

# BIM for Infrastructure: A vehicle for business transformation

**Summary:** Building Information Modeling (BIM) is widely recognized as a mature design methodology in the building industry, with high adoption rates by architects, engineers, and contractors. The application of BIM for Infrastructure is rapidly accelerating as owners and engineering service providers increasingly recognize the benefits of 3D modeling using intelligent objects.

*BIM is an information-rich, model-centric process with the power to transform project delivery and add value across the lifecycle of infrastructure assets.*

Infrastructure firms that implement BIM as just a more powerful version of traditional CAD—that is, firms that use BIM only for design-specific workflows—will fail to realize the full value and transformative power of this model-centric process.

This paper will discuss BIM for Infrastructure as a vehicle for business process transformation that can:

- Increase **clarity** of project intent for all stakeholders—better informing decision making and reducing risk
- Ensure data fidelity and **continuity** across the lifecycle of a project—improving quality and productivity
- Provide the critical foundation for business **agility**—utilizing technology enablers to maximize profit and growth opportunities

# Critical need for transformation

*The Organization for Economic Cooperation and Development estimates \$60tn of needed infrastructure spending thorough 2030 [which] is likely to be met with only a \$24tn spend by the world's leading economies.*

—CG/LA Infrastructure CEO Norman Anderson

Traditional ways of working are insufficient to meet the unrelenting need for new and rehabilitated infrastructure amid today's economic realities. The methods by which projects are delivered and assets are managed must undergo a fundamental change in order to meet critical objectives. Improved productivity and transparency will help to close the gap between soaring investment demand and limited access to capital.

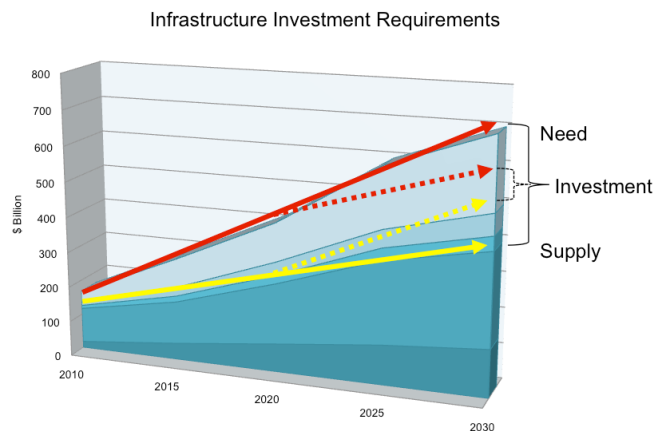
Given the pressures on local and national governments to cope with aging infrastructure and explosive urban growth, there is considerable attention being paid to innovations that can close the funding gap. Methods that use private sector financing, such as public-private partnerships (PPPs), are gaining popularity as a solution but will not

solve the problem on their own. At the 2012 [CG/LA](#) Global Infrastructure Leadership Forum presenters from McKinsey and Company singled out poor productivity as an important factor in eroding returns and making infrastructure less attractive for private investment, and suggested a focus in this to make the economic model more attractive to investors.

Building Information Modeling (BIM) is the vehicle by which the business of planning, designing, building, and managing the world's infrastructure will be transformed to deliver higher productivity, quality, and cost-effectiveness.<sup>1</sup>

## Capital innovation

In an era where waste and inefficiency are intolerable, policy makers are looking to expedite project delivery, reduce costs, and ensure that every dollar is invested wisely. PPPs are being utilized at a record pace because, among other benefits, they incorporate greater accountability into the process, helping



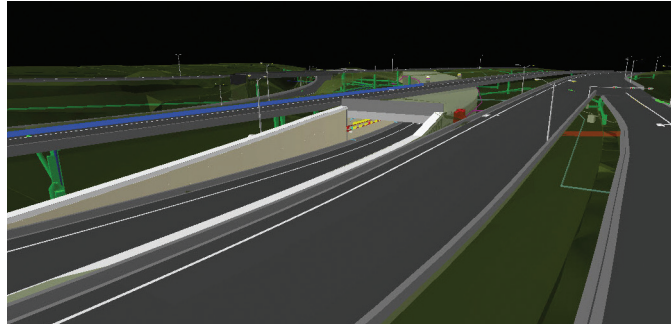
BIM for Infrastructure can help close the funding gap by reducing costs and increasing potential sources of funding with more predictable ROI. (Growth scenario from CG/LA Infrastructure LLC, "The Global Infrastructure Marketplace: The Next 20 Years")

<sup>1</sup> <http://www.infrastructureinvestor.com/Article.aspx?article=58941&hashID=6073B1B3F07EBB1D0CEA70434DEE670A084FF39E>

to reduce potential for wasteful spending because all stakeholders share project risks and rewards.

