

WHITE PAPER



# BETTER BUSINESS RESULTS WITH BIM



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## EXECUTIVE SUMMARY

While the demand for new, upgraded, and maintained infrastructure is growing everywhere, investment levels vary. Some locations face an unprecedented demand for the execution of infrastructure improvements. These needs may stem from the delay of critical improvements due to funding constraints or, perhaps, an area's rapid development. Other communities may encounter a combination of these and other factors, such as exploring new forms of transportation and mobility to ease congestion on roads and highways.



The causes vary, but they all lead to a rise in civil infrastructure projects that require billions of dollars in annual spending. A [2017 report](#)<sup>1</sup> from the G20-backed Global Infrastructure Hub (written by Australia-based GIH and Oxford Economics) says that the world will need to spend \$94 trillion on infrastructure by 2040 to close the gap in project need.

Since BIM maximizes quality and productivity when used in civil engineering projects, it is seeing an ever-growing level of acceptance in the industry. Evolving from a traditional 2D approach to 3D with BIM wasn't easy. Those early adopters who've shared their success stories and lessons learned have paved the way for broader use.

The results are encouraging. Many proponents of the model cite the same benefits that have become evident in the vertical world – improved collaboration, quality, productivity, and capacity.

This paper will review where we stand with leveraging some of the common advantages of BIM in the AEC industry, discuss some of the distinctions of use between project type, and explore how increased adoption of BIM across all civil projects can result in broader gains both industry-wide and in tandem with the capabilities of Big Data and IoT.

A man and a woman are in an office setting, looking at a tablet. The woman is pointing at a line graph on the screen. The background shows a blurred office environment with computer monitors and desks.

# 1

## BENEFITS ACROSS THE CIVIL SPECTRUM

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## BENEFITS ACROSS THE CIVIL SPECTRUM

The use of BIM in civil infrastructure is expanding globally across a spectrum of different types of projects.

In fact, BIM adoption rates have essentially doubled in the past two years, according to Dodge Data and Analytics, who recently produced two reports based on surveys of professionals working on civil projects. Its 2017 Smart Market Report on [The Business Value of BIM for Infrastructure](#)<sup>2</sup> assesses the changes in the perception and use of BIM since Dodge's last report in 2012. It is primarily focused on the industry's use of BIM within transportation infrastructure. In 2018, Dodge followed up with a [SmartMarket Report on BIM](#)<sup>3</sup> that is focused on the water sector.

Both reports show a dramatic growth in BIM use, and respondents expect it to continue in the coming years.

The 2017 transportation infrastructure survey queried respondents from four countries, including the United States, the United Kingdom, France, and Germany. Nearly 80% of these respondents reported that they use BIM for their infrastructure projects to some degree:

- Project teams working on tunnels appear to leverage BIM most often, with 86% reporting they use it on those kinds of projects.
- Bridges are close behind at 79%.
- BIM is often used on rail /mass transit projects, with a respondent rate at 77%.
- Road and highway projects also rated high, at 76%.



Survey respondents from Dodge's 2018 BIM Water Report say they expect BIM adoption rates to be even higher:

- Water and wastewater treatment facilities and mining industrial sub-markets ranked the highest with an expected 97% adoption rate for these projects by 2020.
- The average overall rate on the five water sub-project types of Water/Wastewater Treatment Facilities, Mining/Industrial, Linear Infrastructure, Tunneling, and Hydroelectric comes in at an expected 89% adoption rate by 2020.
- At the time of the survey, the average overall adoption rate for water projects was 69%, with the Water/Wastewater Treatment facility submarket remaining at the high end with an 88% adoption rate.

**So, perhaps the “early adopter” phase of BIM for civil infrastructure projects is over and turning into mainstream acceptance. Let's review the overall value-adds from BIM and the nuances of use in specific civil engineering project types.**



## BENEFITS FOR PUBLIC STAKEHOLDERS

**The majority of infrastructure projects continue to be publicly procured and managed, regardless of where in the world the project is needed. The European Union has led many efforts to improve the use of BIM industry-wide, providing government support for research and measurement, as well as pressure through mandates.**

A team of industry leaders in the EU helped create a Handbook for Building Information Modelling by the European Public Sector<sup>4</sup>. The public building market in the EU represents 9% of the EU's gross domestic product and employs 18 million people. The handbook's intent is to provide industry guidance and data to help current and future generations understand best practices and leverage the power of BIM in the public realm.

