people could see otherwise. It may even be possible for visitors to don virtual reality headsets and watch a generator turn the energy from moving water into electricity. For wider outreach, the model could provide a virtual tour through the dam, or a sneak peak of what's in it. "We work for the public," says Winslow. "The people have given us the authority to build these facilities and to manage them in the best way that we can—so helping them to understand what we do is important."

Piloting Long-Term Improvement

The Glen Canyon BIM model is piloting a transformation that Winslow hopes will benefit all Reclamation's regions, providing design and construction personnel with a better understanding of how the design relates to other systems and components; providing facility management, security and operations personnel with more information from a single interface; providing maintenance personnel with increased access to updated system information; and providing public affairs personnel with the ability to create images and video presentations from the model to educate the public. "It's going to be a long time into the future that these facilities will be around and can be useful to the nation," says Winslow. "We're looking for ways to manage them better, be smarter and disseminate ideas for improvement." ■

The model of the dam can be accessed on a tablet to help with operations and maintenance.

Endgame:

CIM for Lifecycle Asset Management

As Civil Integrated Management (CIM) gains traction in the transportation sector, practitioners on CIM's leading edge are beginning to expand its application beyond design and construction to include lifecycle asset management.

Not simply the adoption of BIM into the horizontal construction sector, CIM encompasses "the technology-enabled collection, organization, managed accessibility and use of accurate data and information throughout the life cycle of a transportation asset," according to a definition provided by the Federal Highway Administration. It integrates sensing and data management tools as well as modeling. The path to its adoption is not fixed, but varies according to each agency's vision and current state of practice.[1] Regardless of the path taken, however, "CIM has a wired connection with asset management," says William Pratt, a principal engineer with Connecticut's Department of Transportation. "That's what it's about."

A Programmatic Approach

CIM-based asset management has the potential to provide a cradle-to-cradle approach where the asset information required in each phase of project delivery drives how asset data is collected and used, leading to efficient business plans and truly lean asset management. That's the vision of one of the most advanced early adopters of CIM for asset management, Utah Department of Transportation (UDOT), which is evolving its asset data collection program into the first fully integrated asset management system in the U.S.

Models created for the construction of major projects now provide data for asset management throughout the life of the asset.

UDOT takes a programmatic approach, based on the belief that "the basis of lifecycle asset management is knowing what you have," says Stan Burns, UDOT's recently retired asset management director, and now a CIM consultant, "and believe it or not, DOTs do not know what they have." To remedy that, UDOT let contracts to digitize every visible feature within the right-of-way across 6,000 centerline miles of state-owned roadways: every sign, guard rail and intersection, the width of every road, the location of every pavement stripe. UDOT then integrated this information into an innovative data management system which the Department's multiple business units had previously collaborated to develop. "Ultimately we're doing this because everybody believes you can make better decisions with data than without data," says Burns. "We want to get to the point where it's an authoritative, single source of truth that's updated and current."

CIM's potential benefits include cost and time savings, improved information flow and increased effectiveness of agency professionals and service providers, benefits that apply to lifecycle asset management as well as to planning, design and construction. In inventory

Image Courtesy of Wisconsin DOT - SE Freeways, Lance Parve

reporting alone, for example, UDOT's newfound ability to examine roadway features without leaving the office is expected to generate labor-related savings of about $200,000 a year, a reduction of 84% compared with performing the same work using previous methods. The department's Highway Performance Monitoring System reporting is expected to drop from 3,300 hours to 700, producing inventories of bike corridors to drop from 300 hours to half an hour, and producing billboard inventories and measurement to drop from 90 days to one day.

With the capacity of today's technologies to measure at highway speeds the length, width and depth of every crack in the pavement, system planners face a significant challenge in prioritizing what data to warehouse and update. Broadly speaking, suggests Burns, the data that is worth collecting will vary with both the value and the importance of the asset. A bridge in critical condition poses a higher risk than pavement in critical condition; pavement, as the network's single most valuable asset, warrants a close watch; and delineators, cheap to fix and easy to replace, may be scarcely worth documenting at all. Looking ahead, innovations such as tools for sensing subsurface infrastructure and vehicles that drive themselves will present even more factors to consider.

Just Do It

The sheer volume of decisions can be daunting, warns Charles Hixon, a senior project manager at EDGE-Global Technology Solutions. "Trying to solve every aspect in advance slows down the implementation process," he says. "It's an almost impossible task." Instead, Hixon references the history of CAD: adopted in bits and pieces, and perfected on the go. He also sees project-specific BIM execution plans as a useful precedent from the vertical construction world, with standards, guidelines, tools and processes focused to the needs of each project, and offering lessons to carry forward to the next.

Wisconsin provides an example of a DOT making headway with a project-led approach. Wisconsin DOT SE Freeways, an early adopter of CIM for model-based planning, design and construction, is looking to update and reuse its project-generated models for maintenance and asset management. Driven both by the quantity of infrastructure now reaching the end of its useful life and by the instigation of a nationwide effort to evaluate the status of transportation facilities by MAP-21 (a highway funding act signed into law in 2012), current levels of reconstruction and resurfacing, restoration and rehabilitation work "require a project-by-project and a more comprehensive approach to data warehousing to generate coverage that is both detailed and broad," says Lance Parve, a senior project engineer and CIM coordinator with WisDOT.

Using the major and mega projects of the urban southeast section of the state as an incubator, WisDOT intends to mine data generated in its design and construction models, as well as existing data from multiple disciplines, to create a pilot regional GIS-based data warehouse with links to statewide GIS databases. In addition to prioritizing which data to warehouse, Parve identifies the most significant challenges, such as keeping data up to date with continual infrastructure changes, and working around shortcomings in the interoperability of CIM's diverse software and systems.

Beyond these technical challenges, perhaps the most significant obstacle to CIM for lifecycle asset management is a cultural one: the silo-based processes and work habits that evolved before CIM's level of coordination was possible. Under the new paradigm, information stashed in someone's spreadsheet or file cabinet is virtually useless: "If it's not in the portal," says Burns, "it's not data." And yet, he adds, CIM is not just a matter of the separate divisions within a transportation agency tossing their databases and programs into a portal and expecting it to supply useful answers. Divisions likely have different base maps, updated only as their particular needs warrant, and may be out as much as half a mile from each other. Financial data bases may report by calendar, state or federal fiscal year, yielding three different answers to a fiscal question. And if one division is asked to update its base map or jig its parameters to meet the needs of another, questions about the appropriate allocation of time, money and other resources will need resolution. At every level of the endeavour, "in CIM," notes Hixon, "the "I" stands for "integration." ■

[1] NCHRP Report 831: Civil Integrated Management (CIM) for Departments of Transportation provides an implementation framework and case studies for agencies mapping their transition to CIM.

Data: BIM ROI

Perceived ROI on BIM

Currently, the construction industry does not have a standard way to measure the return on investment (ROI) of BIM. However, most who invest in using BIM are aware of its benefits and costs, and therefore have an idea of the degree to which they are seeing a positive return on that investment. In all its BIM research, Dodge Data & Analytics has asked BIM users about their perceived ROI, and in this study, the question was asked of engineers and contractors. In addition they were asked how frequently, if ever, they formally measure ROI and for how long they have been doing it (see page 40).

As a whole, nearly two thirds (65%) of the survey respondents across all four countries report experiencing a positive return on their investment in BIM. This is a particularly positive finding given the fact that nearly half (42%) have been using BIM for three years or less (see page 11), and most BIM users find that longer and more extensive use of BIM yields a better return.

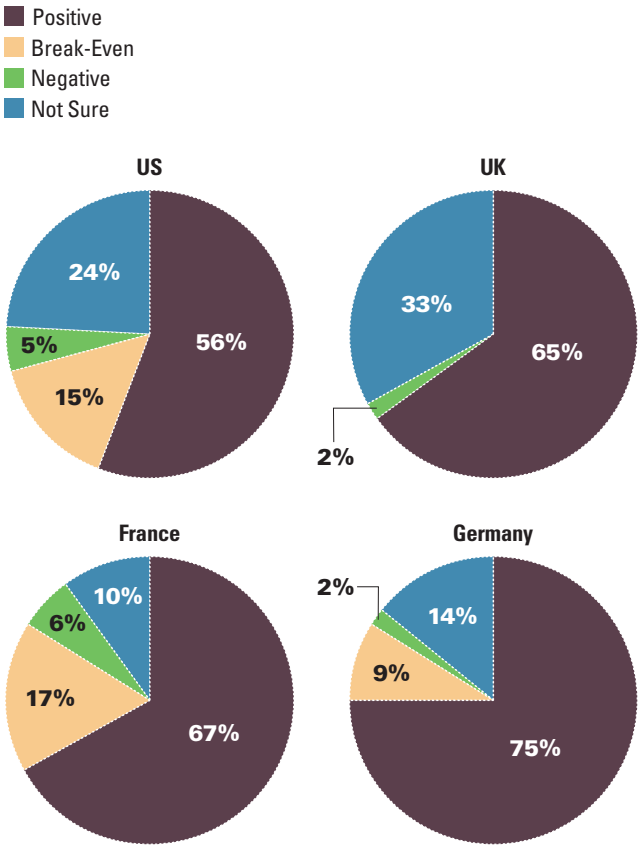
Variation by Country

The chart at right shows how the perceived ROI varies by country.

- **There is greater uncertainty in the US and UK about the ROI they are experiencing from BIM than in Germany or France.** Fewer respondents from the US and UK conduct formal measurements of BIM ROI than do those in France or Germany, a likely cause of this uncertainty. (See page 40)
- **When looking at all respondents, Germany has the highest percentage (75%) experiencing a positive ROI, and the US has the lowest (56%).**
- **However, when those who are uncertain about ROI are factored out, the remaining users in the UK report an overwhelmingly positive response, with Germany right behind.** Among those who feel they can estimate their BIM ROI, 97% in the UK report a positive return, followed by 87% in Germany and 73% in France and the US. One factor that is a likely influence on the overwhelming positive response in the UK is its recent BIM mandate. This has increased overall BIM use and also standardized the level that the models are expected to achieve. Generally, most BIM users experience a higher value from BIM when the model is shared across the project team and can enhance collaboration and improve workflows.

Perceived ROI on BIM (According to Engineers and Contractors Using BIM by Country)

Dodge Data & Analytics, 2017



Perceived ROI on BIM CONTINUED

- **Those who believe that they experience a negative ROI from BIM are low across all four countries, but a relatively high percentage in the US (15%) and France (17%) believe they are just breaking even.** The study findings show that BIM users in France have been using BIM for a shorter time than the other countries (see page 11), and they are also earlier in the implementation scale (see page 10), so the relatively high percentage still just breaking even is not surprising. However, the US responses are more surprising, given the fact that BIM users in the US average the highest years of experience and levels of implementation with BIM. The most likely factor accounting for this is the high percentage of BIM users in the US that do not formally measure their BIM ROI, but more investigation is needed to confirm that there are no other causes.

Degree of Positive ROI

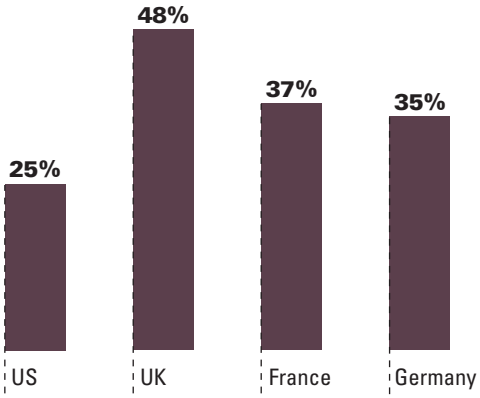
Those who report a positive ROI from BIM were asked to describe the degree of return that they experience. Nearly half of all respondents (43%) believe they have an ROI of 25% or higher, a compelling case for BIM investment.

The chart at right represents the differences by country in the percentage who state that their BIM ROI is 25% or more.

