WHITE PAPER

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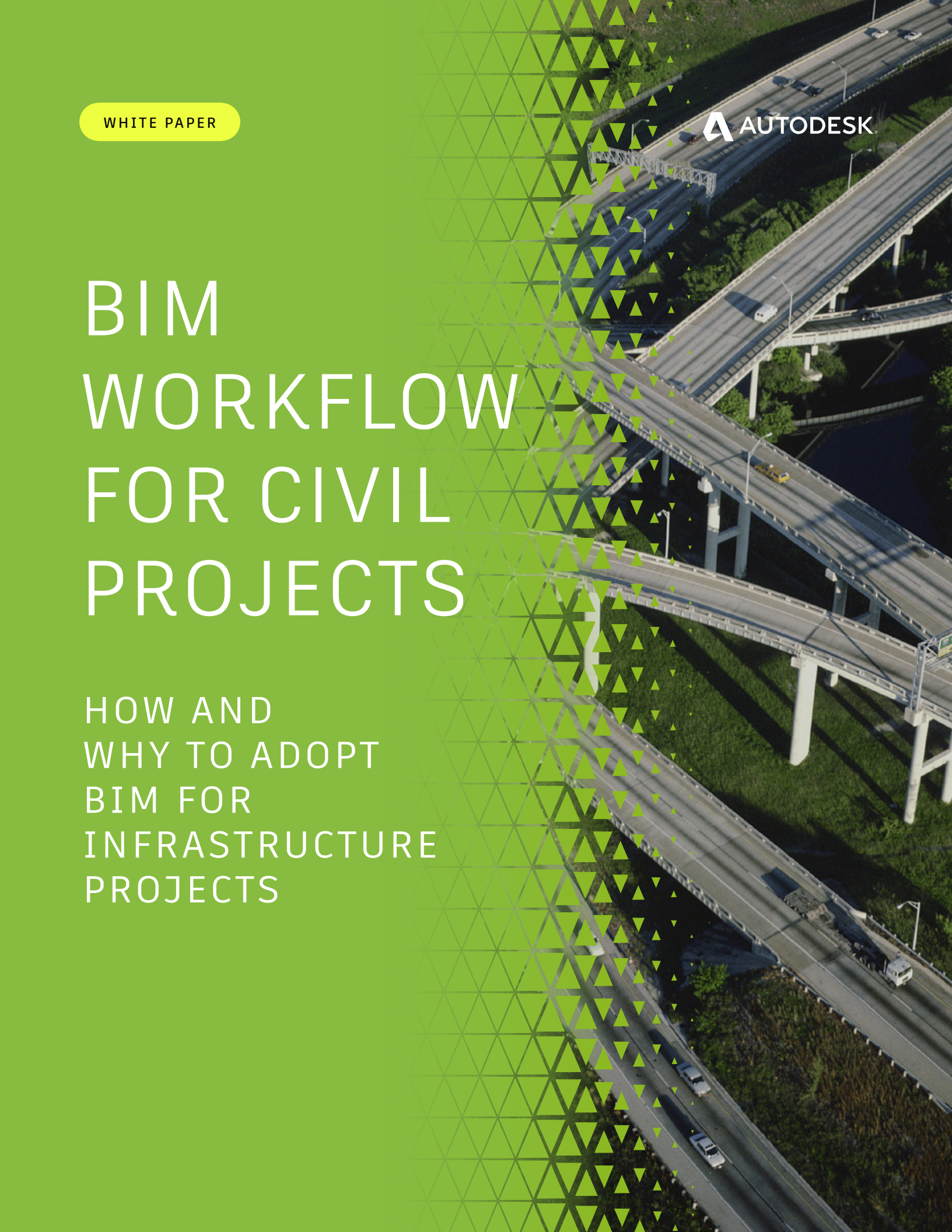
BIM WORKFLOW FOR CIVIL PROJECTS

HOW AND WHY TO ADOPT BIM FOR INFRASTRUCTURE PROJECTS



TOPICS

EXECUTIVE SUMMARY

The AEC industry may focus on creating and maintaining today's changing infrastructure, but the industry itself is evolving as BIM adoption continues to spread.