BIM's ability to streamline workflows from a centrally-shared model and quickly test the viability of proposed solutions is a boon for public owners facing project pressures such as tight funding or timelines.

The EU handbook outlines the “economic, environmental and social benefits across a range of different public stakeholders” that BIM offers.

Among them are:<sup>5</sup>

- Greater productivity – delivering more built assets for the same or less expenditure
- Improved output quality of built public assets
- Adapting to a sustainable built environment – one that supports the challenges of climate change and the need for a circular economy
- Increased transparency of construction performance
- New opportunities for sector growth, through exports and additional service offerings
- A stronger and digitally-skilled sector
- Public planning and support for new or updated public infrastructure that aligns with local communities

**BIM offers new ways to model the real world, improve human understanding with data, integrate the Internet of Things (IoT), and incorporate performance and usage data to create better projects. It is an intuitive means to communicate and interact, fueling quicker collaboration and an all-digital workflow. Paper still exists as a convenient medium when needed, but it is no longer the primary medium for design.**



## BETTER QUALITY AND REDUCED LIABILITY

**Imagine exchanging data in real time to try different ideas and fine-tune a design. The model makes it possible.**

It documents existing conditions with reality-capture and intelligent data. For example, project planners can better inform the design from the start by importing data from laser scanning and other software systems, such as photogrammetry.

The result is a better quality design. BIM is frequently cited as a tool to reduce errors and omissions. In Dodge's 2018 [BIM Water SmartMarket Report](#), BIM's ability to reduce errors and omissions was rated among the top project outcome of BIM across the survey group, with 73% of these respondents citing it as a benefit.

Overall improved design quality typically reduces Requests for Information (RFIs) and change orders, leading to a smoother process with fewer surprises. Yes, there are contractual mechanisms based on project parameters, but BIM's more transparent and collaborative process can help outline the shared risk and determine liability.

**The top benefits from both of the Dodge Reports on BIM for transportation and infrastructure include better collaboration and client relationships, thanks to improved project understanding.**

## IMPROVED COLLABORATION AND GREATER PRODUCTIVITY

**BIM's value increases as projects become more complex. Close coordination between various trades, distribution and piping systems, surface improvements, schedule controls, or other parameters can be managed through the central data hub of the model.**

The perceived ROI of BIM is reported as positive by 65% of the survey respondents to Dodge's 2017 transportation infrastructure report. Those who stated they are making an effort to measure this return in one way or another perceive an even higher level of return. Users in this category in the UK rate the highest, with 97% reporting a positive return on investment. The results in Germany are not far behind, at 87%. France and the US report a 73% return.

**The top benefits from both of the Dodge Reports on BIM for transportation and infrastructure include better collaboration and client relationships, thanks to improved project understanding.**



## SUSTAINABILITY

Beyond sustainability on a project level, infrastructure planners face new challenges with regards to climate change, the demands on finite resources, and the effects of global warming on our water systems. These challenges have become important factors in today's infrastructure design and construction projects. Many owners are looking beyond traditional project constraints to those we may be facing globally in our futures.

**Working with the model as our central shared data point, we may be able to better explore anticipated or potential future scenarios such as rising sea levels, flooding, drought and other extreme weather events. BIM allows project planners to better explore potential impacts or consequences of any given approach and how they may play out on a broader scale**

## ACCOUNTABILITY

Large infrastructure projects with complex contracts often involve multiple players with overlapping timelines. By using the model as the central hub, all team members are synced on the current design and data.

**Accountability is transparent to everyone on the team, reducing or eliminating misconceptions or misunderstandings about responsibilities or deadlines.**

Project safety improves when project information is delivered down to the individual worker, especially since the construction industry often includes inherently dangerous work.



## SAFETY – ON THE PROJECT SITE

Project safety improves when project information is delivered down to the individual worker, especially since the construction industry often includes inherently dangerous work. The model provides data that can help drive the daily work plan, ensuring that everyone stays informed about upcoming tasks.

BIM users can integrate the exchange of information from design to the field via the use of handheld devices to keep track of workers, progress and safety concerns. The visual power of the model can help cut through language barriers to improve worker understanding and provide a means for additional training.