- **The UK not only has the highest percentage who report experiencing a positive ROI, but also the highest percentage of those achieving an ROI of 25% or more.** Again, the most likely reason for this is the implementation of the BIM mandate, which has helped to ensure that more project team members use BIM and provided consistency in how BIM is used.
- **The lowest percentage of those reporting a 25% or greater ROI are in the US.** Again, this may be influenced by low levels of formal measurement of BIM ROI in the US, but the lack of a consistent BIM standard in the US may also contribute to this finding.

Perceived ROI of 25% or More (According to Engineers and Contractors Who Report a Positive BIM ROI)

Dodge Data & Analytics, 2017



Formal Measurement of BIM ROI

Use of Formal Measurement

Engineers and contractors who use BIM were asked whether they formally measure the ROI of their investments in BIM, and if so, on what percentage of their projects. **Overall, 74% report that they do formally measure BIM ROI, and measurement occurs on average on about one third (34%) of their projects.**

Among those who are not currently measuring ROI on their projects, only 9% think it is likely their company will begin measuring ROI in the next year and about one quarter (27%) think that their company will probably never measure BIM ROI. The lack of interest among those not currently measuring suggests that these figures are unlikely to change in the near future among current BIM users, but it is quite possible that as companies that are currently not using BIM decide to adopt it because of its reported benefits, they will be motivated to track their ROI on that investment.

VARIATION BY COUNTRY IN USE

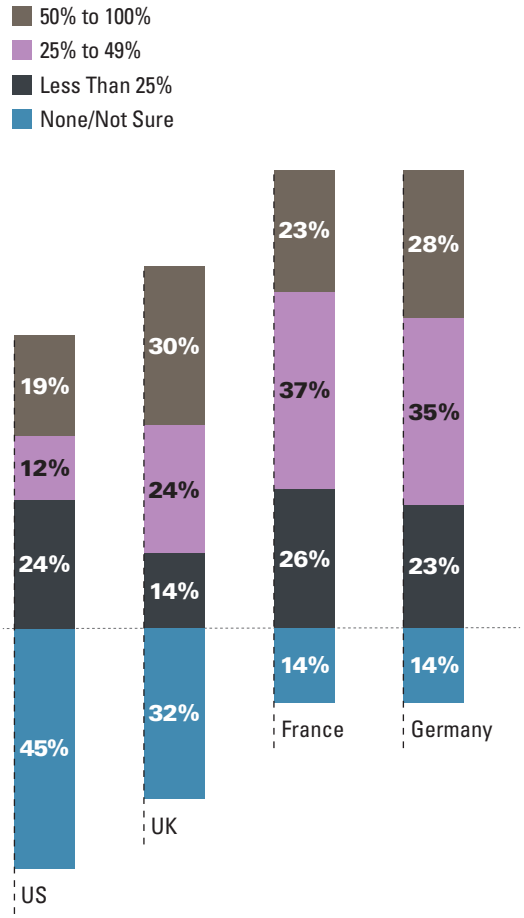
Nearly half of the US respondents (45%) report that their company does not formally measure BIM or that they do not know whether their company formally measures BIM or not. This finding is in stark contrast to the responses from Germany and France, where only 14% report that they do not measure or do not know whether their company measures BIM ROI. It is also consistent with previous international studies about BIM for the building sector conducted by Dodge, in which the US consistently performs much worse in formal measurement than most other countries.

Since the US has one of the longest histories of BIM use, it is possible that US BIM users believe that the benefits of BIM are well understood, so formal measurement is unnecessary. However, the findings on the perceived ROI of BIM (see page 38) suggest that US BIM users may be underestimating the value they achieve from BIM because of the lack of formal measurement.

The UK also lags notably behind France and Germany, with nearly one third (32%) reporting that they do not formally measure BIM. The fact that BIM is mandated on all government projects may reduce the need to quantify the value of using it by companies in the UK.

Percentage of Projects on Which ROI is Formally Measured (According to Engineers and Contractors Using BIM by Country)

Dodge Data & Analytics, 2017



Formal Measurement of BIM ROI CONTINUED

VARIATION BY ROLE IN USE

Engineers are doing more formal measurement of BIM ROI than contractors currently, with 18% of contractors reporting that they do not conduct formal ROI measurement compared with 8% of engineers. However, if they are measuring, engineers and contractors are doing so on roughly the same average percentage of projects.

VARIATION BY COUNTRY IN FREQUENCY

Not only do fewer engineers and contractors in the US formally measure their ROI, but a much higher share of them only measure BIM ROI on less than a quarter of the projects than do their European counterparts.

In contrast, among those who are formally measuring BIM ROI in the UK, the majority is doing so on 50% of their projects or more, the highest level of all four countries when only considering those who conduct formal measurements.

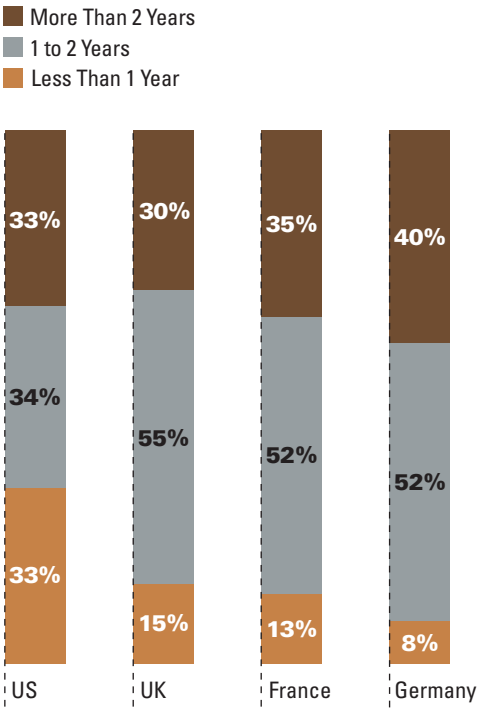
In both Germany and France, the highest percentage conduct BIM ROI measurements on between one quarter and one half of their projects.

Years Measuring BIM ROI

Most companies measuring BIM ROI have been doing so for more than one year, and a healthy percentage of those have been doing it for more than two years. Surprisingly, the US leads the rest in terms of those who have only been measuring by less than a year, with more than twice the percentage in that category. It is possible that this represents growing awareness in the US of the value of measuring the financial benefits that they gain from BIM.

Years Measuring BIM ROI (According to Engineers and Contractors by Country)

Dodge Data & Analytics, 2017



Interview: Thought Leader

Cory Dippold, PE, Vice President, Digital Delivery Services, Mott MacDonald

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

What are the biggest changes that have occurred in the use of BIM for infrastructure in the last five years?

DIPPOLD: Five years ago, we were just starting to see the potential of BIM for infrastructure. BIM for infrastructure is fundamentally different from BIM for buildings. Where buildings are made from a lot of very precise pieces that are easily quantified in a computational environment, BIM for infrastructure is a lot softer. Existing grades, ground elevations, existing conditions information can be more ambiguous and difficult to compute. In the last five years, we've seen a huge leap forward in the software that's fit for infrastructure. Key modeling applications have become very good at dealing with infrastructure computations, understanding ground control, being able to compute complex infrastructure that has a lot of bidirectional curvature and that varies over the center line. In 2012 and prior to that, applications struggled to model that really well.

Another thing we are seeing in terms of BIM for infrastructure is technology that allows us to capture very high quality existing conditions information, whether it is surface or subsurface information. Our ability to de-risk a major infrastructure project that could be in the millions of dollars is dependent on our ability to capture high-precision existing conditions information, such as buildings, pipes, roads, gutters, ground conditions and technical conditions. Our use of current generation laser scanning, photogrammetry and reality capture techniques have improved our ability to develop good, very high quality linear and data infrastructure models.

What impact have you seen from BIM on project delivery for transportation infrastructure projects?

DIPPOLD: Project delivery is critically dependent on our ability to manage information. The data sets we deal with are getting larger year by year. Ages ago, you could measure your digital project data in megabytes. Then it became gigabytes of information. Today a major infrastructure job could have multiple terabytes of information ... To perform high-quality project delivery, you have to manage that data in different ways, which includes new roles on projects. [You need to] understand how that information is related to other information in complex ways. The sheer volume and scale of information that we deal with has to be managed differently.

We spend a lot of time focused on the evolving nature of how we manage complex infrastructure information in a BIM environment so that we handle it efficiently and in a way that improves the overall project delivery process. First, can we deliver projects with less risk? And second can we deliver projects with more value to the owner? Improving the way we manage information, which also extends beyond the modeled environment, helps us deliver projects more effectively.

What are the new roles that help with information management?

DIPPOLD: Some of the new roles we are seeing include data management specialists who help manage the volume of information. On some projects, we have project platform specialists who are focused on how we use our platform applications and how they are interrelated or interconnected. Most of our major infrastructure BIM works will include BIM managers and/or BIM coordinators. We are very intentional and deliberate in our approach to all that rich and valuable project information. Traditionally, document control had a fairly prescriptive set of duties, whereas data management today requires a much broader skill set to be done effectively.

What are the biggest challenges to wider use of BIM for transportation infrastructure?

DIPPOLD: We are still risk averse as an industry, especially here in the United States, where engineers are held personally accountable for their design work product. Engineers tend to align themselves to known work methods. If they don't understand the technology, it is perceived as a risk. The mind-set is still that efficiency equals doing things as close to the way we did them last

time with improved processes, instead of how far forward can we envision a project delivery effort that uses progressive technology and how closely can we align this particular effort to that vision.

What can be done to improve use of BIM across the project team?

DIPPOLD: We have seen things go well when very early in the project, we have clearly described in plain English what our expectations were in terms of the approach. Partners on projects can have varying degrees of capabilities, and you can only move as fast as the least capable team member ... [To address that], one thing we are doing is .. evaluating partnerships and discussing expectations at the teaming agreement stage. We say, "This is how we want to work: Will you be capable of working with us in this way? Do you have use capabilities with this particular software? Do you use these applications to manage data? Will you commit to a progressive technology and delivery approach to the job?" [These issues are] addressed at the contractual level to ensure that our projects partnerships will operate efficiently.

How much interest do you see from clients in using BIM data during the operational phase of an asset?

DIPPOLD: It is varied but increasing. I believe our clients are aware of the value the information could present ... Everybody lives in the age of iPhones and ubiquitous access to the internet and information. Everybody understands the power of information. And I think everybody has bought into the idea, that when done correctly, [BIM can offer value] in terms of operations and maintenance and lifecycle cost management.

I often caution that we tend to use digital as a proxy for more efficient. In some cases, we may provide more value to the owner by using a BIM approach to do work more efficiently. In other cases, we may use a BIM approach to develop a more robust work product, meaning more information that can be used for downstream benefit. In other cases, we might use a BIM approach to perform work more safely ... When you elect to use a BIM type of approach, it now gives you a choice of different value streams to pursue. From that standpoint, we may not always elect the fastest or most cost effective way to the finish line, but provide a more valuable handover in terms of the information we are providing. That is something that I believe resonates strongly with many of our owners and clients.

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

DIPPOLD: The next major shift in technology, which is likely to be the most impactful, disruptive and compelling, is the potential for A.I. [artificial intelligence]. I mean the full spectrum of A.I.: everything from cognitive computing to machine learning. [I see major opportunities for this technology] for the AEC industry in terms of our ability to perform more advanced analysis faster than ever before and truly arrive at optimized solutions by automating our design workflows, [and by] being able to capture the value of the body of information and data that is developed in the project delivery effort for use in other areas. [A.I. can support] being able to effectively analyze more complex multivariable equations, being able to evaluate more design options, with more inputs that yield better and more predictable asset performance ... I am very focused on how A.I. and generative design technology are going to evolve—not only the quality and technical opportunities in what we do—but evolve the commercial models, evolve our industry standards, evolve virtually everything that we do. ■

Data: Non-Users

Non-Users' Attitudes Toward BIM

At the beginning of the survey, a small share of the respondents stated that they do not either create models in BIM or work with models created by others. Understanding the responses of the non-users is critical to see the potential for BIM growth in the transportation infrastructure market. However, the responses of non-users are too few to conduct an analysis by country, so they will be analyzed in aggregate.

Non-Users Attitudes Toward BIM

Respondents not using BIM for transportation infrastructure were asked to select a sentence that best describes their attitudes toward BIM. Three of the options were positive, ranging from interest in exploring BIM's potential value to active evaluation of it. Two were negative, including those who tried BIM but no longer use it and those who are not interested in trying it.

