WHITE PAPER

AUTODESK.

ADVANCING CIVIL INFRASTRUCTURE PROJECTS THROUGH BIM

TOPICS

1 ADVANTAGES OF BIM

2 IMPROVING THE LEVEL OF ADOPTION

3 FUTURE INVESTMENTS

EXECUTIVE SUMMARY

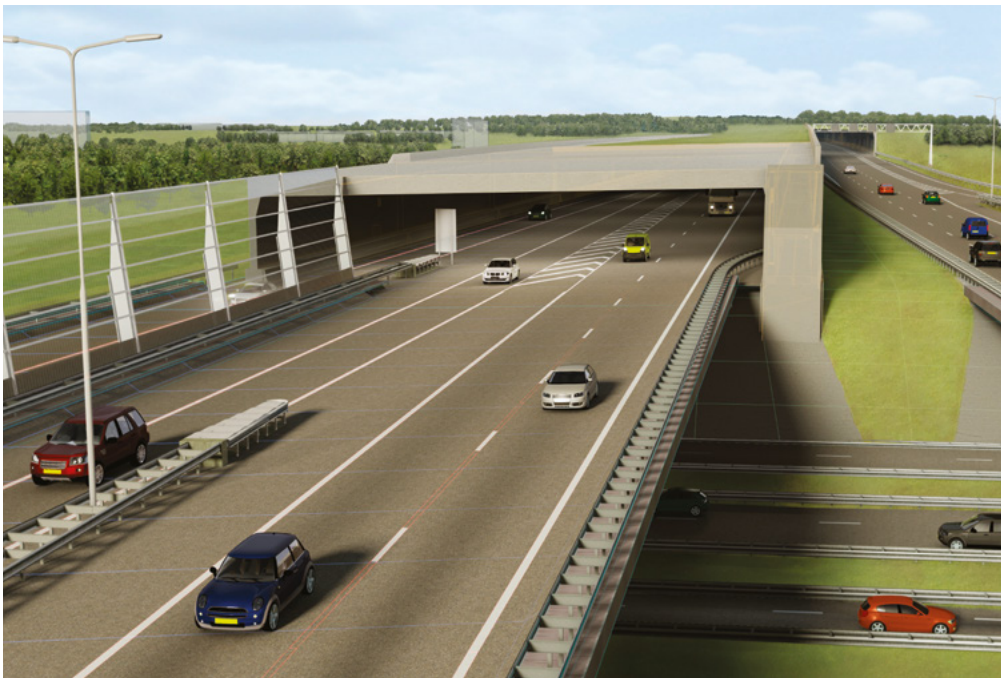
Infrastructure construction is often a public process, involving a public owner and large sums of taxpayer dollars. The projects combine many different stakeholders with a shared goal to build the best possible system for their community. Yet, these stakeholders often have different ideas, backgrounds and approaches. So can infrastructure projects benefit from the centrally-stored, data-rich environment of BIM that has already become the norm in the vertical world? All signs point to yes.

A BIM approach centers around an intelligent model shared among team members, serving as a collaborative hub throughout the entire life cycle of an asset. It's "a process or method of managing information related to facilities and projects in order to coordinate multiple inputs and outputs, using shared digital representations of physical and functional characteristics of any built object, including buildings, bridges, roads, and process plants, „ according to the European Union BIM Taskgroup's BIM Handbook.

BIM may be used as early as the design stage, or it can be integrated later with the help of highly detailed and automated data-capture technologies. The model gains intelligence as team members add their expertise, conditions, operations and maintenance data or actions.

Though the interest in BIM for infrastructure keeps growing, there remains some resistance to implementation. Reasons include little owner demand, as well as reluctance to spend money and resources on software and training. The tide seems to be turning, however, as more professionals begin to realize the benefits of BIM. Reports show that BIM's use in infrastructure projects is rising: Adoption rates by high-level users have more than doubled from 2015 to 2017, according to the Dodge Data and Analytics 2017 Smart Market Report on The Business Value of BIM for Infrastructure.[1]

The civil engineering and construction world, more than any vertical market, may benefit the most from higher adoption rates of a managed modeling approach, especially given the state and quality of existing infrastructure systems. The pressure to repair or replace deficient infrastructure is growing, while funding remains tight.