**The model can also be analyzed for areas that pose safety hazards by comparing incidents on similar sites, making sure past mistakes won't be repeated.**

## BIM FOR PROJECT DELIVERY

Though there is a growing interest in a public-private-partnerships, especially in the US, civil project owners are typically public entities funded by taxpayer dollars. BIM provides a clearer level of visibility on the best use of these dollars, and helps them to see and share the context of a project with authorities and stakeholders.

The full 3D modeling and visualization connections that come from BIM allow for more compelling presentations that demonstrate why the team designed what they did and how the team will execute this design. BIM helps turning concepts into reality.



## SELLING PROJECT GOALS AND GETTING STAKEHOLDER BUY-IN

Industry professionals in the vertical world have already used the visual power of the object-oriented approach of the model to create better project understanding and buy-in. These benefits are also translating to the horizontal world. Increasingly, project planners present models of civil project proposals much earlier in the planning process, creating support and even excitement about what may be realized from a civil infrastructure investment.

Using BIM at a “10,000-foot-overview“ helps owners prioritize their capital projects and get buy-in from stakeholders and funding sources. As they implement it on the project level, they can leverage its power as the design evolves, drilling down to impacts of the design, from cost, constructability performance, and potential future project phasing needs.

BIM’s central hub for the exchange and integration of data also provides flexibility. It offers compelling integrated visuals as a direct extension of the model, which often renders the more traditional practice of creating visuals via a costly and separately procured service unnecessary.

The tendency to discount a new idea or design change due to the impact of costs from additional modified or new visuals is now mitigated. With increasing intelligence and realistic and detailed visualization, the model provides an important means to communicate plans and gain approvals.

**The ability to show existing conditions as well as the planned changes achieves faster buy-in from decision makers who control the budget. Teams are better prepared to overcome objections or answer questions. They can show details such as realistic textures, day- or nighttime conditions, or other possibilities that may impact a project’s approval.**



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## BIM BY PROJECT TYPE

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## BIM BY PROJECT TYPE

Many civil project planners work on a variety of projects, while others specialize in a specific project type. At the same time, levels of BIM adoption fluctuate depending on project type and location.

It is helpful, then, that those who consider themselves high-level users of BIM are sharing lessons learned. They are helping industry professionals everywhere gain a broader understanding of how to best leverage BIM throughout a project's life cycle. With better planning, phased construction, ongoing operations and maintenance as well as other BIM benefits, the following types of infrastructure projects can proceed with the least amount of disruption to traffic, communities, and commerce.

### SITE DESIGN

BIM offers scheduling and safety advantages when it comes to site design, allowing designers and policy-makers to explore how different configurations may affect a project. This could include outlining how proposed access to the site may work, or coordinating utilities as well as other existing conditions that need to be considered with proposed new construction. BIM can help communicate how the phasing of any given site development will affect stakeholders and neighborhoods.



Image courtesy of American Structurepoint, Inc.

### ROADS

BIM provides an advantage to roadway design in several ways, including the ability to see the impact of material types and quantities on project costs. New vehicle technologies such as autonomous or data-connected vehicles are a potential game changer as communities harness more data to create smarter roadways. Project planners can also use the model to incorporate traditional roadway designs and specifications along with transit-related amenities such as bus stops, hard and landscaping features, gantries, and beyond. This not only saves a lot of time – if these elements can be built off-site and delivered just-in-time, it will also reduce the laydown area, as well as on-site congestion, and make construction safer.

**The model provides the means to explore design alternatives and to simulate traffic flow for optimized design performance. It allows users to evaluate how a roadway design performs during peak periods as well as potential hazards during nighttime or extreme weather driving conditions.**

Image courtesy of  
Atkins Global and Arriyadh  
Development Authority (ADA)



## BRIDGES

A model-based design approach lets users test bridge strength and performance with integrated analysis. The model becomes even more powerful with the addition of time for construction sequencing or the accommodation of long-lead procurement materials. It can help evaluate different approaches to meet schedule pressure or minimize the disruption of traffic when there are potential lane closures or limited access either on or below the bridge. The capabilities of BIM for bridges are driving an interest in this sub-market, with 30% of the 2017 Dodge survey respondents involved in bridge work expecting to further invest in BIM software and training in the next two years.