The use of BIM gives this often diverse group of stakeholders a shared understanding of the project

through a model-centric approach which keeps them connected to a more accurate and up-to-date view. Miscommunication, design errors, and, in turn, risk are mitigated while decision making is improved with the ability to use the model to simulate nearly all aspects of the project.



BIM contributes to a deeper understanding during construction by providing a more accurate engineering representation of the project

The entire process of developing, executing and managing infrastructure projects can be transformed—initial surveying and data collection, environmental review, public participation, design and documentation, bidding, construction, and operations and maintenance. The model-centric approach enables planners, engineers, and designers to explore and validate innovative design ideas and what-if scenarios with project investors. Before ground is broken, all parties have a better understanding of scheduling (4D) and cost (5D), environmental impacts are assessed and understood, and the public can visualize what the project will look like at various stages of completion.

Consider London's M25 Motorway, a £6.2 billion expansion and modernization project, completed just in time for the London Olympics. With a design-build-finance-operate (DFBO) contract (a variant of PPP), capital was raised from a total of 16 institutions—making project management a more complex, and riskier, affair. The M25 team made full use of BIM to better coordinate and communicate among a large group of project stakeholders and financial constituents.

"It's not about creating pretty pictures," says David Owens, an engineer at Atkins & Skanska Balfour Beatty Joint Venture. "BIM give[s] us a more accurate engineering representation of the highway and a deeper understanding of the project during construction."

The whole project team was able to view the construction model, using the same up-to-date information when assessing how best to perform construction tasks. The ability to use information-rich models to track and visualize progress even facilitated the budgeting and payment process. Bankers, for example, could easily grasp what had been accomplished. Ultimately, the M25 expansion was completed on schedule prior to the Olympic rush, and the project stayed within budget.

[Read the case study.](#)

## Scalable productivity

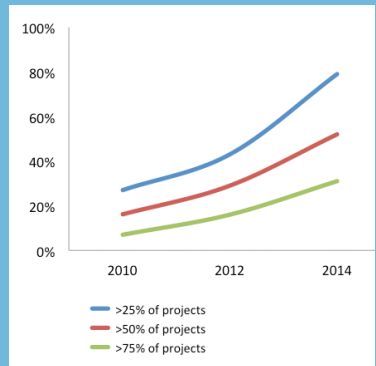
According to 2011 data released by the U.S. Bureau of Economic Analysis and the U.S. Bureau of Labor Statistics, annual real manufacturing output per (U.S.) worker doubled in the 21 years from 1976 to 1997, and doubled again in the 13 years from 1997 to 2010. This well-documented productivity gain is generally attributed to the aggressive adoption of computing-based technology and particularly, in industries such as car manufacturing, to the adoption of model-based design and fabrication processes. During that same period, productivity in construction industries remained essentially flat.

BIM is the obvious candidate for achieving similarly dramatic gains in infrastructure sector productivity, with its ability to aggregate, organize, and analyze the enormous amounts of information related to infrastructure assets. Over the next decade, given the emerging technology-enablers to support large-scale, multidisciplinary projects and the lifecycle capabilities of a model-centric approach, it is conceivable that the infrastructure industry could even surpass the productivity gains achieved in manufacturing.

### Consider the potential:

- **Plan** | The City of Riviera Beach, Florida used BIM to help them produce compliant documentation for local permitting agencies, including the Department of Environmental Protection. This enabled the city to gain quick approval without a single comment, complete the design 60 days ahead of schedule, and save \$30,000 in design fees through increased productivity and efficiency. [Read the case study.](#)
- **Design** | Hatch Mott MacDonald reduced project costs with a BIM approach for a wastewater treatment plant design, using visualizations to help optimize the design, avoid spatial conflicts, and conduct earthwork calculations. [Read the case study in the 2012 Autodesk® Excellence in Infrastructure Awards.](#)
- **Build** | Sundt Construction, Inc. is using BIM to help rebuild a complicated highway interchange in Arizona. Virtual construction models are helping to lower costs and increase productivity. For example, the need to create paper-based documentation for machine guidance and to manually determine elevations has been drastically reduced. Says Eric Cylwik, Sundt Modeling Engineer, "In some circumstances we estimate that for every \$1 invested in creating virtual construction models of the project, we are saving at least \$5 in construction costs." [Read the case study.](#)
- **Manage** | Neolant was able to help the Moscow Department of Cultural Heritage better understand the impact of new development on existing historical sites. Using new tools for 3D spatial analysis, models of culturally important buildings were integrated into its existing GIS platforms, along with details of the surrounding environment. [Read the case study in the 2012 Autodesk® Excellence in Infrastructure Awards.](#)