The chart at right reveals that nearly two thirds (64%) of those not currently using BIM has a positive attitude about it, with 20% of total non-users in the process of actively evaluating it. This suggests that continued growth in BIM use in the transportation infrastructure sector is likely.

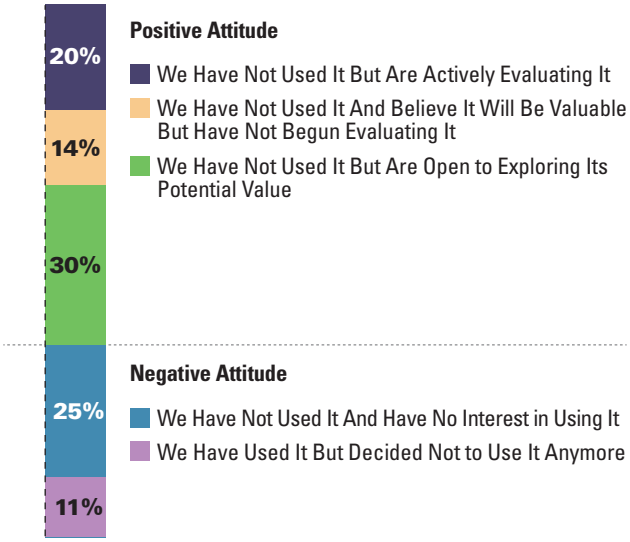
Among non-users, **engineers have a more positive attitude about BIM than contractors.** 36% of contractors say that they are not interested in using BIM, nearly three times the percentage of engineers (13%). In addition, 44% of engineers say that they are open to exploring the potential of BIM, twice as many as contractors (22%).

Expected Importance of BIM in Five Years

Another example of the generally positive attitude about BIM among non-users is that **the majority (71%) expect BIM to be at least moderately important for transportation infrastructure in the next five years.** The need to stay competitive may encourage those who feel BIM will be important to consider using it.

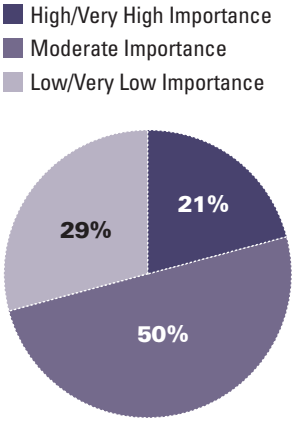
Non-Users' Attitudes Toward BIM for Transportation Infrastructure

Dodge Data & Analytics, 2017



Expected Importance of BIM for Transportation Infrastructure in the Next Five Years (According to All Non-Users)

Dodge Data & Analytics, 2017



BIM Use for Infrastructure by Competitors

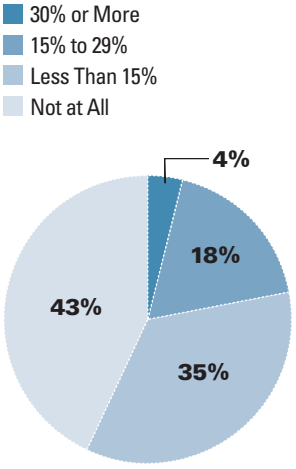
Respondents who said that they do not use BIM were asked how frequently they think the companies that compete with them for infrastructure projects are using it. Believing that the competition is using BIM can be an important driver in BIM adoption as companies try to stay competitive.

Over half (57%) of the non-users believe that their competitors are using BIM. However, nearly all of them believe that even the competitors using BIM are using it on less than 30% of their projects. In fact, the study demonstrates that **their competitors who use BIM are doing so on average on nearly half (48%) of their projects,** and they expect that use to grow in the next few years (see page 10).

This finding suggests that non-users may face greater pressure in the near future due to competitor adoption of BIM than they currently believe.

Frequency With Which Competitors Are Using BIM (By Percentage of Projects According to Non-Users)

Dodge Data & Analytics, 2017



Frequency of BIM Requests by Owners

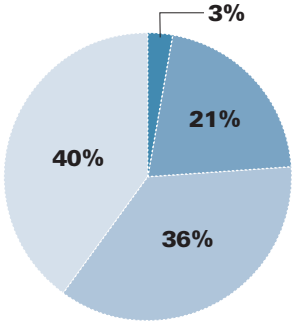
Respondents who said that they do not use BIM were asked how frequently current or prospective clients request BIM on their projects. The chart at right reveals the level of demand for BIM that they experience from clients.

Most non-users (60%) report at least some level of client demand for BIM. However, as with their perception of BIM use by competitors, most report that this only happens on a small percentage of their projects, on average well below 30%. Those working in tunnels experience the highest levels of client demand for BIM, with nearly half (44%) reporting that owners are requesting BIM on at least a moderate (15% or more) percentage of projects.

Greater client demand could be an important driver for wider BIM adoption in the transportation infrastructure sector. As more owners become aware of the design and construction phase benefits, and some begin to capitalize on models for their asset management programs (see pages 36 to 37), it is likely that owner demand for BIM use will rise.

Frequency With Which Clients Request BIM (By Percentage of Projects According to Non-Users)

Dodge Data & Analytics, 2017



Reasons Why Companies Are Not Using BIM

Respondents who said that they do not use BIM were asked to rate each of a list of 10 potential reasons on a scale of one to five, from no influence to the greatest influence. The chart at right represents the percentage of non-users who rate each reason as high or very highly influential (4 or 5 on the scale) in their decision, and the one on the following page shows the top differences between engineers and contractors in terms of the influence of each of these reasons for not adopting BIM.

Client Demand

The biggest issue reported by non-users, rated as highly influential by nearly half (42%), is that they do not see enough demand from clients and/or other organizations. This challenge is also evident when they were asked about the percentage of projects on which current or prospective clients ask for BIM (see page 45). Client demand is typically a critical factor to help drive BIM use, but other factors, such as the benefits accrued from using BIM, can ultimately be equally important. Interestingly, the 24 owners who participated in the study and who have experienced BIM use on at least some of their projects report that they request BIM on nearly half (43%) of their projects. This demonstrates that as owners become more familiar with BIM use in this sector, they are more likely to widely implement it, which would produce a tipping point for owner demand in the future.

Software Challenges

Non-users also had several reasons for not using BIM based on their perception of the software, but the degree of influence varies among these reasons.

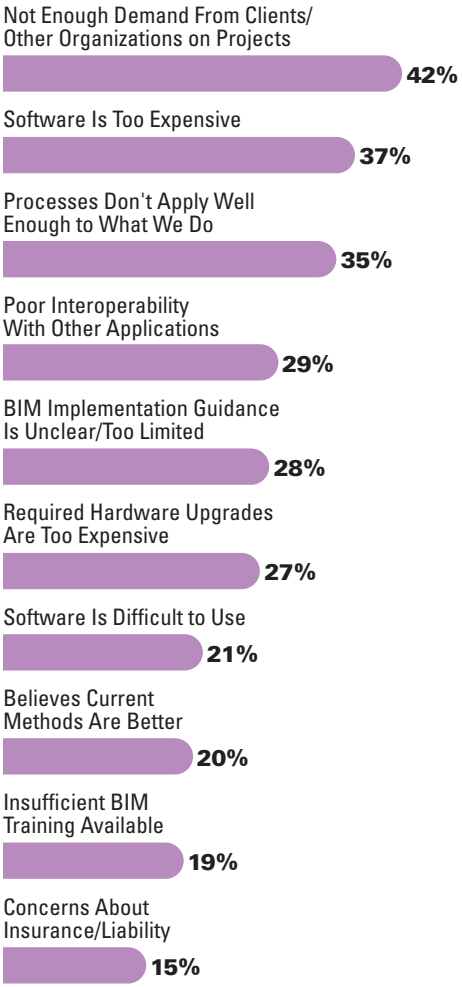
COST

A relatively high percentage (37%) believe the software is too expensive. This is a much bigger concern among non-users than hardware upgrades that may be needed to utilize BIM. However, only two-thirds have either tried the software or are actively evaluating it, so this could be more of a perception issue than an actual evaluation of costs versus benefits.

- **By Country:** Non-users in France are notably less influenced by the perception that the software is too expensive than their peers in other countries, with only 13% rating this as highly influential in France, compared with 35% in the US, 41% in Germany and 50% in the UK.

Reasons Why Companies Are Not Using BIM
(By Percentage of Non-Users Who Rate These Reasons as Having a High/Very High Influence)

Dodge Data & Analytics, 2017



- **By Role:** While the number of owners not using BIM who participated in the survey is very small, it is notable that more than half of them consider the expense related to the software a big issue, a much higher percentage than the engineers (22%), but more closely on par with the contractors (44%). Contractors (38%) are also more concerned about the cost of upgrading hardware to support the use of BIM than are engineers (16%).

FUNCTIONALITY

The most important concerns about functionality include that BIM processes don't apply well enough to what they do (considered highly influential by 35%) and that it has poor interoperability with other applications (highly influential for 29%). Less significant but still notable is the percentage who are highly influenced by the perception that the software is difficult to use (21%).

- **By Country:** Nearly half (48%) of non-users in the US believe that the processes don't apply well enough to what they do. In the UK, concern is greater about poor interoperability with other applications (44%) than in the other three countries.
- **By Role:** A much higher percentage of contractors are influenced by their perception that the software is difficult to use (29%) than engineers (13%).

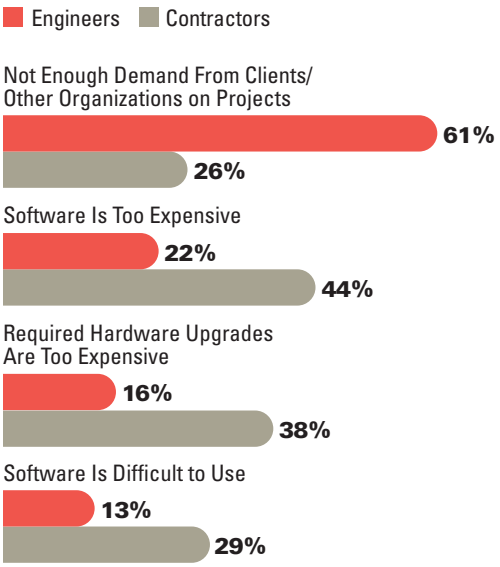
Other Reasons

- **Lack of Effective BIM Implementation Guidance or Training:** A moderate percentage of non-users (28%) believe that BIM implementation guidance is unclear or too limited, but only 19% report being highly influenced not to adopt because they believe that insufficient BIM training is available to them.
- **Believe Current Methods Are Better:** One of the more positive signs of the potential for wider adoption of BIM for transportation infrastructure is that only a relatively low percentage (20%) report that they are resisting BIM because of the notion that their current methods are better. This finding, along with the non-user attitudes, suggests that if some of the obstacles like concerns about cost and interoperability could be overcome, the majority of non-users may become more interested in adopting BIM.
- **Concerns About Insurance/Liability:** This is the least influential reason provided in the survey.

Reasons Why Companies Are Not Using BIM

(Top Differences Between Engineers and Contractors by Percentage Rating Factors as Having the Greatest Influence)

Dodge Data & Analytics, 2017



Factors Delaying the Decision to Use BIM on

Transportation Infrastructure Projects

As with the variety of industry factors that current users say would improve their experience of value from BIM (see pages 27-28), non-users also cite a number of factors that they believe are contributing to their continued non-adoption.

For this study, respondents who are not using BIM were asked to select the top three factors that have the most impact on delaying the use of BIM on transportation infrastructure projects by their organization from a list of 11 possible factors.