The use of BIM , or Building Information Modeling, has grown tremendously since it developed from a more traditional design program in the early 2000s into the robust, multi-dimensional tool of today. Now viewed as nearly ubiquitous in vertical development, BIM is poised for widespread use in the infrastructure world. Adoption levels vary across the globe by organization size and by project type, but snapshots of data help tell the story:

- Overall, BIM adoption in North America was at just 17 percent in 2007, but it jumped to more than 70 percent by 2012.[1]
- In the UK, claims of adoption have risen from just over 10% in 2011 to over 70% in 2018.[2]
- Similar levels of BIM adoption are becoming apparent in the civil infrastructure industry around the world.

While the parameters of measurement vary depending on who does the measuring and when, recent surveys shed some light on the state of BIM in infrastructure across a global market. Let's review where and how BIM is best leveraged in infrastructure, and how it can advance the AEC industry.

1

THE STATE OF BIM FOR INFRASTRUCTURE

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Project planners and designers increasingly rely on BIM for their infrastructure projects, whether it‘s in the travel or transport industry, structural design, construction or commercial plants.

Two recent reports by Dodge Data and Analytics illustrate this shift and provide some interesting data about BIM adoption in the civil world.

According to a 2017 Dodge SmartMarket Report[3], which surveyed professionals working on infrastructure projects in the U.S., the U.K, France and Germany, BIM adoption in civil projects related to transtportation was at just 50% in 2015. In 2017, that level rose to nearly 80%.

In 2018, Dodge produced a similar report, the Business Value of BIM for Water Projects[4], which included a survey of professionals primarily focused on civil water improvement projects, including water-related treatment facilities, tunneling, linear water projects, and hydroelectric projects, among others. The respondents were located primarily in North America (81%), with the rest coming from Europe and Asia. The level of BIM adoption in these kinds of projects averaged 69% in 2018, and is projected to be adopted at a level of close 90% in one way or another on these project types by 2020. Those working on water treatment facilities had the highest level of BIM adoption at 88%, perhaps due to typical integration with vertical structures.

DRIVING THE SHIFT TOWARD BIM

What's been driving this shift toward BIM for the AEC industry?

The simple answer, of course, is money. The benefits of improved design, better management of project schedules, reduced errors, and better control of costs are tangible for all vertical or civil infrastructure projects.

The return on investment comes in the form of improved efficiency and money savings when BIM is integrated into the workflow. Tracking materials and quantities in the model results in better cost adjustments. The time savings from eliminating costly redesign or resolving issues in the field quickly translates to positive financial return.

With the integration of BIM and the creation of better designs and successful projects, those involved garner additional rewards, from meeting the public's expectations to improving the owner's and project team's reputations.

BIM users in the Dodge reports readily agree that they are reaping a wide range of benefits on civil projects, including :

- Experiencing overall value from BIM (87%) [3]
- Collaboration among different companies and team members on a project (58%)[4]
- Client satisfaction (45%)[5]
- Enhancing an organization's reputation as a leader (35%)[6]

2

BIM'S EVOLUTION

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Highways England uses models for their roadways projects, like this example created by Jacobs, to improve information flow across the asset lifecycle.

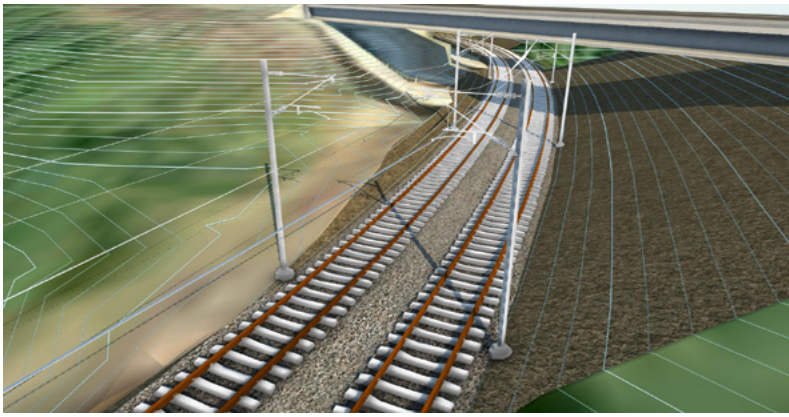
Based on the survey results, it's clear that BIM is worth the effort. Early adopters of BIM can offer valuable lessons learned for those who might be starting to use BIM in the civil engineering environment.

The power of BIM first became evident when the world started transitioning to a digital environment in the late 1990s and beyond. As technology evolved, many different organizations and institutions began to research BIM applications and to implement them on pilot projects. While many of these early adopters came from large, private companies looking to gain an edge on their competition, several owners, government entities, and academia also helped BIM become more mainstream. The overall growth of BIM during the last dozen years validates these efforts.