## AIRPORTS AND PORTS

Increasingly, these highly-managed and complex hubs are turning to BIM for project work, as well as enterprise operations and maintenance. If a team is involved with a project at an airport or port, they are typically dealing with a multitude of facility operations personnel, design and construction teams, who may all be spread out over a large area, or otherwise working remotely. The power of the cloud and BIM integration becomes highly effective in this scenario, providing a central place for back and forth communication. The model also turns into a more effective tool for the life cycle-management of the facility by supporting predictive maintenance and more efficient operations.

## RAIL

Rail projects are critical to infrastructure and mobility, particularly in Europe. Rail systems supporting public transportation networks must integrate with other major infrastructure systems, sometimes crossing major highways or traversing rivers. Passenger stations can also be complex civil structures with specific constraints or requirements. These may be related to service frequency or locations – after all, a train station in a dense urban environment will be different than a stop in the suburbs or countryside. BIM helps manage all of the interfaces required in rail, including physical constraints, phasing, and scheduling.

In France, for example, BIM is being implemented on parts 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. The team decided to implement BIM due to the complexity of the associated stations. Some of them are deep underground, and the team is leaning on BIM to manage the interfaces, for example.<sup>6</sup>

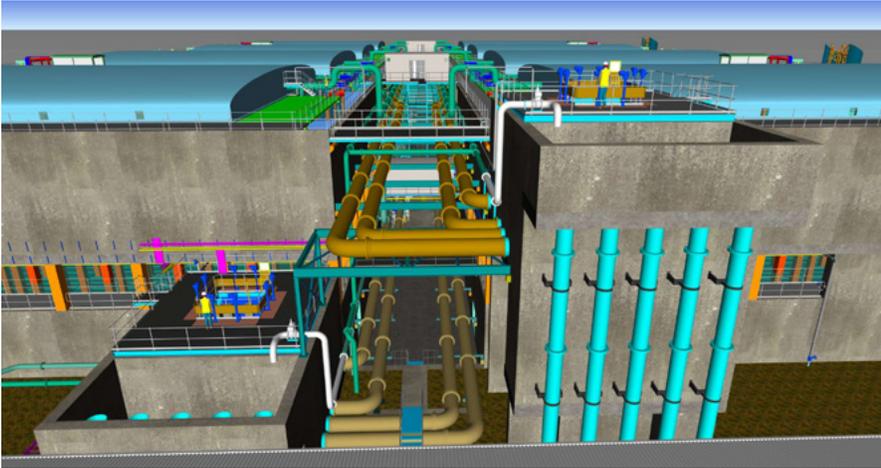


Image courtesy of  
Galliford Try Costain Atkins

## WATER AND SEWER NETWORKS

The tools within the model for pipes and pipe placement applies established design standards that include the characteristics of the pipe (e.g. size, thickness, material, etc.) to make sure they align and that the design will perform according to the plan. This automation includes entire pipe-network modeling to monitor and improve performance. BIM also integrates with Geographic Information Systems (GIS) to make sure the design and materials fit in the context of the surroundings.

## STORM WATER

Teams can model storm water networks and whole watersheds with BIM to test different design approaches and their effects on a community's water resources management. Analysis of storm water helps to accurately model infiltration of rainwater, which helps to plan green infrastructure for optimal retention. Models can include details of textures and shadowing, and they can integrate with related projects, such as park spaces, trails, bike lanes, and infrastructure that supports improved mobility beyond the automobile.



# 3

## ADVANCING BIM FOR FULL LIFE CYCLE BENEFITS

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> Beyond 3D

## ADVANCING BIM FOR FULL LIFE CYCLE BENEFITS



### BEYOND 3D

BIM is evolving into a tool that owners can use long after a project is completed. It can even be incorporated into a larger facility asset management system.

Throughout the entire project, modeling has progressed beyond 3D to include elements of construction scheduling, cost, operations, and sustainability. These added dimensions use the 3D model as the base, relying on its accuracy and completeness to provide predictive analytics and simulations for all project phases.

Adding the fourth dimension of time to the model allows teams to plan out project phasing and sequencing of construction. Today's funding realities mean that many infrastructure projects must be phased. With the model acting as the central point-of-truth across a project, considerable time is saved by eliminating the need to recreate data at different project phases. The model shows how all the elements of a project will come together along a timeline that everyone understands.