## Accelerating BIM for Infrastructure



- 47% of survey responders are using BIM on at least 25% of their infrastructure projects today
- Within 2 years, almost 80% will be using BIM on at least a quarter of their projects
- 4.4x increase in "Very high" (>75% of projects) over the four year period (7% to 31%)

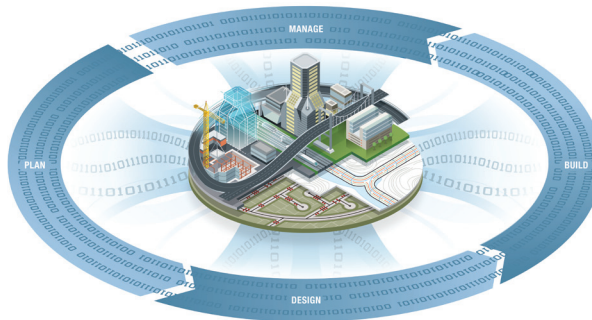
Source: 2012 McGraw-Hill SmartMarket Report: The Business Value of BIM for Infrastructure

## BIM is *not* a 3D model

According to the recently published McGraw-Hill *SmartMarket Report*, nearly half of the respondents (46 percent) report that they are “just scratching the surface” of BIM’s potential. Given the nascence of BIM for Infrastructure, this makes sense. But, as stated earlier, firms that implement BIM solely for design workflows are missing the mark. The potential for transformative value *begins* with the creation of a design model, but it doesn’t end there.

The models created for BIM are **not just 3D geometry**; they are data-rich objects which are:

- ✓ **intelligent** | parametric engines help define relationships between objects and keep changes consistent and coordinated
- ✓ **knowledge-based** | can be constrained by things like AASHTO codes, design criteria, and company standards
- ✓ **scalable** | able to aggregate huge amounts of data from multiple sources
- ✓ **visual** | enable better analysis, simulation and communication



BIM is a model-centric business process that enables accurate, accessible, and actionable insight across the asset lifecycle.

BIM is a process that *uses* the intelligent model to facilitate coordination, communication, analysis and simulation, project management and collaboration, and even asset management, maintenance and operations.

The resulting value of BIM for Infrastructure differs for owners and their consultants. Reported benefits range from improved marketing and project quality to higher profit margins, reduced risk, and new opportunities for growth. (For more, read the 2012 McGraw Hill *SmartMarket Report*: [The Business Value of BIM for Infrastructure.](#))

# Profit from project insight

Implementing BIM on capital projects can provide benefits across planning, design, delivery, and operational areas. Access to coordinated and consistent model views by all stakeholders supports:

## Increased project control

- Improved coordination through clash detection and visual analysis
- Mitigated cost and schedule risk with real-time assessment of project data and interdependences
- Accelerated delivery using visual representations for approvals and stakeholder coordination
- Greater accuracy of construction documentation and handover information
- Better predictability with integrated schedule (4D) and cost (5D) information to support logistics and supply chain management

## More efficient asset management

- Improved quality using analytical tools to help ensure compliance to engineering codes and safety standards
- Potential to reduce post-construction rework and costs of operation supported by earlier project visibility and data continuity
- Link precise geometry associated with asset data to enterprise asset management and facilities management systems
- Simplify location and identification of built assets during inspection and maintenance activities
- Support facility assessments for renovation, rehabilitation, and replacement needs

With BIM, project information is available and actionable throughout every phase of the infrastructure lifecycle.

## Planning

Every infrastructure project begins with existing conditions, and massive amounts of data. Gathering and understanding the constraints of nearby assets and land-forms along with regulatory considerations can be overwhelming. And for owner organizations, the ability to simultaneously analyze scheduling and costs for multiple projects across a major capital program is hugely valuable. Right away, a BIM approach can improve the accuracy and speed of the planning process by helping to aggregate multiple types of data from a variety of sources into a single reference model.

This comprehensive view of existing conditions provides all stakeholders with greater clarity—which can help inform their decisions. Visualizations from this information-rich model can be shared with non-professional stakeholders, helping to ease approvals and further speed the planning process. (See Sidebar: *Seeing is believing*). Just as important, the information and decisions at this point are captured in the model and will remain consistent through project completion.