Civil engineers and contractors responding to the 2017 Dodge survey were asked how frequently potential clients are requesting BIM in new business solicitations. The respondents estimate that they're seeing owner requests for BIM on roughly one-third (35% average) of their projects, showing a growing influence of the owner when it comes to BIM's use in infrastructure. Overall, 80% of respondents report that owners are requesting BIM on at least some of their business opportunities.

Conversely, lack of owner pressure was frequently cited as one of the reasons why those non-users of BIM have not yet fully embraced the model, with 43% saying owners are not asking for BIM. Owner influence is clearly a factor in BIM adoption.

The growth in BIM adoption is being driven by private industry as well as government investments and mandates. The impetus for a broad level of BIM adoption is likely a combination of factors for those countries viewed as leaders in the use of BIM, though mandates certainly seem to force the issue. For example, BIM was mandated in the United Kingdom in 2016, when the government announced that every construction project funded by the central government be delivered with "fully collaborative 3D BIM."



According to the NBS National BIM Report 2018,[7] the industry has seen nearly a 20% increase in BIM use since the 2016 mandate. Almost three-quarters are now using BIM, a 12% increase since last year, which is the highest year-on-year growth since 2014, according to the report. In France, BIM's use was mandated[8] as part of its effort to standardize and digitize the construction industry through its official BIM Standardization Roadmap for the Construction Industry.[9]

Until recently, Germany had not employed mandates for BIM. The infrastructure market will be one of the first to adopt this approach with the Federal Ministry of Transport and Digital Infrastructure planning to officially announce that BIM will be mandatory for all transportation projects by the end of 2020.[10]

So far in the US, mandates have not taken off on a national level, although the General Service Administration (GSA) has encouraged its use by establishing the National 3D-4D-BIM Program[11] in 2003. Since then, the GSA has partnered with private entities and industry organizations to advance the adoption of BIM. In 2010, Wisconsin became the first state in the country to mandate its use on all public projects valued at $5 million or more. Several higher education institutions have also implemented stringent requirements for BIM on their capital improvement projects.

Norway, Finland, and Denmark are cited as other country leaders in BIM implementation due to "various activities organized by these three government bodies in order to increase the BIM adoption," according to a 2018 paper published by Universiti Teknologi MARA (UiTM) in Seri Iskandar, Malaysia[12]. This paper also says the Australian government will "rigorously implement various strategies in BIM implementation through proposed work programs" and in Hong Kong, its "Housing Authority has developed standards and requirements in BIM adoption and implementation."

The move to BIM requires a measured and thoughtful approach to retool processes and workflows, enhance training, and in some cases, reorganize departments and business units. This kind of demand on resources can be challenging for companies to implement. By documenting and researching current levels and approaches to BIM adoption, the academics at UiTM and other institutions hope to use this data to help professionals who are just now beginning to understand the benefits of BIM.

Image courtesy of China Railway Siyuan Survey and Design Group Co., Ltd.

The potential for growth persists in other parts of the world, including China. A study by China Construction Industry Association (CCIA)13 concluded the level of BIM adoption in China hovered at 15% in 2012.[13]

A 2017 study of BIM use for tunneling projects[14] in China showed that BIM is mainly applied during design rather than during construction and operation, even though tunneling projects may greatly benefit from BIM due to "complex geological conditions, more construction quantities, more unknown factors and more significant resource allocation during construction." Proposed solutions from the study included improving integration with third-party software and tools, such as Geographic Information Systems (GIS), to benefit operations and maintenance phases.

Another research effort at Shandong Jianzhu University in Shandong, China and Tongji University in Shanghai[15] looked at ways industry professionals may be able to better deploy BIM in organizations classified as small- to medium-sized enterprises (broadly defined as companies with 10–300 employees). The study says improvements of BIM adoption in this demographic will help raise the overall level of BIM implementation in China.

While the approach to BIM and the progress on its implementation in the civil industry may vary across the globe, the interest driven by economics keeps growing everywhere. According to the EU BIM Handbook[16], the wider adoption of BIM is set to unlock 15–25% savings for the global infrastructure market by 2025. A 2017 market research report[17] claims that the world BIM market will be a $11.7 billion (US) industry by 2022.

3
STANDARDS

STANDARDS

Most industry professionals agree that the development of standards is key to unleashing BIM‘s full power and advancing the tool within the industry. The establishment of common standards and guidelines are among one of the primary goals of the authors of the EU BIM Handbook.