The top factors most frequently selected as delaying use of BIM echo the points of resistance noted in their top reasons for not using BIM (see page 46):

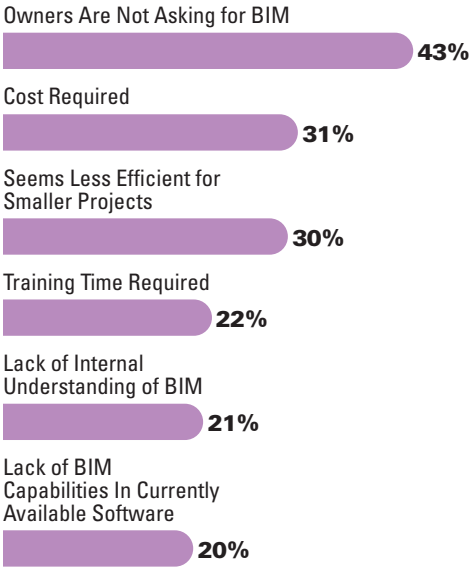
- **Owners Are Not Asking for BIM:** Findings across all the non-user responses suggest that increasing owner interest in BIM would be very influential in driving wider BIM use.
- **Cost Required:** Non-users are particularly concerned about cost. This concern may need to be addressed before many firms will truly consider using BIM.
- **Seems Less Efficient for Smaller Projects:** Concerns that the functionality does not directly align with the kind of work done by the non-users is also an important factor. Another highly ranked issue that aligns with the concern about functionality is the lack of BIM capabilities in currently available software.This is also likely related to the concern about the lack of interoperability that was a top reason for not adopting BIM.

The factors that are least frequently ranked in the top three by respondents include legal contracts not adequately addressing BIM issues, unclear roles/change in roles by participants due to BIM being introduced on a project, and lack of BIM certification programs.

Top Factors Delaying Decision to Use BIM on Transportation Infrastructure Projects

(According to Non-Users)

Dodge Data & Analytics, 2017



Benefits With Greatest Influence on

The Decision to Adopt BIM if They Could be Proven

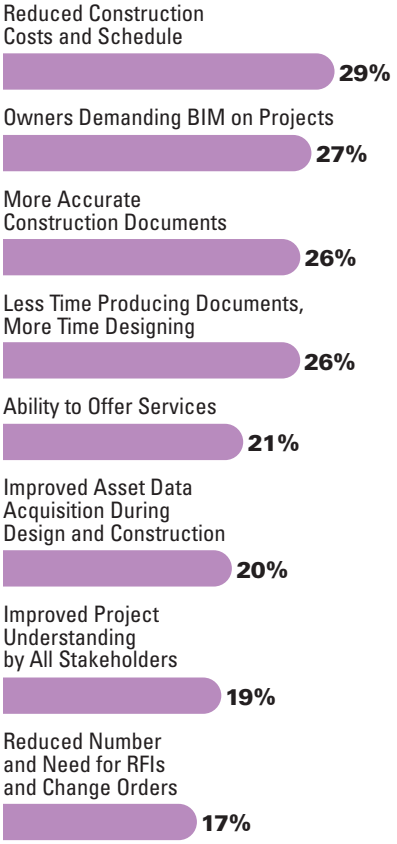
The findings have demonstrated that much of the resistance to BIM by non-users in the transportation infrastructure sector is due to the perception of insufficient owner demand and concerns about the cost of the software (see pages 46 and 48). In some cases, these concerns can be overcome if the company can be convinced that BIM will offer project and business benefits, but knowing which benefits to prioritize is critical. To identify this, non-users were asked to select up to three benefits from a list of 15 that they think would have the most influence on their organization's decision to adopt BIM on transportation infrastructure projects in the future, if their ability to achieve that benefit by using BIM could be demonstrated.

The chart at right shows their responses, which demonstrate that no single benefit is the most critical driver for BIM adoption. Instead, the findings reveal that several benefits could be important, and, encouragingly, they include many benefits which Dodge Data & Analytics research shows are frequently experienced by BIM users (see pages 17 to 19).

- **Improved project performance is most influential.** Demonstrating that BIM helps to reduce construction costs and schedules on projects and to produce more accurate construction documents is critical to encouraging wider adoption. Less influential but still important to a relatively high percentage is the ability to demonstrate that use of BIM reduces the number of and need for RFIs and change orders
  - Owners are very concerned with reducing construction cost and schedule. Two thirds select this among their top three most influential benefits, compared with 29% of contractors and 19% of engineers.
  - More respondents from the US would be influenced to consider BIM due to its ability to produce more accurate construction documents, with 43% selecting this benefit among their top three, compared with 12% in the UK, and 18% in France and Germany.
- **Process improvements would also be important to many non-users.** The most influential is the opportunity to spend less time producing documents, more time designing, a commonly reported benefit of BIM by users. While ranked in the top three by fewer non-users, the ability of BIM to improve project understanding by all stakeholders is also of some importance. However, at this point, parametric modification of designs and increased ability to analyze the design scheme are not highly prioritized process improvements.

Top Benefits With Greatest Influence on the Decision to Adopt BIM if They Could be Proven (According to Non-Users)

Dodge Data & Analytics, 2017



- **The ability to offer services is also influential,** an important finding given the high frequency with which this benefit is experienced by users. More non-users from Germany (41%) consider this a top benefit than in the US (22%), UK (13%) or France (13%).

The benefits of data handover for asset management, improved standards compliance, improving sustainability and an improved ability to do digital fabrication were the least influential of the benefits included in the study.

BIM Creates Value on Rail Projects

In January 2014, the European Parliament issued a directive for European Union member states to encourage—or even mandate—use of BIM on publicly-funded projects, and some are extending that into rail infrastructure.

Germany

In Germany, the Federal Ministry of Transport and Digital Infrastructure has launched a series of pilot projects to test BIM's potential with the goal of using BIM on all new projects by 2020. Deutsche Bahn's first major project to use BIM is the refurbishment of a 180-km rail line from Karlsruhe, Germany, to Basel, Switzerland. The project includes a 4.3-km long tunnel near Rastatt, Germany. Heinz Ehrbar, head management of major projects at Deutsche Bahn, says the decision was made to implement BIM on the project after designs were already underway. Although the designs were completed as traditional drawings, BIM models of the project are being created.

"We are very happy because we can compare the two solutions," he says. "Scientific experts from the government observe what we do. They can make comparative studies and later decide how we will work with BIM models."

Ehrbar sees the potential for numerous project benefits through use of BIM, such as higher quality designs, improved clash detection and better visualization for communication with stakeholders and the public.

"One important thing for this project is acceptance by public opinion," he adds. "Rail makes noise and is not always beautiful. People want to know what it looks like from the window and the garden."

Ehrbar says one of the biggest issues he sees on major rail projects is inaccuracies in estimations and scheduling, something he hopes to address through 4D and 5D BIM. "We need higher acuity in the time schedules," he says. "That's one of the problems on major projects. We want to improve the time schedules and if the quality of the time schedules is better, then the costs should be more stable than with a conventional design approach."

In the long term, Ehrbar expects BIM to play a big role in asset management. As part of that effort, Deutsche Bahn is working on its own standards, as well as common industry standards among rail companies in other countries. As part of its plan, Ehrbar says he hopes to see information from BIM models used in conjunction with track maintenance monitoring systems. "If we can relate this information to BIM models, then we can create more economical programs for maintenance," he says.

Another critical component of Deutsche Bahn's BIM strategy is the emergence of more collaborative contracting models. He notes that many of these collaborative methods used in other countries are not allowed in Germany. "It's quite clear that the goal of the federal government is that, at the end of 2020, all infrastructure has to be done with BIM," he says. "But it works only when we have the corresponding contract models... With a classic system, there can be a lot of fighting. It's a very bad situation. BIM is one of the big possibilities to create a better situation."

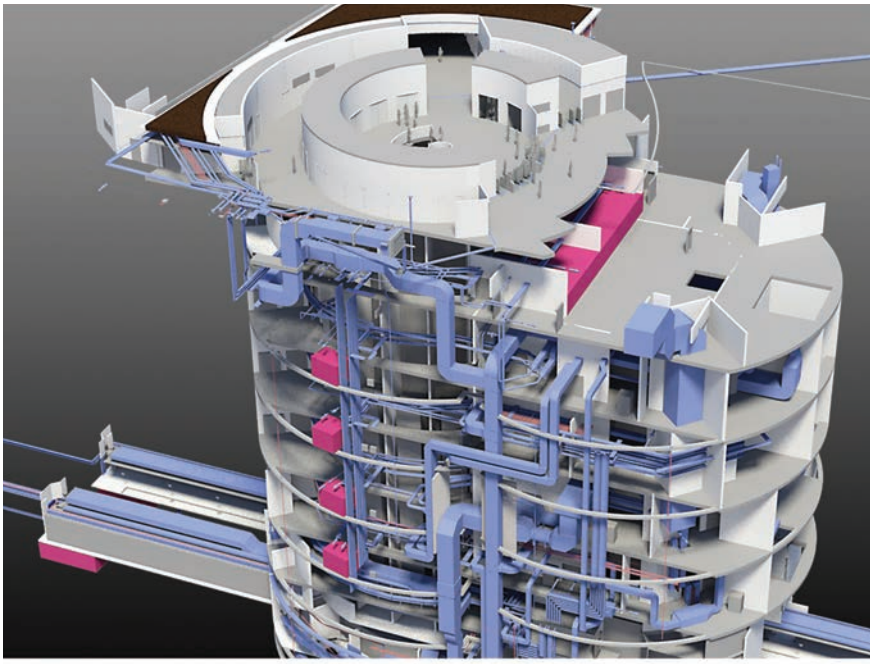
Ehrbar estimates that the financial benefits of BIM use could be significant. "In Germany, we invest in 7 billion to 8 billion Euros per year in railway infrastructure," he says. "Say half of those projects are done with BIM. If BIM works very well and we can reduce the cost in the project by 10%, that's $400m per year. It's a very easy business case."

In addition to finding enough designers and contractors who are proficient in BIM, Ehrbar says the biggest challenge that Deutsche Bahn faces is getting its own people to embrace BIM. Ehrbar says that when Deutsche Bahn started BIM implementation in 2015, it estimated that 80% of its internal needs would be in education and change management, while 20% would be in hardware and software. "What did we do in the last two years? We invested 80% in hardware and software, and 20% in people," he says. "We have to change this immediately."

France

In France, BIM is also in use on portions of the Grand Paris Express (GPE) project. The $24.7-billion Euro project will deliver 200 km of new tracks to the Paris Metro system, including 68 new stations. Systra is leveraging BIM on its portions of the project. Eric Pruvost, director of the Production Development Tools Dept. at Systra, says the company chose to use BIM on its GPE projects, even though it was not required

Image Courtesy of Systra



BIM model of one of the stations for the Grand Paris Express.

in its first contract by the client, Société du Grand Paris. "On the first one, we decided to implement BIM on the stations only because we were convinced it would help with management because of the complexity of the stations," he says. "Some of them are very deep—up to 40 meters. So, we thought using BIM could secure our design and help us manage the interfaces."

Based on its initial results, Systra says BIM proved most beneficial in the collaboration between the architect and the engineers while designing the stations. "The change management in the design is much easier to follow and to track," he says, noting that a federated model was created of the architectural, MEP and structural designs.

BIM also helped address concerns with connecting its stations to the streetscapes and other city infrastructure. "It's a very complex project with lot of interfaces with the urban environment," he says. "There's a lot of co-development objectives. Some lines are within a very dense environment."

As its projects advance to construction, Pruvost expects to see other benefits, such as improved clash detection, better quantity take-offs/estimates and better schedule controls. He adds. "The main issue for us is how to manage the interface [between different actors and between infrastructure and railway systems]. BIM is good at helping us. If we have the right collaboration process, we will have good improvement."

Pruvost says some benefits are more pronounced for rail than for vertical building projects, such as interface management. "We have all of the sequencing—not only in terms of geometry, but also in terms of phasing," he says. "For example, we will have to interface with railway operations." He states that Systra is seeking to implement 4D modeling in order to secure the construction work.

Systra has gone on to use BIM on other portions of GPE. The company is contracted on three of six portions of the infrastructure GPE project, serving in both engineering and construction management roles. As the projects evolve toward detailed design phases, all civil engineering work is planned to be done in BIM, not just the stations. "The challenge is to be able to manage the amount of engineering work," Pruvost says. "It was massive, and the construction work will be massive as well. In terms of managing all of this work, you need to have the right tools and the right processes."