By now, BIM's value for managing detailed construction costs, reducing design errors, and decreasing the cost and time of field coordination is well established. But as our data-driven world expands and data sets become available on a broader scale, there are even more ways to leverage BIM.

In the water market, for example, many firms have been using BIM for treatment plants for years, according to Dodge's 2018 SmartMarket Report on The Business Value of BIM for Water Projects[2]. The report clearly demonstrates a growing interest in taking BIM to the next level for horizontal water projects. While 88% of the 74 respondents to this survey said they currently use BIM for water treatment plants, only 68% use it for linear water projects. However, both categories expect to see growth in BIM implementation, with 97% of respondents planning to use the model for water treatment plants by 2020, and 88% planning to adopt BIM for linear infrastructure.

As BIM becomes more widely adopted for infrastructure projects, companies often use their BIM expertise to stand out and to improve business. BIM is already considered a standard business practice in the vertical world, and there is a growing perception that it is a minimum requirement to get a seat at the shortlist interview table. A better, well-coordinated design that seamlessly transfers to construction through the use of BIM is a value proposition that cannot be ignored if a company or owner wants to remain competitive and successfully execute today's projects.

This white paper takes stock of current BIM adoption rates and points out the advantages of BIM for civil infrastructure projects. Not surprisingly, there are benefits to using BIM throughout the life cycle of an asset, which is leading to a growing acceptance of BIM for new projects, ongoing operations, or planned retrofits.

1

ADVANTAGES OF BIM

BIM‘S VALUE FOR ROI

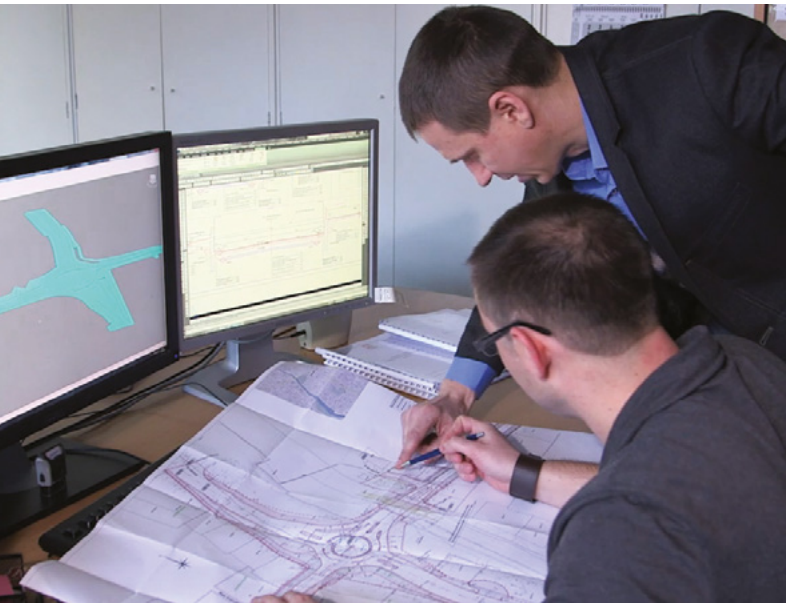
According to Dodge‘s 2017 SmartMarket Report, 87% of BIM users report that they see positive value from their use of BIM, with about half of those reporting an ROI of 25% or more. The report “The Business Value of BIM for Infrastructure 2017“ was developed from an online survey of professionals working in design firms (including planning, engineering and architectural), contractor firms and facility owners. It included 368 respondents from the US, UK, Germany and France. More than 40% of the survey participants have been using BIM for three years or less on transportation infrastructure projects.