As an example, let's say underground utility locations are captured with ground penetrating radar (GPR) and incorporated into the model for a road rehabilitation project. This kind of information is vital during construction to avoid damage and expensive delays and change orders. With the model-centric coordination that BIM makes possible, designers can minimize potential impact and contractors are in the know long before ground is broken. Later, when the municipality contemplates future expansion or repair, the utility data persists in the model and can be updated as changes are made, with no loss of fidelity or time-consuming rework.

## Preliminary design

Using the existing conditions model, designers can then work with 3D concepts in a representation of the actual environment.

Consider the Keystone Parkway in Carmel, Indiana. Built in the 1960s, the parkway had become a sluggish and dangerous four-lane roadway. Carmel collaborated with American Structurepoint Inc. to create a long-term solution that would be minimally disruptive to the heavily developed surroundings, and incorporate facilities for pedestrians and bicyclists.

After creating a model of the existing interchanges, American Structurepoint evaluated a variety of configurations and geometries to understand their effect on adjacent properties. An unexpected solution—a double-roundabout interchange—quickly emerged as the best way to meet all requirements.



### Seeing is believing



Visualization is particularly useful when seeking feedback and approvals from non-professional stakeholders. Few people can easily comprehend typical 2D plan sets, but understanding is nearly universal when stakeholders can interact with an animated representation of the design in three dimensions.

To help the public understand San Francisco's Presidio Parkway Project, the California Department of Transportation (CalTrans) imported 3D visualizations into a video game engine, which interested citizens could download onto iPads (or other devices) and use for virtual drive-throughs and other views of the proposed new construction.

BIM-enabled simulations of real-world performance proved to be invaluable to communicate the unusual design to the public and meet project goals.

Image courtesy of American Structurepoint, Inc.

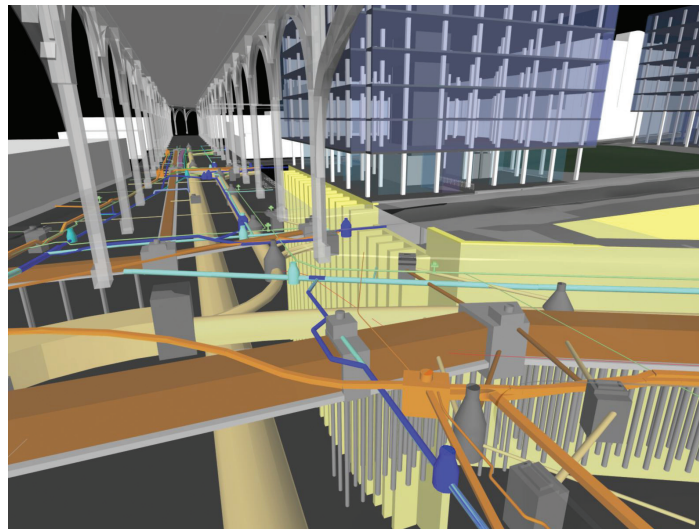
Using BIM helped the team to confidently select this unusual alternative because the process was able to simulate real-world performance and help the public envision how it would look and function once completed.

[Read the case study.](#)

## Detailed design & engineering

The complexity of many infrastructure projects requires intense multidisciplinary collaboration. Since the model is comprised of data-rich objects with defined relationships to each other and to the environment, immensely useful information is accessible by all project stakeholders, who in turn can contribute to the model—all without loss of data fidelity.

Columbia University's new 17-acre campus in the Manhattanville manufacturing zone of West Harlem in New York City provides a case in point. When complete, the mixed-use development will feature more than 6.8 million square feet of mixed-use space, including a labyrinth of below-grade pedestrian hallways, mechanical spaces, and classrooms, and a site with widely varying elevations. Precise coordination is critical.



Integrated model view showing the complexities of subgrade utilities.

Image courtesy of Stantec, Inc.

Stantec, Inc. is using BIM to develop a detailed 3D infrastructure model for spatial analysis, collaboration, and coordination. The model incorporates existing conditions—including telephone duct banks and sewer, water, gas, and electric utilities—in order to coordinate the connections between the proposed utilities and buildings. The model is also facilitating visual cross-discipline collaboration and coordination. As the project progresses, Stantec incorporates design models (created by other project consultants) into the infrastructure model, regardless of the authoring software used by the consultants. This integrated project model facilitates whole-project visualization, clash detection, and construction planning.

[Read the case study.](#)

This is just one example of how BIM enables large team workflows, and how it can impact the types of projects firms bid on, as well as the partners, clients, and consultants they choose to work with. Before adopting BIM, Stantec typically delivered 2D plans for these types of infrastructure projects. “Now we can show our clients the complexities of a project in three dimensions,” says Eric Smith, who is a project manager at Stantec. The firm’s success on the Columbia Manhattanville project has attracted a number of inquiries from potential civil engineering clients.