While Systra is reaping benefits from BIM, Pruvost recognizes that challenges still exist. "The difficulty for rail is the lack of interoperability of the tools," he says. "We're not at the same scale as with a building, where you can do everything with the same tool—you can develop the metadata and go into the full BIM. For infrastructure, we don't have IFC well defined yet. There are a lot of tools that are not completely mature, and that's made it difficult in rail infrastructure."

On the latest contract, Pruvost says models will be provided to the client, although its potential use in future operations, maintenance and asset management is a work in progress. "With construction due to last until 2024, the capacity of the [facility management] tools and the competency of tools will evolve," he says. ■

Data: France

BIM Activity and Trends

in France

Contractors see the strongest benefits from BIM in France. Even though a higher percentage of French engineers use BIM, contractors have much higher implementation levels, experience more benefits from BIM use and are more frequently experiencing high ROI on their BIM investments.

BIM Usage

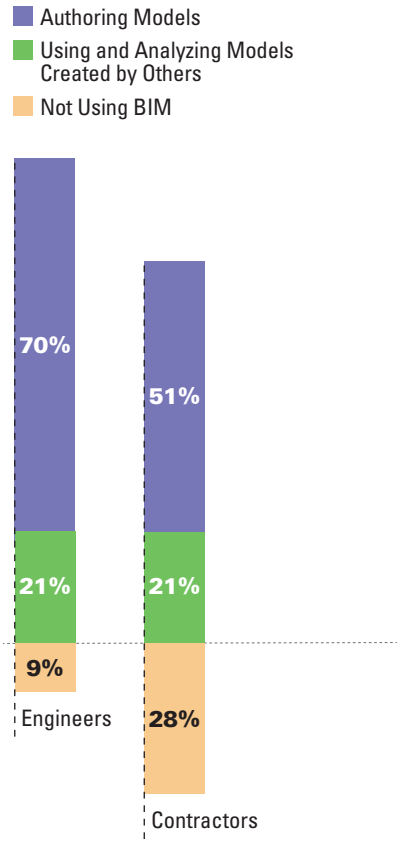
USE OF BIM

Engineers in France have a much higher level of BIM use for transportation infrastructure than French contractors do. Not only is a much higher percentage of engineers (91%) using BIM in general compared with contractors (72%), but more engineers are also authoring models (70%) than are contractors (51%).

This finding is consistent with the fact that the respondents in France average only 3.6 years using BIM, relatively consistent with Germany (3.8 years), but less than in the UK (4.2 years) and significantly less than in the US (4.7 years). In BIM studies across the globe conducted by Dodge Data & Analytics, design firms tend to lead adoption at the beginning, but contractors eventually surpass them as familiarity with BIM grows and its benefits become clear.

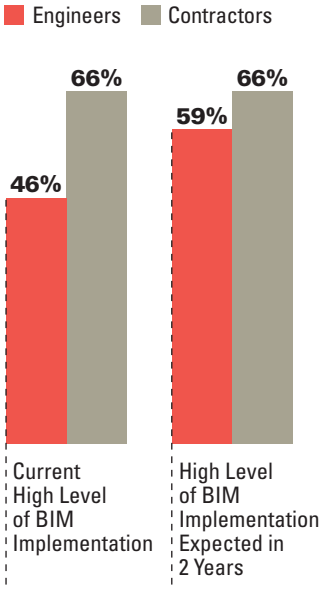
Use of BIM on Transportation Infrastructure (According to Engineers and Contractors Surveyed in France)

Dodge Data & Analytics, 2017



Current and Expected Future Levels of High Implementation (50% or More of Projects) (According to Engineers and Contractors in France)

Dodge Data & Analytics, 2017



BIM IMPLEMENTATION

In a reversal of the general use of BIM trends in France, **BIM implementation levels are higher for French contractors than engineers.** Not only are more contractors at a high implementation level (use of BIM on 50% or more of projects) than engineers (see chart below), but on average, engineers use BIM on 40% of their projects, while contractors use it on 51%.

Within two years, though, the percentage of French engineers who plan to implement BIM at a high level leaps up 13 percentage points from 46% to 59%. The percentage of contractors implementing BIM at a high level remains at 66%. However, more contractors expect to move up the implementation spectrum in the next two years from a low level of BIM implementation (less than 25% of projects) to a moderate level (25% to 49% of projects), which results in the average percentage of projects on which French contractors use BIM increasing to 55%.

- **Variation by Project Type:** Over two thirds (68%) of those doing aviation projects in France have a high level of BIM implementation on projects, compared with roughly half doing other types of transportation projects (54% doing roads, 53% doing bridges, 48% doing rail/mass transit and 48% doing tunnels).

BIM Benefits

Most (89%) French BIM users receive some benefit using BIM, but on average, they think they experience only a third of what BIM has to offer.

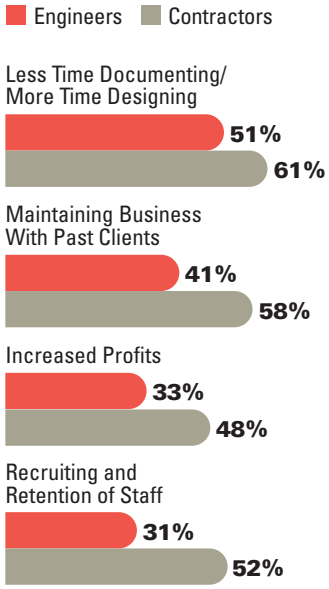
The top three business benefits reported by BIM users in France, all rated highly by more than 50%, are:

- Improved Ability to Show Younger Staff How Projects Go Together
- Offering Services
- Less Time Documenting/More Time Designing

Benefits are not experienced equally between engineers and contractors. Contractors more frequently rate four benefits at a high level, as the chart below reveals. This may be in part due to their wider use of BIM on projects, since Dodge studies on BIM consistently demonstrate that wider BIM implementation is associated with achieving more benefits. Planned implementation increases among engineers, thus, may help them achieve more benefits.

Business Benefits With Greatest Differential Between Engineers and Contractor Responses (All French BIM Users Experiencing High/Very High Level of Benefit Due to BIM)

Dodge Data & Analytics, 2017



BIM Investments

The top three investments French BIM users intend to make to improve the value of BIM are developing collaborative BIM processes with external parties, increased marketing of BIM capabilities and strategic BIM deployment.

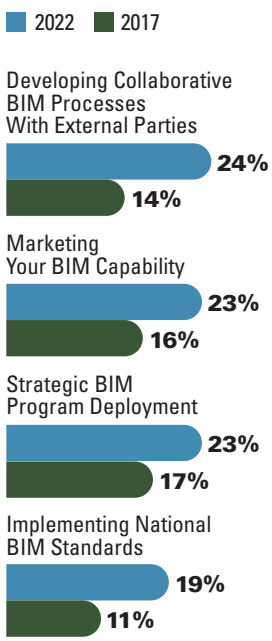
BIM ROI

Overall, about two thirds (67%) of French respondents believe they are getting a positive ROI from BIM, and one third (33%) believe that their ROI is 25% or more.

Not surprisingly, given their experience of BIM benefits, many more contractors (55%) report that they experience an ROI of 25% or more than do engineers (21%).

BIM Investments Considered a Higher Priority in 5 Years (According to French BIM Users)

Dodge Data & Analytics, 2017



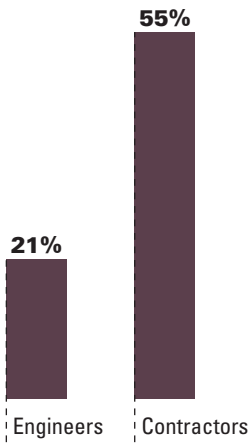
Non-User Trends

The findings from 17 respondents who do not use BIM reveal challenges to BIM adoption and the key benefit that must be demonstrated to increase adoption.

- Less than half (47%) of current non-users have a positive attitude about BIM.
- Most (88%) believe that their competitors are not using BIM on many projects.
- Non-users say proving that BIM provides improved asset data acquisition during design and construction would encourage them to adopt.

Experiencing ROI of 25% or Greater on BIM (Percentage of BIM Users in France)

Dodge Data & Analytics, 2017



Data: Germany

BIM Activity and Trends

in Germany

One of the most striking features of the use of BIM in Germany is the parity in levels of implementation, benefits and ROI reported by engineers and contractors. A high percentage of Germans also report that BIM provides them with benefits that help them win work, suggesting a strong business case for BIM in Germany.

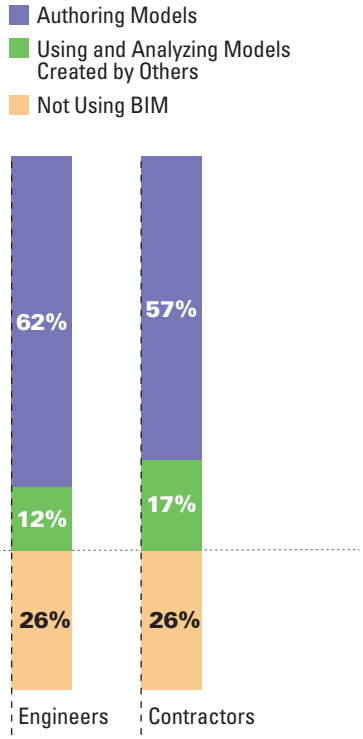
BIM Usage

USE OF BIM

Overall use of BIM is equally distributed between engineers and contractors in Germany. Currently, engineers are authoring models more than contractors are, but the difference is only 5 percentage points, far smaller than the difference in France (19 points), the UK (13 points) or the US (11 points). This near parity is distinct among the countries in this study, and not typical of other BIM studies conducted by Dodge globally.

Use of BIM on Transportation Infrastructure (According to Engineers and Contractors Surveyed in Germany)

Dodge Data & Analytics, 2017

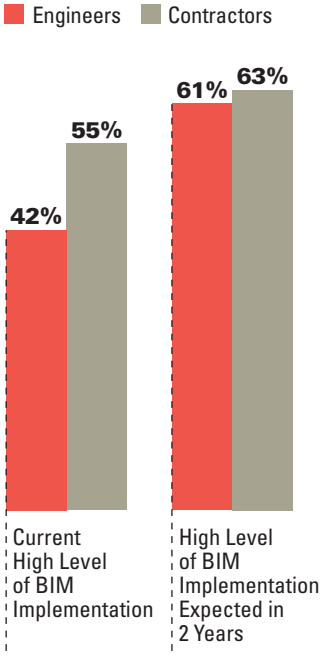


BIM IMPLEMENTATION

As in France and the UK, more contractors (55%) currently use BIM on 50% or more of their projects in Germany than do engineers (42%). However, the gap in implementation is again much smaller than it is in France or the UK.

Current and Expected Future Levels of High Implementation (According to Engineers and Contractors in Germany)

Dodge Data & Analytics, 2017



Engineers and contractors in Germany expect their BIM use to grow aggressively, with engineers in particular expecting much higher rates of BIM implementation than they currently have. In fact, by 2019, nearly the same percentage of German engineers (61%) and contractors (63%) plan to implement BIM on 50% or more of their projects.

BIM implementation in Germany is also consistent across all types of infrastructure projects.

These findings demonstrate a more uniform market for BIM in Germany than in other countries.

BIM Benefits

Most German respondents who use BIM (88%) believe that they receive some benefit from doing so. However, over half (53%) do not think that they are experiencing even one quarter of the total benefit they could be achieving from BIM.

German respondents agree that they are able to find and win work from using BIM, as is evidenced by three out of the top four business benefits that they experience at a high level from their use of BIM:

- Maintaining Business With Past Clients (70%)
- Improved Ability to Show Younger Staff How Projects Go Together (64%)
- Increased Win Rates (63%)
- Offering Services (63%)

In fact, a higher percentage of German respondents report experiencing business benefits from BIM than in the other countries surveyed.

