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
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** | KFW Engineering used BIM to impress their project review team and help win work. They pulled data from existing geospatial and utility data, supplemented it with field verification, and created a 3D model of an actual intersection within the project’s boundaries in only 8 hours.

- **Design** | ProRail (the Dutch agency responsible for railway infrastructure) used BIM to enable their team to automatically create high-quality rendered visualizations of design options, helping everyone better understand alternatives. In a single afternoon, the team generated and analyzed seven different options for a proposed project, working together to share design insights, compare the different designs, and to help speed up the decision making process.

- **Build** | iNFRANEA used BIM to model, coordinate, and plan a river-widening project on the River Waal Nijmegen. The firm created and managed an integrated 3D model of the entire project for improved project coordination and visualization of this very large,
complex project. INFRANEA then used this model for clash detection, visual impact analysis, and configuration management. Additionally, data outputs from the model helped drive GPS machine grading for the project’s earthworks and dredging.

- **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.

**BIM is not a 3D model**

According to the 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** | dynamic engines help define relationships between objects and keep changes consistent and coordinated

- **knowledge-based** | can be constrained by things like regional design codes and criteria as well as 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**

- Improve 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 landforms 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.

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.

**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.

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.

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, 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.

In 2010, the Wisconsin Department of Transportation (WisDOT) conducted four pilot projects 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) and the city-state of Singapore, 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 for construction projects.

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1. 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 CI4707.

2. [http://www.gsa.gov/portal/content/105075](http://www.gsa.gov/portal/content/105075)