“People are starting to understand that BIM can really help with the spatial analysis of infrastructure projects”, says Smith.

## Construction and program management

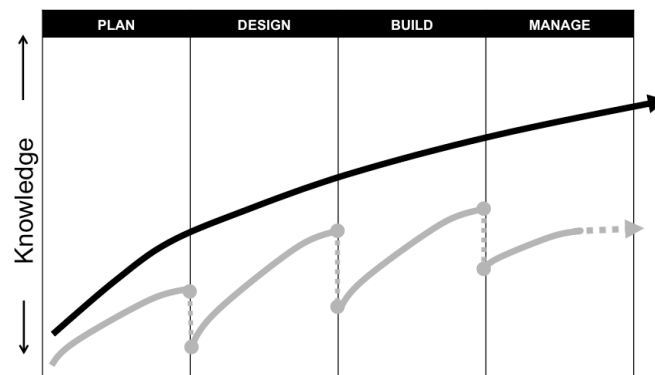
Without the data continuity and discipline coordination that the BIM process enables, information is lost and must be recreated at every hand-over. By contrast, BIM conserves and uses information across the lifecycle of an infrastructure asset.

Historically, at the end of the design stage a construction firm received 2D plan sets that often dumbed down much of the engineering data that went into creating those plans. These flat document sets then became the primary interface between builders and designers and owners. This not only inhibits collaboration, increases risk, and works against design fidelity, it can create onerous rework for contractors on competitive bid projects.

Owner organizations are plagued with issues deriving from poor communication. BIM systematically dismantles that

problem by providing owners greater program control, ultimately enhancing major capital program construction planning. Multi-project visibility and greater insight into possible conflicts, impacts, logistical constraints, and other critical variables is better coordinated across internal and external projects.

Using the BIM process, the design model is available earlier to better inform preconstruction planning for activities such as staging, sequencing, scheduling, quantity take-off, and estimating. Given access to the model, contractors can produce more accurate bids in less time by evaluating various coordination activities, such as temporary roads, location of material, and other logistics prior to breaking ground. Construction operations are also facilitated by the BIM process, as data can be added to the model to support schedule (4D) and cost (5D) project management.



BIM represents a fundamental shift in project execution and management of the asset lifecycle.

In 2010, the Wisconsin Department of Transportation (WisDOT) conducted four pilot projects<sup>2</sup> in which models were provided to contractors as part of the bid package. After successful completion of the projects during the 2011 construction season, WisDOT interviewed bidding contractors and was told that the availability of the models resulted in:

- ✓ Less uncertainty and risk in bidding
- ✓ More time to prepare multiple bids
- ✓ Easier identification and design of cost reduction initiatives
- ✓ Better planning of earthwork activities

### Asset management, operations and maintenance

The operations and maintenance phase of the infrastructure asset will persist longer than any other project phase, so advantages gained here have cumulative effects. Using a BIM process operators have access to the richest information streams ever created, including detailed data from the post-construction model and information from real-time sensors that continuously update the model during operation.

That owners and operators can benefit from rich, detailed information about a particular asset is intuitively obvious; however, owner/operators are usually responsible for a wide array of interconnected and often interdependent assets. BIM facilitates improved management and analysis of project-level information, which can be used in large-scale integrated asset management workflows.

Revisiting our Keystone Parkway example, the team used actual traffic data to determine optimized design, and traffic counts and demographic data showed how the new facilities would meet future needs. Those early simulations are paying off in quantifiable benefits to the city of Carmel today in the form of:

- **Public Safety** | Personal injuries have been reduced by 78 percent at remaining intersections.
- **Sustainability** | City officials have the option of establishing tighter controls over traffic with sensors and automated management of peak flows, which could help further reduce emissions due to less idling and promote bicycle and pedestrian travel.
- **Efficiency** | Improved maintenance schemes and longer facility life are also expected. For example, laser scanning can help reveal subtle wear patterns and enable proactive maintenance and rehabilitation. Decisions about future expansions and modifications will be based on higher-quality information.

As operators become accustomed to integrating models into their operations and maintenance plans, they are beginning to specifically ask for BIM deliverables. Large entities, such as the U.S. General Services Administration (GSA)<sup>3</sup> and the city-state of Singapore,<sup>4</sup> have established standards for BIM model handoff and require 3D models in some cases. The U.K. government has specifically cited efficiency gains and improved supply chain management as the primary driver of their BIM mandate<sup>5</sup> for construction projects.