The experience of business benefits between German engineers and contractors is similar, except for the following:

- **More engineers report BIM helps younger staff improve understanding and increases win rates for new work.**
- **More contractors find that BIM use improves profits and reduces claims/litigation.**

BIM Investments

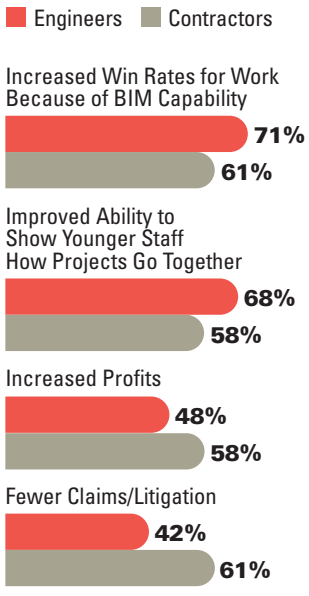
Currently, the highest percentage of German respondents (36%) seeking to get more out of BIM on their transportation infrastructure projects are investing in developing internal collaborative BIM workflows. Germany leads the other countries in the study in making this a top priority. BIM training and software are the other two major areas of investment in Germany, with at least one quarter selecting these as priority investments.

By 2022, training will still be a major area of investment, but they expect a much higher level of investment in other areas, such as marketing their BIM capabilities and getting new/upgraded hardware.

Business Benefits With Greatest Differential Between Engineers and Contractor Responses

(All German BIM Users Experiencing High/Very High Level of Benefit Due to BIM)

Dodge Data & Analytics, 2017



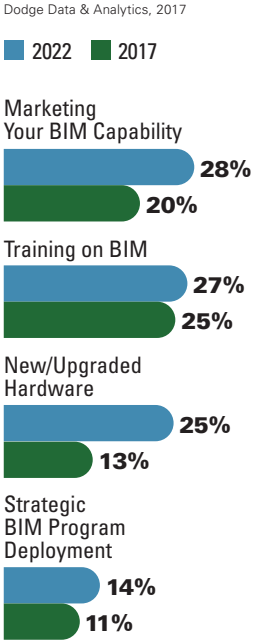
BIM ROI

Nearly all (89%) of German BIM users believe that they are experiencing a positive ROI from BIM, with engineers slightly more likely than contractors to experience an ROI of 25% or more.

BIM Investments Considered a Higher Priority in 5 Years

(According to German BIM Users)

Dodge Data & Analytics, 2017



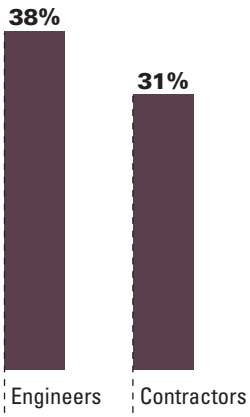
Non-User Trends

Many German respondents who are not currently using BIM recognize its importance.

- More than half (54%) have a positive attitude about BIM.
- Nearly three quarters (73%) believe BIM will be at least moderately important in the transportation infrastructure sector by 2022.
- The ability to offer BIM services is the top benefit that, if proven, would influence the decision to adopt BIM by non-users. This happens to be one of the top four business benefits that BIM users report achieving at a high level.
- The top concerns reported are lack of client demand and expensive software, but a good business case could help overcome these objections.

Experiencing ROI of 25% or Greater on BIM (Percentage of BIM Users in Germany)

Dodge Data & Analytics, 2017



Data: United Kingdom

BIM Activity and Trends
in the UK

BIM implementation growth is particularly high in the UK, with a notable percentage of contractors planning to use it on nearly all of their projects.

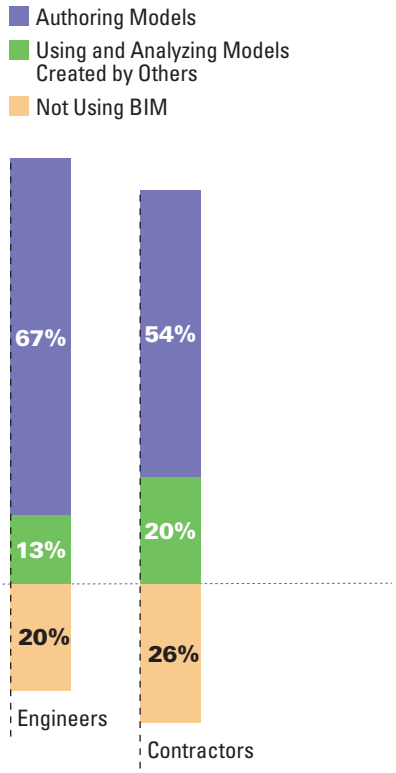
BIM Usage

USE OF BIM

UK engineers have a slightly higher level of BIM use for transportation infrastructure than do contractors. Over two thirds (67%) of UK engineers are authoring models, compared with 54% of UK contractors. Nearly one quarter (20%) of contractors just use models created by others, compared with 13% of engineers.

Use of BIM on Transportation Infrastructure (According to Engineers and Contractors Surveyed in the UK)

Dodge Data & Analytics, 2017



BIM IMPLEMENTATION

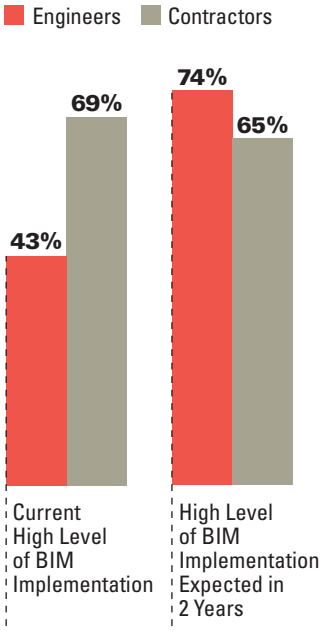
Despite the fact that they author models less often than engineers, **a higher percentage of UK contractors (69%) report that they use BIM on 50% or more of their projects than do UK engineers (43%).**

Just two years out, the picture gets more complicated. By 2019, more engineers (74%) than contractors (65%) expect to implement BIM on more than 50% of their projects. However, **nearly three quarters of the contractors in that group expect to use BIM on nearly all (75% to 100%) of their projects.** In contrast, only about one third of the engineers in that group are expecting to use BIM at that very high level. This results in a higher average of BIM projects expected for contractors (average of 62% of projects) than for engineers (average of 56% of projects).

Combined, these implementation growth projections by both engineers and contractors reveal a robust forecast for UK BIM implementation.

Current and Expected Future Levels of High Implementation (According to Engineers and Contractors in the UK)

Dodge Data & Analytics, 2017



BIM Benefits

Three quarters (75%) of respondents using BIM in the UK receive some benefit from its use. On average, most think they are experiencing only about a third of what BIM has to offer.

The top business benefits reported by more than half of UK BIM users focus on improving a company's basic capabilities:

- Establishing Consistent and Repeatable Project Delivery Processes (experienced at a high level by 56%)
- Offering Services (experienced at a high level by 54%)

Each of these top benefits is reported nearly equally by engineers and contractors, but there are notable differences:

- **UK engineers are more likely to experience increased win rates for work and to be able to maintain business with past clients.**

- **Contractors are more likely to report that their younger staff understand how projects go together better due to working in BIM.**

BIM Investments

The top investment priority for UK BIM users is training on BIM, selected by 40%, and an even higher percentage (48%) identify it as a top priority in the investments they plan to make in the next five years.

Other investments that are expected to become more important among BIM users in the UK over the next five years include software that supports BIM and strategic BIM deployment.

For the most part, the percentage of engineers and contractors that identify the potential investments as priorities are similar, but there are a few notable exceptions:

- More contractors (35%) intend to invest in strategic BIM program deployment in the next five years than do engineers (17%).
- More engineers (25%) intend to invest in developing internal collaborative BIM workflows than do contractors (8%).

BIM ROI

Overall, about two thirds (64%) of UK respondents believe they are getting a positive ROI from BIM. However, nearly all of the remaining one third are not sure about their BIM ROI. When those who are not sure are factored out of the equation, 48% of BIM users report experiencing an ROI of 25% or more. More engineers (65%) report that high level of ROI than do contractors (31%).

Non-User Trends

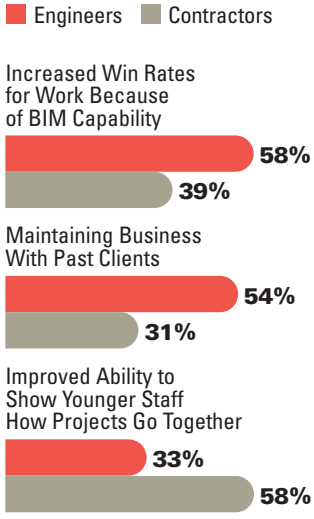
Only 17 respondents from the UK report no BIM use, but the findings suggest the potential for ongoing BIM adoption and also reveal that perception about the prevalence of BIM use for transportation infrastructure needs to be changed.

- Nearly three quarters (71%) have a positive attitude about BIM, and over one third are actively evaluating whether to adopt it.
- Over three quarters (77%) think BIM will be of at least moderate importance for transportation infrastructure in the next five years.
- However, most (81%) believe that their competitors are not using BIM on many projects.
- Nearly half would be influenced to adopt BIM if it could be demonstrated to reduce construction costs and schedules.
- Their top reasons for not using BIM now are lack of client demand and concerns about the expense of adopting it.

Business Benefits With Greatest Differential Between Engineers and Contractor Responses

(All UK BIM Users Experiencing High/Very High Level of Benefit Due to BIM)

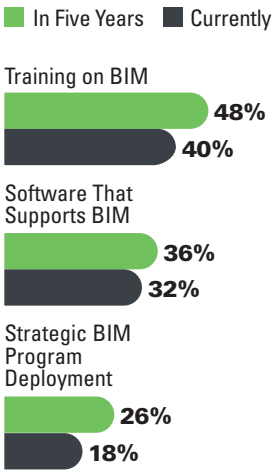
Dodge Data & Analytics, 2017



BIM Investments Considered a Higher Priority in 5 Years

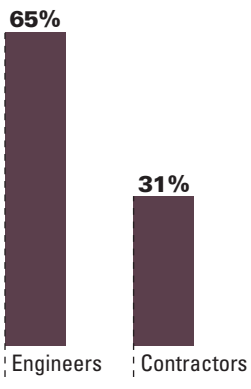
(According to All UK BIM Users)

Dodge Data & Analytics, 2017



Experiencing ROI of 25% or Greater on BIM (Percentage of BIM Users in the UK)

Dodge Data & Analytics, 2017



Data: United States

BIM Activity and Trends

in the United States

Comparisons with the Dodge study on the business value of BIM conducted in 2011 reveal important trends in the use of BIM for infrastructure in the US. The findings of the current study also suggest that US engineers see greater benefit from BIM use than do US contractors.

In 2011, Dodge Data & Analytics conducted a similar study on the use of BIM for infrastructure. Unlike the current study in 2017, the respondents in 2011 were just from the US, and engaged in multiple types of infrastructure projects. The highest percentage worked on transportation infrastructure, including 24% who worked on roads and bridges, and 17% who worked on other types of transportation projects, such as aviation and rail. Other categories of infrastructure worked on by the 2011 respondents included public parks, dams and levees, energy and solid/hazardous waste, but only one other category, water/wastewater, exceeded 10% of the total survey respondents.

Although the comparison is not exact due to the wider range of infrastructure projects in the 2011 study, there are still valuable trends that can be gleaned from comparison of the findings in 2011 to the current study in terms of the use of BIM for infrastructure in the US. There are also some important differences between engineer and contractor responses in the current study that contrast sharply with the findings in France, Germany and the UK.

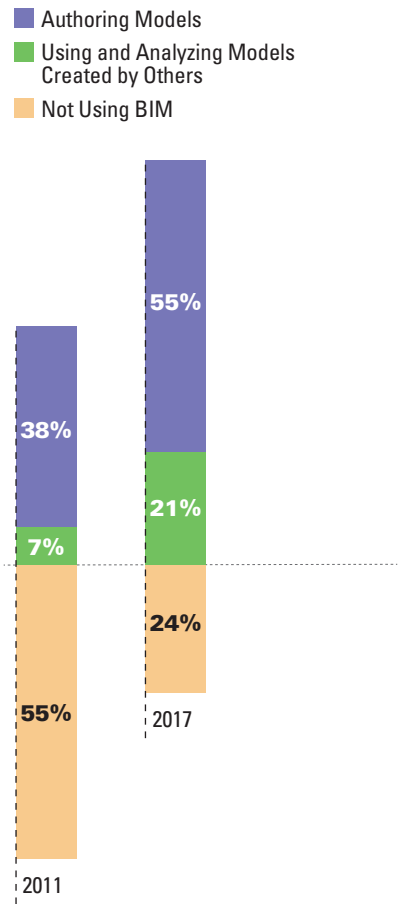
BIM Usage

USE OF BIM

- **Comparison With 2011 Findings: The use of BIM has increased dramatically among study respondents between 2011 and 2017.** In 2011, 55% were not using BIM at all. In contrast, by 2017, 55% are now authoring models, and over three quarters (76%) are using BIM in some fashion.