Interestingly, the report shows a significant gap in the perceived level of BIM‘s value depending on the location of the infrastructure projects. Respondents from France and Germany rated this value much higher than their counterparts in the US and the UK, with 65% of users in Germany rating the project cost and schedule benefits as high value. France was a close second at a 60% high value rate for BIM‘s cost benefit, while the US and UK were at 30% and 28% respectively.

The differences in the results between these countries provides some interesting food for thought about how demand and/or mandates might be affecting BIM‘s level of adoption in the horizontal world.

What‘s Here and What‘s Next

So, how do we benefit from BIM? And what‘s next for BIM? As the evidence for cost savings and improved efficiency continues to accumulate, it‘s worth taking a look at recent advancements and predictions for BIM‘s future.



For Kelprojektas to stay competitive, remain a leader in Lithuania and expand globally, it is necessary to integrate BIM with transportation projects.

AN INTEGRATED KNOWLEDGE BASE

Civil engineering projects are complex by nature. They may intersect roads, tunnels and bridges, the underground infrastructure of water, sanitary and storm sewers, and other utility infrastructure such as gas and electric. This network of critical systems demands a high level of detailed existing conditions. Potential conflicts must be known and addressed to make any given improvement or connect to a new system. The model becomes the centralized hub for information throughout the life of the project. It offers value from planning to preliminary design, detailed topographic and asset surveying, detailed design, construction, and then maintenance. It is the foundation and central hub for data about the project.

BIM FOR PLANNING

BIM can be an effective tool for overall capital planning, as well as planning on the individual project level. Stakeholders prioritize budget, singling out the most critical needs and green-lighting new projects based on impacts and objectives.

A city's public works department or other similar types of government agencies will typically have a detailed representation of their roadways, water and sanitary lines, and other civil assets, as well as a backlog of projects that have received some form of vetting and approval. Many agencies are increasingly integrating BIM with their Geographic Information Systems (GIS) and other existing knowledge or data. BIM can help comparing costs and effects based on the modeling of different scenarios before any dollars are spent in the field. As an example, BIM can incorporate performance data in simulations to show actual traffic volumes at different times of day and which design option may perform best.

Such testing with simulated traffic volumes is critical in the decision-making process to find design alternatives that perform best within budget constraints.

LiDAR scan data (top) provide input for 3-D modeling and rendering (bottom), which was created in Autodesk InfraWorks.

BETTER DESIGN, MORE COST SAVINGS

BIM provides a means to share each phase of work and resolve conflicts before they become time and money-wasting issues in the field. In the 2017 Dodge SmartMarket Infrastructure Report, respondents consistently rated fewer errors and greater project cost predictability as two of the top three benefits of BIM.

Every infrastructure project involves competing spheres of schedule, scope, and cost. BIM provides more predictability for all three. Its ability to help reduce re-work is a direct effect on a consultant's or contractor's bottom line. For the project, exacting quantities brings an enhanced transparency, because the contracting agency and bidders are clear on the model's material outputs, and they can receive their own copy of the model to test and ensure pricing accuracy.

CAPTURE OF EXISTING CONDITIONS

BIM for infrastructure allows users to capture high quality information on existing conditions, both surface and subsurface. Even before the design phase begins, the modeling environment gains intelligence with information on existing conditions, which may include a topographic survey or other traditional data.

Light detection and ranging (LiDAR) is a another method of data capture that the model accommodates. It uses infrared laser light, instead of radar, to bounce off objects and return details about surroundings in what's called a point cloud, with each point representing a surface data point. The point cloud provides detailed ground-surface measurements, as well as accurate representations of roadside assets such as lamp posts, curbs, storm drains, guardrails, signs, overpass and underpass clearance and complexity, and surrounding vegetation. Such detailed 3D capture is tailor-made as a starting point for BIM, as the measurements and visualizations can easily be integrated into the model. This forms the basis for design and simplifies communication.

In general, the model helps project teams take into account existing conditions and environments, so they can create better customized designs. The team can also use the model's information on required materials to begin procurement, which can be critical when long-lead items threaten project schedules.