<sup>1</sup> WisDOT pilot project information taken from agenda for *Wisconsin DOT: Adopting a Model-Based Approach to Roadway Design and Construction*, an Autodesk University course, Code C14707.

# Enabling technology: what you need to know now

The rate of innovation for web, mobile, and SaaS continues to accelerate. These platforms, along with emerging technologies, are amplifying the transformative potential of BIM for Infrastructure. In fact, technology is what enables for BIM, connecting stakeholders to the information-rich model and helping them make sense of the data in order to drive significant ROI. Here's what you need to know now:

## Putting big data in context

No infrastructure project exists in a vacuum. BIM helps to collect, analyze, and aggregate the huge amounts of data necessary to connect designs to the context of the surrounding environment. Major advances in how infrastructure models



A model of the Presidio Parkway in the context of its environment includes all of the underlying design, GIS, and reality captured data—data that remain accessible for interrogation and update throughout the asset lifecycle.

are created make useful vast amounts of data related to the project environment and its constraints. BIM employs parametric engines to make the connections between design and reality with its intuitive object-oriented and rules-based design and decision making.

GIS data is essential for this model-centric approach, but GIS data alone does not add context that can be critical to decision making and communication. Now it is possible to unlock that information for real-time use, with location-based data acquisition and management capabilities. Civil engineers, planners, contractors, and owners have immediate access to geo-referenced data directly into the infrastructure model. GIS—as a system that stores and analyzes geographic information—is simply becoming one component of the BIM process.

*The design authoring tool is a lens into an almost infinite source of data—using intelligent objects to represent real-world assets within the actual context of the surrounding environment.*

<sup>3</sup> <http://www.gsa.gov/portal/content/105075>

<sup>4</sup> [http://www.corenet.gov.sg/integrated\\_submission/bim/BIM\\_Guide.htm](http://www.corenet.gov.sg/integrated_submission/bim/BIM_Guide.htm)

<sup>5</sup> <http://www.buildingsmart.org.uk/buildingSMART/buildingSMARTnews/uk-government-construction-strategy-published-by-the-cabinet-office-may-2011>

## Actionable reality

**Reality capture:** Capturing existing physical conditions is critical at every point in the lifecycle of an infrastructure asset. Traditional surveying is one method, but existing conditions are now as (if not more) likely to come from reality-based point clouds captured via laser scanning or digital photographs (photogrammetry). Sensors that capture real-time data, ground-penetrating radar—even crowd sourcing—are other examples of emerging reality capture technologies that will revolutionize the type, accuracy, and quantity of data available for infrastructure assets, existing and proposed.

The key is connecting reality to the design model, so that the rich data can be accessed, analyzed, and adapted over time. For example, contractors create interim as-builts that update the model during construction, and owners may monitor performance of current designs, such as traffic patterns or load on bridges and roads.

**Virtual Reality:** When it comes to portraying proposed reality virtually, the industry is moving far from what has been called “Hollywood BIM” to visualizations that are created directly from the model and contain all of the underlying data. These animations can have just as much “blockbuster” appeal visually and help facilitate more effective connections to the public to speed the approvals process. But the rising star here is the ability to interact with, manipulate, and scale the data in real time. Planners can sketch multiple scenarios (even while meeting with clients or the public) and understand the potential impact of design options well before moving into design phase.

## Augmented

**reality:** The goal of this approach is to make the future a reality. Using augmented reality, any stakeholder can connect to an array of complex information in the context of what’s real. Then spatially referenced mobile devices can take the model off the desktop and into the field. The technology has valuable applications for construction asset management, enabling real-time insight into existing infrastructure location.



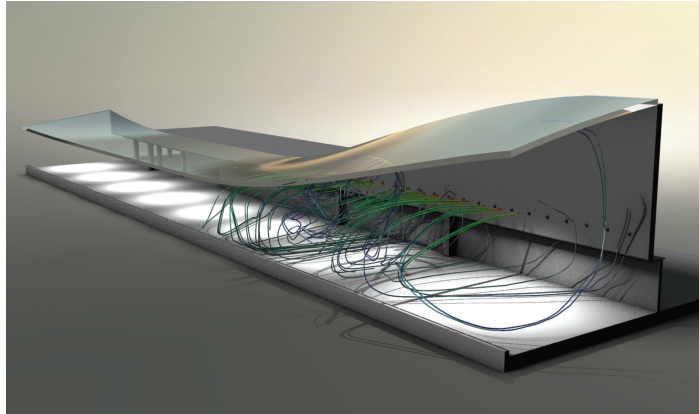
Images of intersections viewed through a mobile viewer. Within the viewer the existing underground and above-ground utilities are shown overlaying the existing roadway. Images courtesy of VTN Consulting.