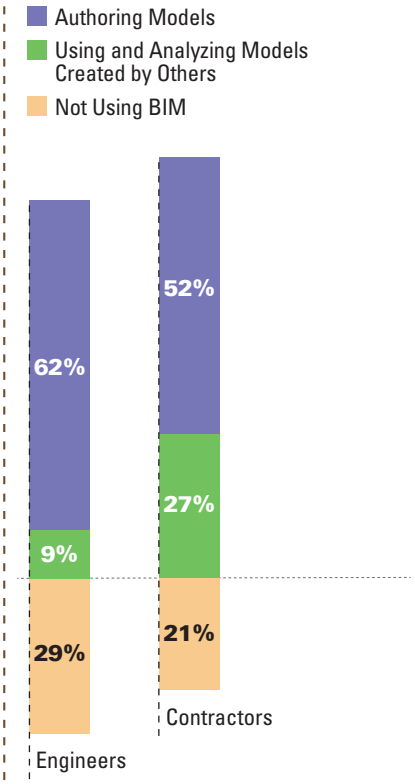
Use of BIM on Infrastructure Projects (By All US Respondents Surveyed in 2011 and by All Respondents Surveyed for Transportation Infrastructure in 2017)

Dodge Data & Analytics, 2017



Use of BIM on Transportation Infrastructure Projects in 2017 (According to US-Based Engineers and Contractors Surveyed)

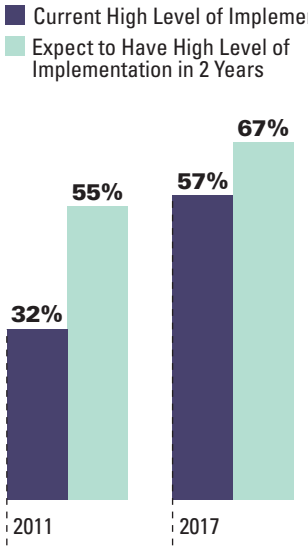
Dodge Data & Analytics, 2017



- **Variation by Role: Even though more engineers are authoring models, more contractors are using BIM for transportation infrastructure.** However, the difference is relatively slight, with overall rates of use relatively high.

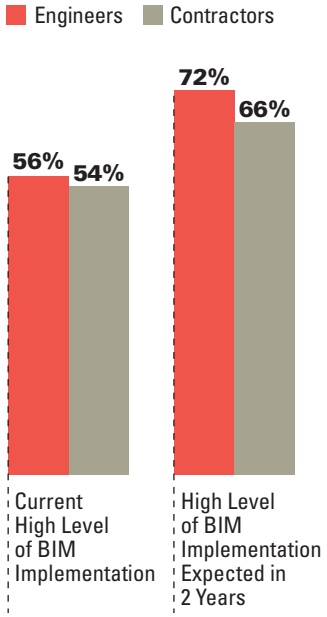
Current and Expected Future Levels of High Implementation (According to US Respondents in 2011 and 2017)

Dodge Data & Analytics, 2017



Current and Expected Future Levels of High Implementation (According to Engineers and Contractors in the US in 2017)

Dodge Data & Analytics, 2017



BIM IMPLEMENTATION

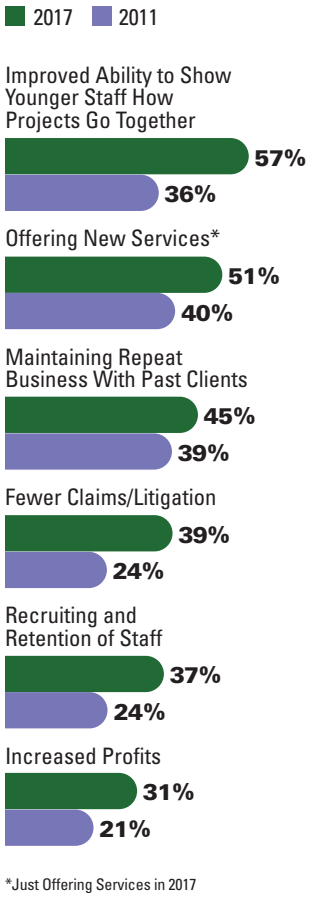
- **Comparison With 2011 Findings: While less than one third of the respondents in 2011 (32%) reported implementing BIM at a high level (using it on 50% or more of their infrastructure projects), more than half (57%) of respondents in 2017 are doing so,** a dramatic growth in the level of BIM implementation in the US in the last six years. However, it is notable that BIM users also expected a dramatic growth in their level of implementation in the near future in 2011, but that the level of growth anticipated to 2017 is more moderate. This suggests that BIM use for infrastructure is maturing in the US.
- **Variation by Role: The current percentage of users implementing BIM at a high level (50% or more of projects) is nearly consistent between engineers and contractors, but a higher percentage of engineers expect to be implementing BIM at a high level by 2019 than do contractors.** This shift from close parity to heavier BIM use by engineers is very different from the patterns of implementation in France, Germany and the UK, where the shift is toward more parity in two years than exists currently between these two groups.
- **Variation by Project Type: Those doing roads have a notably lower level of implementation currently,** with just 29% using BIM on their projects currently compared with nearly half of the respondents doing bridges (51%), rail/mass transit (47%), tunnels (50%) or aviation (56%). However, by 2019, many of the respondents who do road projects (59%) expect to hit that higher level of implementation, narrowing the gap between them and the percentage of those who work on other types of transportation infrastructure and implement BIM at a high level, which ranges between 61% and 70%.

BIM Benefits

- **Comparison With 2011 Findings: Six business benefits are reported by a higher percentage of US BIM users in 2017, compared with those in 2011.** These include benefits that yield direct financial gains such as maintaining repeat business with past clients and increased profits. These findings suggest that higher implementation levels and greater experience allow US respondents in 2017 to better reap the benefits offered by BIM than those in 2011.
- **Variation by Role:** While most business benefits are experienced by roughly equivalent percentages of engineers and contractors, **there are three benefits that engineers experience more frequently at a high level.** Two of them, increased win rates and increased profits, have a clear connection to a company's bottom line. The third, improved recruiting and retention of staff, is particularly relevant in the current US market, where many design and construction companies report that finding skilled workers is a significant challenge.

Business Benefits of BIM Experienced at a High/Very High Level (US Respondents in 2011 and 2017)

Dodge Data & Analytics, 2017



*Just Offering Services in 2017

Business Benefits With Greatest Differential Between Engineers and Contractor Responses in 2017 (All US BIM Users Experiencing High/Very High Level of Benefit Due to BIM)

Dodge Data & Analytics, 2017

BIM Investments

The percentage of US respondents who prioritize investing in training on BIM to increase the value they get from BIM on transportation infrastructure projects has grown dramatically since 2011 and is still expected to grow by 2022. This is the only benefit that sees continued growth across that time span.

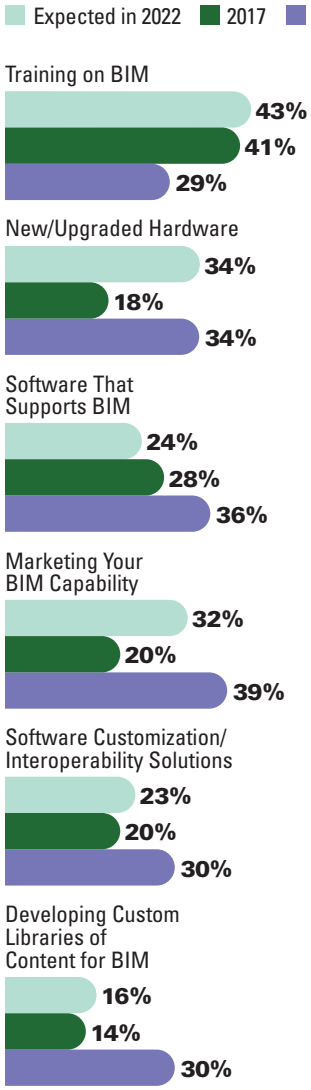
The prioritization of new and upgraded hardware investments, on the other hand, has fluctuated, with 34% considering it a top investment in 2011 and 2022, but only 18% who consider it a priority in 2017. In contrast, the percentage of US respondents who expect their company to prioritize investments in software that supports BIM has seen a steady decline.

One investment not included on the chart that is expecting to see significant growth among US respondents between 2017 and 2022 is developing collaborative BIM processes with external parties. In the 2011 study, no distinction was made between internal and external collaborative BIM processes, so the responses are not comparable.

The decline in early stage, tactical types of investments required to initially launch BIM in an organization, combined with an increasing focus on developing strategic processes that enhance more sophisticated BIM usage are additional indications that the US BIM market for infrastructure is maturing.

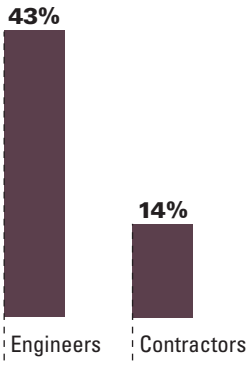
High Priority BIM Investments (Percentage of US Engineers, Contractors and Owners Prioritizing These Investments in 2012 and 2017 and Those Expecting to Prioritize Them in 2022)

Dodge Data & Analytics, 2017



Experiencing ROI of 25% or Greater on BIM in 2017 (Percentage of BIM Users in the US)

Dodge Data & Analytics, 2017



BIM ROI

Interestingly, despite the fact that so many more benefits are experienced at a high level in 2017 by US BIM users compared with 2011, their perceived ROI is nearly the same, with 70% believing that they experience an ROI of 25% or more in 2011 and 73% reporting that high level of ROI in 2017.

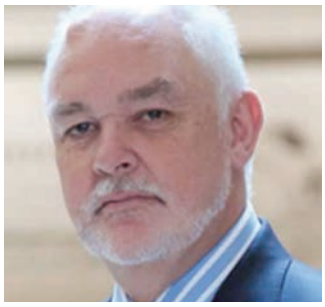
There is, however, a sharp difference in the perceived ROI of engineers compared with contractors in the current study, with **more than three times the percentage of engineers reporting an ROI of 25% or more than contractors.**

Non-User Trends

While US respondents who do not use BIM are generally positively disposed to it, there are also headwinds to greater adoption, including a perceived lack of competitive pressure and client demand. In addition, many are skeptical that BIM applies well enough to what they do.

- Over three quarters (77%) of US non-users have a positive attitude about BIM.
- 70% also believe that BIM will be of at least moderate importance in transportation infrastructure in the next five years.
- However, the non-users are not feeling much competitive pressure, with 83% believing that BIM is used on very few projects by their competitors.
- Between 40% and 50% of US non-users consider four reasons highly influential in their decision not to use BIM: insufficient demand from clients/other organizations, the processes don't apply well enough to what they do, BIM implementation guidance is unclear or too limited, and the software is too expensive.
- Over 40% say that the benefits of reduced construction costs and schedule, more accurate construction documents, and reduced number and need for RFIs and change orders would positively influence their decision to adopt BIM in the future, if they could be demonstrated.

Interview: Thought Leader



Professor Tim Broyd, BSc, PhD, CEng, FREng, FICE, FRSA President, Institution of Civil Engineers (ICE), UK

Tim Broyd is a Fellow of the ICE, the Royal Academy of Engineering and the Royal Society of Arts, Manufactures and Commerce. He is Director of the UCL Institute for Digital Innovation in the Built Environment.

What is the biggest change you have seen in the use of BIM for transportation infrastructure in the last five years?