With a BIM approach to infrastructure project delivery, the model contains a detailed representation of the job site to the point where virtual construction is possible.

CONSTRUCTABILITY

BIM's ability to vet a design's constructability is also key to project success, as constructability issues can have a major impact on a project's cost and schedule. By leveraging the model, team members can look at specifics and consider alternatives. They can use the data to support the most viable solutions and dismiss those that don't make sense for the situation at hand.

With a BIM approach to infrastructure project delivery, the model contains a detailed representation of the job site to the point where virtual construction is possible. With a roadway, for example, that translates into a more-detailed understanding of needed volumes of cut and fill, and a clear idea of road leveling and repaving challenges

STAFF DEVELOPMENT

The next generation of civil engineers and designers also benefit from BIM. More than 58% of the Dodge survey respondents rated BIM's ability to show more junior staff how projects go together as a high or very high benefit of BIM. The model helps to keep all team members up to date, and it helps establish improved processes and designs. This, of course, allows companies to compete for more complex projects.

As more professionals embrace BIM, they also find new ways to integrate the model into innovative programs. In Chicago, for example, a team is working on a ground-breaking holistic development along the Chicago River called The Chicago Urban River Edges Ideas Lab[3]. The primary design medium for the Lab, which was developed by WSP USA in partnership with Autodesk, is BIM. The project covers 600 acres of the city of Chicago and will explore typical and problematic conditions in 3D. The goal is to find a design solution that leads to a unified look for the riverfront.

Companies that can compete for exciting large-scale BIM applications such as these also attract top talent: More than 40% of the respondents to the Dodge survey said BIM helped them be effective in recruiting and retaining staff.

BIM'S COMPETITIVE EDGE

To be successful in the civil engineering industry, companies must seek out projects and clients, provide concepts to compete, and show why their firm is the best choice for high-dollar projects.

Savvy company leaders will understand how to best present their BIM expertise and essentially "prove" the ROI on the owner's budget. Not only can they rapidly generate contextual models to show multiple solutions to prospective clients, companies can also generate ideas, validate preliminary constructability, and demonstrate that they're interested in stakeholder input and understanding.

The model also becomes the primary means to communicate project details to the public. For stakeholder meetings, a 3D design can be overlaid on a model of existing conditions to create a realistic depiction of what the project will look like after construction. The 3D presentation and information behind the model in the context of what's there now helps non-technical observers understand the project and make it more compelling.

Modeling ease is changing this process to the point where suggestions can be input during a meeting and be displayed and analyzed in real time to accelerate consensus. The team at Chicago Urban River Edges Ideas Lab, for example, uses the BIM model as a basis for developing panoramic renderings. Using augmented and virtual reality, members of the public can see an overlay of what's proposed for a site and provide feedback. These are just some examples of what the rich and intelligent 3D modeling of BIM offers to infrastructure projects in the public realm.

POSSIBILITIES FOR INTEGRATION WITH THE INTERNET OF THINGS

BIM can help evaluate transportation or mobility options that promise more efficient movement of people and goods with reduced traffic congestion and emissions, and far greater safety. Opportunities with new transportation technologies, such as autonomous vehicles equipped with sensors connected to the "Internet of Things" are enhanced by the detailed road models that BIM provides.

In the trucking sector, such detailed models aid efficiency. With heavy loads, trucks lose speed and wear out brakes over hills and valleys. With an onboard model and adaptive transmissions, trucks can accelerate or downshift to even out the gains and losses for quicker times and less fuel use. Moving toward BIM in transportation is vital to advancing engineering-grade models that can provide millimeter-level accuracy to vehicles that ply our roadways.

As new smart city developments come online, the data offers an exciting opportunity to see how BIM can integrate with traffic management systems, emergency response systems or other infrastructure developments to optimize design, construction or maintenance projects.