*More accurate and contextual data translates into higher levels of confidence in the project design, improved communication, and more efficient management of completed assets.*

## Cloud-based optimization

Engineering analysis connects the design to data and is critical to success. But it also can be the most resource-intensive and error-prone part of the process. With cloud-based computing, multiple iterations of very complex analyses can be done in near real time—versus minutes, hours, or even days. This ability provides greater project clarity earlier in the design process and can reduce the need for costly expert analysis or hardware. Generalists and designers can now run analysis more often during conceptual design—using the information to guide choices and better ensure optimal outcomes—before an expert validates the results later in the detailed design stage.

With the virtually infinite power of cloud-based parallel processing, it will soon be possible to do simultaneous analysis of multiple factors in a shared model environment. This multivariable optimization will result in even higher-quality, more cost-effective design solutions.



Air flow simulation for airport walkway as part of a terminal expansion project. Image courtesy Johnson, Mirmiran & Thompson (JMT)

*Cloud-based design and analysis deliver greater project clarity earlier in the design process.*

## Mobility and collaboration

Connecting diverse and distributed teams to the project requires data continuity: consistently accurate data that is accessible at any time, by anyone, working anywhere. Using BIM, the information inherent in the model provides the foundation for today's web-based and mobile collaboration tools, with a model-centric approach to better coordinate large, diverse, and distributed team workflows and keep projects on course.

Further, the use of mobile devices in the field vastly increases project efficiency during construction. Using a tablet to instantly check current model details is considerably faster and more effective than rooting through plan sheets in the site trailer.

Engineers and contractors in the field can connect to the corporate office through RFID tracking, GPS logging, mobile computing, and other technologies that will further advance project management. Reporting can be continuously updated, and managers will be alerted to budget and logistical conflicts in time to do something about them.

*"Why exactly is your project team in the trailer again?"*

—overheard at the *Engineering News-Record's (ENR) FutureTech Conference* in San Francisco

## Project controls

Reliable visibility across all aspects of the project is necessary in order to oversee and report on the execution of project goals. With a model-centric process, data remains coordinated and consistent throughout the project, connecting schedules and budgets with reality to better assess risk and status.

BIM scheduling tools are being used on large project sites, and can be viewed as visualizations of GANTT charts—virtual timelines showing constraints and dependencies. If a crane needs to be in place on a certain date, the visualization can be fast-forwarded to that date to see if necessary staging areas are clear or obstructed. And since this kind of work is essentially an extension of existing interference and clash detection tools, the way seems clear for continued improvement.

In addition, visualizations can help to calculate the associated cost impacts of design options in real time, as well as analyze and validate sustainability impact (6D).

There is considerable will among large, established makers of enterprise software to tie their solutions to BIM in support of other mission-critical operations such as procurement, resource deployment, and estimation. Most already have second- or third-generation entrants in the field. As owners and their consultants develop and use intelligent models to drive efficiencies, it is a logical next step to connect this process with work management systems.

Greater value is realized when BIM is used “beyond design” in order to better manage the project.



A model-based project dashboard enables more complete project clarity at any point in time.

## Generation next

By the year 2020, an entire generation will have grown up in a primarily digital world. While not a technology per se, “millennials” will help drive the business transformation that technology makes possible. They have been described as “digital natives” and are connected, content-centric, community-oriented, and always clicking. By some accounts, this group (born between 1979 and 1995) will comprise 40 percent of the workforce within the next decade—and they will be charged with solving some very big and complex problems.

Attracting and retaining a younger, skilled workforce has become increasingly critical, especially in the engineering ecosystems where the majority of experienced workers are approaching retirement age. To do so successfully, the approach taken to pursue this up-and-coming workforce must change. Firms that have made investments in BIM, supported by a strong vision for BIM implementation, will hold the advantage in attracting the valuable, multi-process thinking in this new workforce, which already thinks in three dimensions, works without wires, and doesn’t hesitate to crowd-source solutions.

Modern model-based design applications, which use visualization tools that were developed for the gaming industry, provide an environment that is much more familiar and stimulating for the millennial generation than 2D CAD drawings. Cloud computing and collaboration platforms make the process of planning and designing infrastructure more intuitive, social, and immediate. With rules-based design and documentation, BIM can help to capture the knowledge of experienced workers and transfer it to generation next, while maintaining high rates of productivity.