BROYD: In May 2011, the British government issued a new construction strategy... [including] a statement that the government would require procurement of buildings and infrastructure to be undertaken within a Level 2 BIM environment within five years. Over that five-year period, processes were put in place to ensure that [those procuring construction projects] would be in a position to procure using BIM techniques by April 2016, and that included both reprocessing of procurement techniques and significant education of the central government procurers, as well as a lot of work with the supply side to ensure that both customer and supplier of construction services were up to the mark.

What impact has that mandate and BIM in general had on project delivery for transportation infrastructure?

BROYD: In a very narrow sense, government financial records show that for procurement using BIM techniques—actually, it's not just BIM but lean and agile techniques as well—the general outcome is that procurement costs have been reduced by about 20%.

I should be absolutely clear that BIM is not just "software" as far as I am concerned. It is a software-enabled set of processes coupled with new behavior mechanisms. To do BIM, the main stakeholders of a project come together at a much earlier stage than is traditionally the case. There's a smoother information flow that both speeds up the processes and reduces the cost.

What are the biggest challenges to wider use of BIM for transportation infrastructure?

BROYD: Standards. A general understanding of what BIM is and can do. I think the supply side [understands], but customers don't take well to having the supply side suggest ways of doing things that might be better. There's too much of a lack of trust at times....The big need in all this is the use of case studies to educate people. I'm not saying the customer is completely responsible, but they do have a responsibility. It's they who determine which contract will be used, which things will be undertaken. If they don't [call the shots in regard to BIM], it's much harder.

What impact do you think BIM has on team coordination and what can be done to make it even more effective?

BROYD: Customers need to have a permanent idea of what they want to procure. In BIM, this comes down to them having a detailed set of EIR (Employee Information Requirements) set out before they go to BIM, so that people actually know what is being asked of them. The second thing is to ensure that work is being done in a common data environment ... Then the contracted parties need to have a really good BIM execution plan. They need to work out what level of detail (LOD), etc. That needs to be determined right at the beginning because otherwise, it is potentially the cause of a lot of misunderstandings as the work is undertaken.

How do you see owners using BIM for operations and asset management?

BROYD: We are just coming into that in the UK. [Provides the example of the Crossrail project]. Crossrail is a new piece of infrastructure, but it fits within infrastructure of various ages. It is not enough then to get the operational asset management sorted through BIM. You have to make sure as far as you can that the asset management procedures and processes are as similar as possible with the surrounding mature infrastructure assets.

What are your thoughts on the future of BIM?

BROYD: If used properly, we can extend the work that's being done on construction through asset management into getting a much better handle on real time performance of transportation infrastructure. ■

Interview: Thought Leader

Daniel Philbrick, Director of Product Development for Infrastructure, Autodesk, Inc.

Daniel is responsible for product strategy and development of InfraWorks and Autodesk® Civil 3D. Daniel has presented at Autodesk University many times and enjoys sharing his product insights with the user community.

What changes have you seen in BIM for infrastructure in the last five years?

PHILBRICK: In the past, people associated BIM with buildings, but ... [the past five years has led to] the convergence of horizontal and vertical BIM.

Another change is that reality capture (laser scanning, collecting data via drones or mobile devices) is becoming much more mainstream. Sensors are coming down in price, and there is demand for the software to be able to leverage this.

I also see a convergence between BIM and GIS. If we are in master planning and we want to start design, we want to leverage GIS information in the design process. And conversely, we want to be able to leverage that information in the asset management process.

The other change in the last five years is that the industry is moving away from on-premise solutions to a cloud environment, which enables collaboration and can solve some project delivery challenges and really change the industry.

What is the impact of BIM on project delivery for transportation infrastructure?

PHILBRICK: There's a growing number of BIM mandates around the world ... and this is changing how projects get delivered through the supply chain. Autodesk is actively involved in some of these initiatives, like BuildingSMART, for example, and the work they are doing to establish submittal mandates around BIM processes. The establishment of the mandates and vendor-to-vendor agreements really improves the overall project delivery process.

What are the biggest challenges to the wider use of BIM for transportation infrastructure?

PHILBRICK: A traditional workflow often requires paper deliverables or submittal documentation. These become challenging because information isn't passed from one part of the process to the next and often has to be remodeled; information is lost throughout the process. We are seeing a change when you have design build or PPP [public private partnership] projects, where there is more of an incentive to optimize the process. I think the more we see of these types of projects, where we are optimizing from the design through construction and ultimately into asset management, that is going to become the real driver for widespread BIM adoption in the industry.

What is the next phase for BIM to help support team coordination on infrastructure projects?

PHILBRICK: We believe the next era is coordination through a connected BIM process. How can we bring the cloud in and enable a higher level of coordination and collaboration? [We are pursuing] moving infrastructure data to the cloud and having a platform to expose all of this data to project stakeholders, who could be customers or the public, in the form of very visual representations. All stakeholders [such as consultants, partners on the project and workers in the field] can have access to the appropriate information, enabled by cloud infrastructure and technology.

How have you seen owners use BIM in the operational phase of the asset?

PHILBRICK: We are probably seeing the most interest in leveraging the model for operations in airports ... We are also seeing cities that want to model their assets and how the city progresses over time. What is interesting is that city models are more of an aggregation of BIM and GIS information. They are thinking of a visual front end and [they want to use data to] optimize how cities operate.

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

PHILBRICK: We are looking to lead a transformation of this industry by moving information to the cloud, so it is readily available to all types of consumers of that data, whether for design or construction or ultimately for asset management. There's a real opportunity to transform the industry, not only from design to construction, but the entire work practice and project delivery process. ■

Methodology:

BIM for Transportation Infrastructure Study Research

This study was conducted online between October 10, 2016 and February 3, 2017 as a follow-up to the study on the use of BIM for infrastructure conducted by Dodge Data & Analytics (DD&A) in 2011.

The current study differs from the previous study in two ways:

- **The current study is focused solely on the use of BIM in transportation infrastructure.** The 2011 study included all types of infrastructure rather than just transportation.
- **The current study includes respondents from France, Germany, the UK and the US.** The 2011 study only included respondents from the US.

Respondent Profile

368 construction professionals completed the online survey. Respondents include professionals working at design firms (planning, engineering and architectural), contractor firms and building owners. Since 89% of the total design firm respondents work for engineering firms, throughout the rest of this methodology and in all the analysis in the report, that group is referred to simply as engineers.

The margin of error based on a 95% confidence interval for the total study is +/- 5.1%.

The following requirements determined those who could participate in the study:

- **Respondents were required to have experience with transportation infrastructure projects.**
- **Their organizations' projects had to be primarily for roads, bridges, tunnels, aviation, rail and mass transit in at least one of the four target countries.**
- **Owners had to use BIM on at least some of their organization's transportation infrastructure projects.**

COMPLETES BY TYPE AND BY COUNTRY

- **France: 90 total completes**
  - Engineers: 43 completes
  - Contractors: 43 completes
  - Owners: 4 completes
- **Germany: 86 total completes**
  - Engineers: 44 completes
  - Contractors: 42 completes
  - There were no owner completes in Germany
- **UK: 69 total completes**
  - Engineers: 31
  - Contractors: 35
  - Owners: 3
- **US: 123 total completes**
  - Engineers: 35
  - Contractors: 62
  - Owners: 26

All summary data includes engineers, contractors and owners. However, all comparisons between countries in the report only include engineers and contractors to keep the data being compared fully consistent.

COMPLETES BY TYPE OF TRANSPORTATION INFRASTRUCTURE

Respondents were asked to select the types of transportation infrastructure projects that they work on. Respondents were allowed to select all the categories that apply. The analysis in the report includes an examination of the differences in the responses, but the differences cannot be considered statistically significant due to the overlap by category.

- **Roads (66% of respondents)**
- **Bridges (52%)**
- **Rail or Mass Transit (46%)**
- **Aviation (33%)**
- **Tunnels (33%)**
- **Other Transportation infrastructure (17%)**

SURVEY SAMPLE

Survey sample was drawn from the following sources:

- **DD&A Architect and Contractor Panels**
- **DD&A Construction Database**
- **Association Memberships/ Contacts**
- **External Panels**

Partnering associations or organizations included: Autodesk, Chartered Institute of Buildings (CIOB), the Design-Build Institute of America (DBIA), Institution of Civil Engineers (ICE), and Technical University Munich Academic Supervision of BMVI BIM Pilot Projects in Infrastructure / Association IFC Rail & Road (TUM). ■

Resources

Organizations and websites that can help you get smarter about using BIM for infrastructure and the value to be gained from its use.

DODGE DATA & ANALYTICS

Dodge Data & Analytics
Main Website: **www.construction.com**
Dodge Global Network: **www.construction.com/products/dodge-global-network**
Research & Analytics: **www.construction.com/products/dodge-research-analytics**
Sweets: **www.construction.com/products/sweets**
SmartMarket Reports: **analyticsstore.construction.com**

ACKNOWLEDGEMENTS:

We would like to thank our premier partner, Autodesk, for their vision and leadership in helping us bring this critical research to the industry.

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We would like to thank all the people and companies that participated in case studies and feature articles for sharing their data, experiences, insights and project images.

We also want to thank Mott MacDonald for supplying us with a great cover image.

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- **http://www.ciob.org/digital-technologies-construction**

Design-Build Institute of America: **www.dbia.org**
Institution of Civil Engineers: **www.ice.org.uk**
- **www.icetraining.org.uk/courses/building-information-modelling-bim**
- **https://www.ice.org.uk/eventarchive**
- **www.ice.org.uk/disciplines-and-resources/information-sheet/what-is-bim**

Technical University of Munich: **www.tum.de/en**

Other Resources:

American Society of Civil Engineers: **www.asce.org**
BIMForum: **bimforum.org**
BIM Level 2: **www.bim-level2.org**
BIM Regions: **http://bimregions.co.uk/**
bimSCORE: **www.bimscore.com**
buildingSMART International: **www.buildingsmart.org**
The Government Construction Strategy (GCS) 2016-20: **www.gov.uk/government/publications/government-construction-strategy-2016-2020**
Hauptverband der Deutschen Bauindustrie: **www.bauindustrie.de**
Lean Construction Institute: **www.leanconstruction.org**
MINnD: **www.minnd.fr**
Mediaconstruct: **www.mediaconstruct.fr**
National Institute of Building Sciences: **www.nibs.org**
Planen Bauen 4.0: **http://planen-bauen40.de**
UK BIM Alliance: **www.ukbimalliance.org**
US Army Corps of Engineers: **www.usace.army.mil**
US Department of Transportation Federal Highway Administration: **www.fhwa.dot.gov**
Verband Beratender Ingenieure (VBI): **www.vbi.de**

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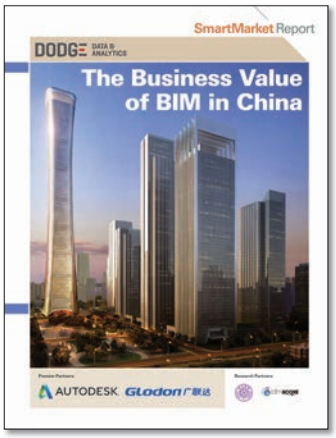

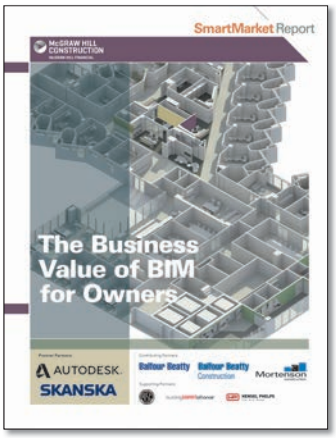

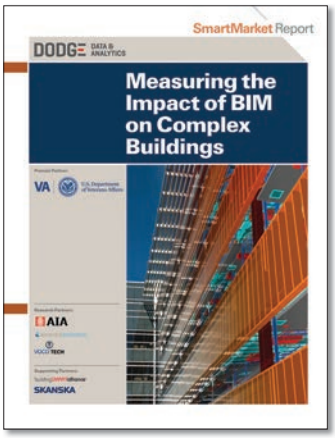

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