Standards help set a baseline, enabling us to measure progress and raise the bar. This is an industry built around documentation and the documentation of standards is no less important. Many organizations start with a BIM Manual that includes information standards and outlines rules for infrastructure design and creation, which often can be modified to be project-specific. The standards are also aligned to contracts, which help ensure compliance on projects via performance measures, and coordinated with process and project workflows. In many cases, there‘s an opportunity to introduce automation to analyze a lot of data or perform simulations based on design performance to improve the model and final designs.

4

BIM WORKFLOW FOR CIVIL PROJECTS: SCALE AND COMPLEXITY

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One of the cost common factors cited as influential to the impact and success of BIM on civil projects is the complexity and scale of the project, as well as the size of the organization embarking on the project.

On the project:

From the owner perspective, project complexity is an important consideration when deciding to implement BIM into the civil project development workflow. Nearly three-quarters of owners find that project complexity contributes to the value they receive from BIM. A few differences are evident in the responses when analyzed by country, role, or sector of work:

- In the US, complexity ranked first among respondents to Dodge's 2017 BIM for infrastructure survey, with 60% of the respondents selecting project complexity as being the biggest factor in realizing a return on investment with BIM.

- Project complexity ranked second for BIM ROI in the UK and France and Germany (31%, 29% and 28%, respectively).

These numbers suggest that respondents from Europe appreciate many different factors when it comes to BIM, while respondents from the US highly value its impact on complex projects.

Rallying around a model helps everyone understand the implications of design decisions or how a change to one component may affect multiple points of coordination or critical path items.

The placement of pipes and cables is an excellent example of complexity that is improved by the model. This problem requires a 3D understanding of what exists, as well as developing a model for what needs to happen in construction. Rallying around a model helps everyone understand the implications of design decisions or how a change to one component may affect multiple points of coordination or critical path items.

The reduction in time to complete these activities with BIM versus more traditional methods can be staggering. A growing number of case studies illustrating the success others have had on similar projects provides further proof that implementing BIM on civil projects reaps many of the same benefits as the vertical world.

The size of a project is also a major factor and often size and complexity go together. The 2017 survey respondents from France ranked project size as the top factor in their decision to implement BIM, with 34% citing this as the primary influence on perceived ROI. In the US, 36% of respondents said project size was an important consideration. Size seemed to be less important to respondents in the UK or Germany, who ranked size as a top factor in BIM implementation only 25% and 22% of the time respectively. This may lead us to conclude that perhaps BIM has a broader level of adoption in these countries regardless of project size due to government policies and mandates.

Within the organization:

BIM is well integrated in many larger organizations, while smaller practices are less likely to have adopted BIM. Per Dodge's data, 80% of medium practices (16 to 50 staff) and 78% of large practices (51+ staff) have adopted BIM. Yet only two-thirds of smaller practices (with 15 or fewer staff) describe themselves as having adopted BIM. Smaller firms may find the adoption of BIM too challenging or expensive. However, many industry organizations have set up training programs and BIM guidelines to help smaller, private firms learn and leverage the power of BIM. Some local and state-level governments offer tax breaks or other incentives. Regardless of an organization's size, it's important to have a BIM champion or team of champions dedicated to sharing best practices and insights in order to help staff better understand the benefits it can provide.

5

REAPING BENEFITS – AT THE OPTIMUM TIME

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BIM is increasingly being used throughout the life cycle of a project, but the timing of its implementation is important to maximize benefits.

By far, the largest percentage of respondents across all four countries in the 2017 Dodge report consider BIM to provide the greatest value during design development. It's safe to assume that much of this value cascades down to construction activity, as contractors get on board earlier in a project's design and may be involved with the model long before actual construction starts. BIM can also provide ROI much earlier in the process when owners or project managers need to "sell" the project to public stakeholders or funding entities.

As a project progresses through design, the model sheds light on responsibilities, combining different disciplines with proposed solutions. It holds valuable information about scheduling and project sequence. This is also where standards help set up a project for success. When the team can define what type and level of information must be shared for the different model elements, it helps inform the rest of the process. Such sharing helps to detect clashes, as all disciplines can clearly see the work of others, down to minute details for complex elements. This promotes a greater understanding of the whole project and helps coordinate maintenance efforts.