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>
> *Brendan Dillon, BIM Manager, Denver International Airport*

ONGOING OPERATIONS AND MAINTENANCE

The biggest plus in terms of cost savings is often improved project management with BIM. As the model approach becomes more widely adopted, companies see the benefit in establishing a consistent and repeatable project delivery process, which was rated as high or very high by 54% of all BIM users responding to the Dodge survey. There also are cost savings throughout the full life of an asset with a model-based approach, because you can use and reuse all the project data, rather than wasting time and money on recreating data.

With a model, there's a record of how things were constructed, providing important data for asset management and maintenance. Denver International Airport (DEN), for example, recently implemented a new facility management program that aims to combine building information modeling and 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.

The airport first embraced this approach for the construction of its 519-room hotel and public transit center. The lessons learned during this $385 million project can be extended to the horizontal world. DEN has continued to pursue this integration on several subsequent projects. The value of facilities or O&M staff to be able to push and pull data from the asset management program, fulfilling data requests from the airport and its stakeholders helps streamline the process and budget.

Ideally, the BIM model is used as the project's living and central record that informs ongoing maintenance and future actions. The shared model becomes the place to generate cross sections and earthwork quantities, without additional software. It also provides the means to measure and track work progress.

DEN's BIM Manager, Brendan Dillon highlights a key point to the overall long-term value of BIM.

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

P3 OPPORTUNITIES

Because capital is so constrained, project planners often seek new financing options such as Public Private Partnerships (P3). After all, local and state governments need to replace aging infrastructure, even when government funding is in decline.

P3 projects are typically design-build or design-build-finance-operate-maintain (DBOM), where the contractor takes the lead on all aspects. P3 helps to accelerate BIM adoption on infrastructure projects thanks to the need for tighter integration between design and construction and an increased focus on project cost and schedule. The need for better coordination and collaboration with designers is crucial to meeting bottom line costs of a P3. The combination of private and public investment requires transparency and monitoring, which is made easier with BIM. The model also helps simplify complex engineering tasks for a greater understanding of where dollars are going. That means better cost accountability.

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IMPROVING THE LEVEL OF ADOPTION

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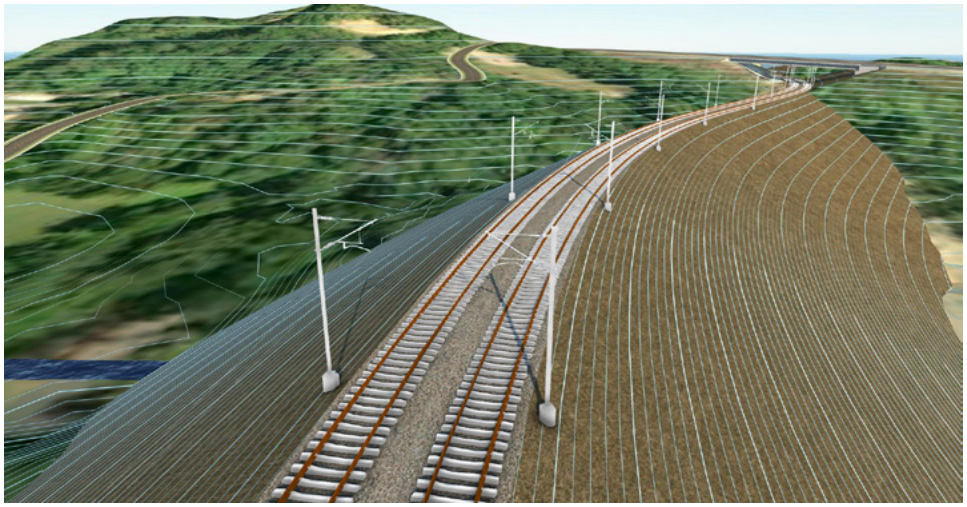

MANDATES VERSUS MARKET PRESSURE

It might seem ambitious to predict an evolution from BIM advantages on project work to BIM fueling economic expansion of a nation. But the UK and Germany are driving innovation and adoption of BIM, introducing mandates and government supported programs that support training and a streamlined BIM practice.