The fifth dimension integrates cost data to the model, allowing project teams to easily update material costs as market conditions or government policies evolve. They can also evaluate cost variations when it comes to material changes or different design approaches. A better understanding of costs helps prioritize budget allocation. Competing interests may try to influence a direction, but the model helps evaluate these influences and supports a buy-in on the optimal solution for the available budget.



Image courtesy of COWI

BIM is also demonstrating its value in the operations stage. This is important across the board of civil projects, as airports, roads or highways, water systems and other civil infrastructure must be up and running at all times. Embedded intelligence combined with performance analytics is only possible with a BIM workflow, and owners and operators are using BIM to better understand impacts to performance and operations. The EU Handbook comes with many case studies that demonstrate BIM's benefits to owners for the ongoing management and operations of the built asset.

“For public clients and governments, this translates to more being built and maintained for the same or less public money: a lower risk of cost overruns on public infrastructure projects, improved project understanding and transparency and greater stakeholder engagement,” according to the handbook's authors.

Today's infrastructure projects are built to last for a long time, in many cases even longer than originally anticipated. Proper maintenance is key to prolonging a project's lifespan, and BIM provides all the necessary data. Rather than reacting to a problem and spending time locating the source, maintenance crews can adopt a proactive approach. They will know all the elements, when and where they were installed, what operational tolerances each piece of equipment has, and when it needs service.

### What's Next: Ready for the Unknown

Imagine the adoption of BIM on a broader scale and how the exchange of data can inform infrastructure projects and improve communities. What are the possibilities coming from the integration of individual projects to broader local or regional goals?

While space for either vertical or horizontal development in densely-populated countries may be limited, infrastructure will still need to be maintained, improved or enlarged to support urban growth. Even if space for development exists, BIM can help create a better-designed project for future conditions. Either scenario will benefit from BIM.

For instance, a road improvement project might require extensive subsurface and surface coordination in a constrained and highly activated corridor, as well as sequencing for utility construction, traffic management, or other requirements. In addition, several smart city greenfield developments promise exciting new ways to leverage the power of data. A greater return on investments is feasible when BIM enables a well-coordinated integration between design, construction and field-controls. It may be especially helpful in phased projects, and it may improve operations and maintenance throughout the life of the project.

The motivation for BIM is all about the bottom line. Efficiency increases when teams can digitally integrate processes that used to be manual and painstaking. The sharing of 3D models rather than 2D drawings provides a single point of truth, and prevents confusion and conflicts that could cause costly delays. A greater understanding and shared responsibility held in the model means a more streamlined construction process with fewer change orders and cost overruns.

Considering where we've come from and the possibilities of the future, it's hard to make any other choice and expect to remain relevant in the future.



# SUMMARY

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## SUMMARY

BIM is becoming standard practice in infrastructure projects around the world. More professionals use BIM for civil projects and understand what it offers to complex design and system coordination, whether above- or below-grade. The model offers many benefits across the spectrum of civil work, regardless of the project type, such as improved collaboration and productivity, better quality design and construction, ensuring accountability for each team member and reducing liability.

Beyond the process benefits of BIM, there are many other areas where it adds value, including selling a project or concept to stakeholders, the general public or funding entities as well as evaluating impacts of sustainable design and construction. BIM is a powerful tool that can integrate past, present, and future through the model, accommodate important data on existing conditions, help everyone visualize project design and construction, and simplify daily operations and maintenance.

The integration of new tools and third-party applications with BIM for particular project types or scenarios also advances BIM's overall power and helps coordinate schedule, cost and sustainability components. This improves the ROI of infrastructure investments not just during design and construction, but throughout the life of the project.

All these benefits validate BIM's importance for today's infrastructure systems, which are critical to supporting communities 24/7 for many generations to come.

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

- <sup>1</sup> Reuters article, July 25, 2017
- <sup>2</sup> Dodge Smart Market Report 2017 on The Business Value of BIM for Infrastructure
- <sup>3</sup> Dodge SmartMarket Report on BIM 2018
- <sup>4</sup> EU Handbook for Building Information Modelling
- <sup>5</sup> EU Handbook, p. 16
- <sup>6</sup> 2017 Dodge Infrastructure Report, p. 50.

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