It's also crucial to set the tone for collaborative project work: Firms that have successfully implemented BIM stress the importance of being open with processes and workflows to foster a team approach that allows users to suggest changes and help troubleshoot problem areas. Keeping an open mind to alternatives helps to implement processes where they work best and results in an optimal end product.

6

BOOSTING CONFIDENCE THROUGH CONSTRUCTABILITY

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Once teams enter the construction phase of the project, they get to see the results of the model in action.

They can access models on phones and tablets and share them with field crews or in their communications with owners and other stakeholders. Portable, handheld devices help teams work together and share information about on-site conditions. During construction, the model-based team approach leads to many benefits, including time savings due to more efficient field coordination, as well as fewer RFIs and change orders.

TRANSITION TO SUSTAINABLE AND EFFECTIVE OPERATIONS AND MANAGEMENT

Though BIM's adoption in civil work is high during a project's design and construction, very few respondents to Dodge's infrastructure survey selected the operations and maintenance (O&M) phase as an area where BIM provides the most value. The majority of the respondents were civil engineers and contractors, but owner responses are not notably different. Only one out of the 24 BIM-using owners included in the study selected O&M as an area benefited by BIM. This may suggest that currently most of those working in the civil market see BIM as a tool to improve design and construction, but that they have not yet discovered its potential to improve the management and operations of their assets.

> Some pockets of the civil infrastructure industry already understand BIM's ability to contribute to their organization beyond the 3D model used for design and construction. As more professionals adopt BIM, they will have more accurate project data when they turn projects over to asset management and operations departments, no matter which type of infrastructure project they work on.

Respondents working in the water markets fared better in getting the most out of BIM for O&M by using it in multiple activities. More than a quarter of the respondents to the 2018 BIM for water projects survey say they integrate the model to plan for asset management. Most respondents (86%) report that, on at least some of their projects, the model is used to support asset management or O&M to some level. Over half (56%) state that this occurs at medium to high levels on their projects. So far, this emphasis on asset management is more pronounced in the water sector than in many other sector-focused studies on BIM conducted by Dodge.

Some pockets of the civil infrastructure industry already understand BIM's ability to contribute to their organization beyond the 3D model used for design and construction. As more professionals adopt BIM, they will have more accurate project data when they turn projects over to asset management and operations departments, no matter which type of infrastructure project they work on. BIM can be integrated with facility data used for asset management and maintenance, and it can become the project's central record that informs ongoing maintenance and future actions. It also measures and tracks work progress.

Why then is BIM adoption growing more slowly in some areas? Some specialists in certain civil infrastructure projects may receive the model after construction is complete. They may understand the benefits of BIM, but they may not have the tools to use and translate the intelligence of the model into their O&M or asset maintenance software.

There are, however, many components of BIM that can be valuable to civil owners, including:

- Automated tracking of equipment lists
- Tracking maintenance activities of built components
- Linking with analysis applications
- Integrating with performance monitors, sensors, or smart devices in the Internet of Things.

Most 2018 Dodge respondents (86%) believe that models from their projects are being used to support operations and maintenance activities to some degree. However, 43% of those respondents characterize that support to be at a low level. The numbers confirm that owners are just beginning to implement models, as well as the data gleaned from those models, into their operations and maintenance work. The measurement of associated O&M costs and return on investments will be interesting to track over time as BIM adoption in this area grows.

7

WHAT‘S NEXT

WHAT'S NEXT

Project planners, designers, and owners may not yet be taking advantage of all BIM has to offer for civil infrastructure projects, but a BIM strategy alignment check can help firms and owners maximize their investment. While approaches may be different due to project constraints or the dynamic of a team or organization, established best practices help set expectations, improve communication, foster collaboration, and reduce conflicts.

Of course, the reports also highlight certain areas where the perceived value of BIM can improve. In the US, for example, 43% of the respondents say they are experiencing 25% or less of the total value BIM has to offer. But these numbers are prone to change as additional training and industry support help improve levels of adoption.