The team reports benefits in streamlining and simplifying designs, and it expects to take advantage modularization via the BIM model in the future. For instance, gantries with electronic displays or refuge areas could be built as multi-trade modular units and then connected to support agencies or roadside assistance services. They also consider an integration with virtual reality.

“The approach here is a full life cycle model,“ says Liam Gallagher, director of information management for the UK transportation and process teams at Jacobs, a key metmber of the program team on this £5 billion effort.

The United States have also pushed BIM, but without mandates. In the transportation realm, the Moving Ahead for Progress in the 21st Century Act (MAP-21) uses incentives to encourage a performance-based approach. MAP-21 promises more flexible funding for projects that use 3D modeling/virtual construction and visualization technology.

Nevertheless, true savings can only be achieved through the widespread adoption of digital processes on mainstream construction projects. It involves adoption rates at scale, and a skilled workforce that collaborates across projects of differing size, complexity and type.

Industry organizations and government initiatives propel additional training programs and share valuable insight, improving outcomes and skill levels of BIM users. For example, the EU BIM Task Group shares information and aims to improve BIM adoption and standards by “working collaboratively with academia and industry to determine what good learning outcomes look like.“[4]

This encourages suppliers to develop and deliver training that meets the skills requirement for the UK BIM performance level.

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TECHNOLOGICAL ADVANCES AND BIM

BIM is enhanced by virtual reality and/or gaming applications, allowing stakeholders to virtually experience a design. It can simulate conditions to enable workflows and models to test different solutions. Simulation replicates patterns in nature with the aid of computer algorithms. Big data analytics helps make sense of all this information and allows project planners to modify designs, which supports the long-term performance of infrastructure even in a changing climate.

Advances in software and mobile data access are blurring the traditional lines of how business was done. With cloud-based computing, users tap into infinite storage and they are able to harness the power of expertise or data no matter where team members may be located. And then there are tools such as storm water modeling that further advance BIM's benefits to workflows on infrastructure projects. The extension of tools specific to these disciplines encourages greater collaboration as the model becomes more central to daily operations.

3

FUTURE INVESTMENTS

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The outlook for BIM is bright, according to the Dodge SmartMarket Report as well as the EU BIM Task Group Handbook.

Many respondents say they expect their current levels of Return on Investment from BIM to only grow stronger. The EU BIM Handbook forecasts that the wider adoption of BIM will unlock 15–25% savings to the global infrastructure market by 2025.[5]

Investment in BIM is expected to expand on a global level. Respondents from all four countries participating in the Dodge survey say training will be among their highest priorities. Other top-rated investments include developing better internal collaborative workflows, developing collaborative BIM processes with external parties and investing in increased marketing of BIM capabilities and strategic BIM deployment.

SUMMARY

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BIM is expanding rapidly in the civil engineering world thanks to positive bottom-line results.

The model allows users to move data efficiently and foster a common understanding of the design. Project planners can fine tune solutions to stakeholders' goals and objectives. Projects run efficiently and with improved outcomes. In addition, stakeholder communication helps eliminate costly rework.

The global marketplace for infrastructure design and civil engineering services has few boundaries, and large international firms work on projects worldwide. Many governments have recognized this competitive landscape and have adopted BIM practices to help their firms and citizens compete.

The trends of big data and sensor proliferation advance BIM further, with data helping to inform the model, and sensors providing input on infrastructure performance.

Future infrastructure projects will be built on the foundation of safety and sustainability. With BIM, a collaborative and quantifiable process ensures that each project contributes toward these goals.

RESOURCES

[1] Dodge Data and Analytics 2017 SmartMarket Report on The Business Value of BIM for Infrastructure, p.10.

[2] Dodge's 2018 SmartMarket Report on The Business Value of BIM for Water Projects, p. 4.

[3] Dodge SmartMarket report, p. 13.

[4] EU Handbook on BIM http://www.eubim.eu/handbook/ p. 51.

[5] EU BIM Task Group p. 4.

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