*“Generation next” will use 3D model-based technologies to solve the world’s most challenging infrastructure needs.*

## The case for BIM

This paper presents BIM as a vehicle for business process transformation, illustrating the many benefits of the model-centric approach across the lifecycle of infrastructure projects. It must be noted, however, that the successful implementation of BIM within the complex and highly diverse companies that carry out these projects poses distinct challenges at every level and requires a careful and structured approach that takes into consideration the many integrated components of an organization’s business. A companion white paper, *A Framework for Implementing a BIM Business Transformation*, published by Autodesk Consulting, reviews the key elements for successful implementation.

BIM-enabled firms hold a competitive advantage today. In the not-so-distant future, BIM may simply be the cost of entry, a requirement on virtually every RFP. Then, only sophisticated BIM shops—firms that utilize the full potential of BIM across the asset lifecycle—will retain the edge. Successfully implementing a BIM process requires vision, leadership, and carefully managed organizational change. As such, return on investment (ROI) is a primary consideration for business and government leaders considering the move to BIM.

The ROI of BIM implementation generally measures key performance indicators (KPI) such as:

**Cost** | cost variance in actual costs to budgeted costs

**Quality** | percentage of rework to overall cost

**On-time completion** | time variance and costs due to time overrun

**Productivity** | performance (costs or man hour per unit), increased profits

**Safety** | lost man hours

Other KPIs may include turnaround times (time effectiveness), revenue per head, reduced costs of traditional approach (printing, travelling), business won (bids won percentage), or overall client satisfaction.

The most quantifiable returns result from better coordination, clash detection, and fewer RFIs and change orders. According to a 2010 [study](#) of firms implementing BIM published in the *Journal of Information Technology in Construction*, half of the firms reported a decrease of project costs of up to 50 percent, and 62 percent reported a decrease of project times of up to 50 percent, compared with projects run with a traditional approach. In addition:

- less than 1.5 percent of the project costs went to approved change orders
- claims and disputes represented less than 0.5 percent of the costs
- correcting errors and omissions also represented less than 0.5 percent of the cost<sup>6</sup>

<sup>6</sup> Becerik-Gerber, B., Rice, S. "The Perceived Value of Building Information Modeling in the US Building Industry" ITcon Vol. 15, 2010.

## Sample ROI calculation

The following ROI calculation is meant only to provide a theoretical example. The assumptions and results come from Autodesk Consulting and are based on years of experience implementing BIM on projects and helping organizations measure the ROI of using BIM over traditional project execution methods. The calculation is based on a major capital program (>\$20B USD) over a three-year timeframe, where the total investment in BIM is 0.2 percent of the total program budget.

### Assumptions:

**BIM implementation costs average 0.5 percent** of the total program budget (average accepted by the industry as standard for major capital projects/programs).

**Cost overruns in project delivery may usually be reduced by 15 percent** (a conservative estimate) from industry average of 20–24 percent, primarily due to a reduction in RFIs, addenda, and engineering change orders.

**Savings from reduced rework after project close is estimated at 5 percent** of program budget.

**Savings due to better visibility** of the contractors' cost breakdown is factored into both the bidding and negotiation phases, as well as controlling the as-built.

**An average saving of about 5.5 percent** of the total program budget based on industry experience in major capital projects where BIM is implemented.

**The resulting savings of using BIM on this theoretical program over traditional methods is approximately 4 percent, meaning a return of about 20X the original investment (ROI = 20X).**

This theoretical ROI calculation may be conservative, as it considers only selected aspects of the savings potential. There are many more aspects (such as reduced work for preparing tender documentation, handling RFIs, and more efficient operation and management). Also, these savings are based on a single program over three years, whereas there are likely to be other programs that will use the BIM investment over that same period of time.

It also conservatively assumes that the efficiency increase and reduction in cost overrun would only be achieved gradually and progressively over the course of three years. A more immediate increase in efficiency would improve the ROI calculation significantly. A more detailed ROI analysis would also take quantitative project execution processes into consideration (staff/roles, tools, manual or automatic tasks, artifacts/data objects/inputs & outputs, resources/costs/time).

# Industry transformation

Different titles and acronyms have been tested to describe a model-based approach to design for civil engineering—virtual design and construction (VDC) and civil information management (CIM), to name two. However, it is clear that despite early resistance to the term as applied to civil engineering and related disciplines, BIM for Infrastructure is entering the mainstream.

BIM changed the nature of how buildings are designed, constructed, and operated, and will even more rapidly drive the transformation of infrastructure project delivery and ownership. The potential for improvements in productivity, cost, and quality of infrastructure design, construction, and asset management is virtually unlimited.

The old ways of working are no longer adequate and soon will be obsolete as government, public, and private entities look to BIM to reduce lifecycle costs and close the gaps in funding in order to meet the world's critical infrastructure needs.

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