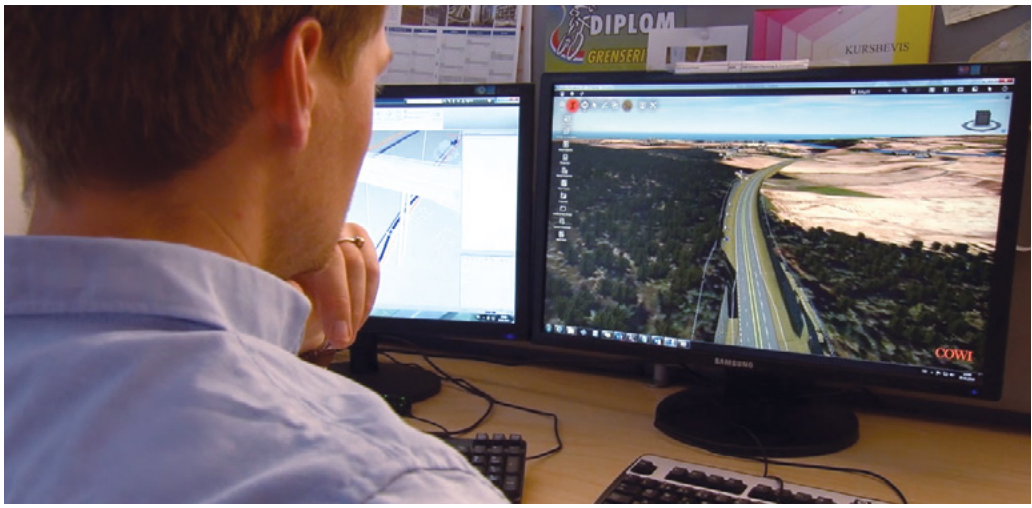
TRAINING

BIM training has evolved as the next generation of civil engineers and builders emerged from colleges and universities with a strong understanding of BIM. For professionals already in the field, the development of training and standards for BIM can help them improve their work. A better understanding of BIM also helps them to be innovative and to remain competitive in marketing and business development.

BIM makes it easier to train more junior staff. Survey respondents ranked this high in the list of benefits of BIM, with 59% saying BIM helps younger staff better visualize how projects go together.

BIM also allows professionals to spend more time designing and less time documenting , providing an avenue for less experienced professionals to visualize the outcomes of any given design approach rather than solely focusing on a prescribed task. This is linked to the third top-rated benefit of BIM, which is its effectiveness in helping companies recruit and retain talent. Almost half of all respondents to the survey (43%) rated this benefit as high or very high.

Additional support for BIM implementation cited in the report includes a variety of tactical deployment. It also embraces several commonalities such as accreditation and training, along with investments in software and hardware upgrades.



IMPROVED BIM SOFTWARE/TOOLS

The findings of the 2018 Dodge survey demonstrate that improving BIM software and tools, including making them more applicable for certain infrastructure sectors, would help increase the effectiveness of BIM for the respondents.

Improved interoperability between multiple software applications is the most frequently selected factor in improving the effectiveness of BIM, chosen by 43% of respondents.

Nearly two thirds (61%) of highly experienced BIM users (five or more years) believe that improved interoperability is one of the top factors that would help them achieve greater benefits from BIM use. More than one third of respondents (35%) say the ability to incorporate more components detailed in 3D (such as valves or pipes) would increase the benefit they receive from BIM.

SUMMARY

A key element is the integration of BIM tools and processes within planning, design, and construction firms, as well as with all stakeholders across the entire project life cycle. Collaborative workflows that break down barriers are central to improved processes and better-quality project outcomes.

SUMMARY

Many organizations involved with civil projects continue to implement BIM in a variety of ways, and documenting and measuring this development will provide valuable insight. There's a need for wholesale process , workflow improvement, and better integrated tools to deliver civil projects within the constraints of the triple bottom line – time, money, and resources.

A key element is the integration of BIM tools and processes within planning, design, and construction firms, as well as with all stakeholders across the entire project life cycle. Collaborative workflows that break down barriers are central to improved processes and better-quality project outcomes.

The need to innovate is a balancing act, with a focus on cost savings and improved outcomes. Design approaches are often vetted around time savings and money. BIM for civil projects can influence outcomes with its ability to test multiple scenarios. BIM is being widely adopted because it provides data-driven assurance and confidence that projects can be delivered on schedule and on budget. BIM offers the benefits of this shared information throughout the project's life cycle, with results that are particularly compelling when compared to traditional methods of project delivery.

As we head into a phase of widespread BIM adoption for civil infrastructure, it's important to establish standards that still allow a certain flexibility for fine-tuning outside of rigid frameworks. This enables project teams to set expectations and maintain progress and accountability. At the same time, they can be innovative and determine optimal processes and solutions.

We're in an era of greater connectivity among designers, civil engineers, contractors, and operators. Tools such as BIM help teams to collaborate and achieve the desired project outcomes – in design, construction, and operational phases.

RESOURCES

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