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White Paper

Building Information Modeling and Intelligent Green Buildings

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Introduction

In May 2011, the U.K. government started a four-year Government Construction Strategy by looking at implementing building information modeling (BIM). The U.K. government is now committed to introducing Level 2 BIM on all its construction contracts awarded from 2016 and intends to introduce Level 3 BIM by 2025. Its main aim is to maximize efficiency in the construction industry through legislation and best practices aimed at lowering costs, speeding delivery, lowering emissions and increasing exports. This will encourage collaborative behaviors that will unlock new, more efficient ways of working at all stages of a project lifecycle—from earliest concept through operation. The key objective is to reduce capital cost and the carbon burden from the construction and operation of the built environment by 20 percent.[1]

According to McGraw-Hill Construction, BIM usage is accelerating powerfully, driven by BIM mandates from the U.S., U.K. and other government entities.[2]

So what is BIM? And how will BIM fit into the drive for intelligent green buildings?

Building Information Modeling (BIM)

BIM is a business process for generating, leveraging and managing building data to design, construct and operate the building during its lifecycle. It covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components, project management and post-construction facilities management.

BIM uses 3D, real-time, dynamic building modeling software to increase productivity in building design and construction. The data can be used to illustrate the entire building lifecycle from cradle to cradle—from inception and design to demolition and materials reuse—including quantities and properties of materials (which can be easily extracted from the model) and the scope of works (including management of project targets and facilities management throughout the building's life). Furthermore, systems, components, assemblies and sequences can be shown in relative scale to each other and, in turn, relative to the entire project.

Managing a construction project and building lifecycle using BIM can result in substantial savings in both time and money—from design and construction through to ongoing maintenance.

The model saves time and waste on site, and renders extra coordination checks largely unnecessary; the information generated from the model leads to fewer errors on site caused by inaccurate and uncoordinated information. When all members of the construction team work on the same model—from early design through to completion—introduced changes are automatically coordinated through BIM, across the whole project, and information generated is therefore of high quality.

BIM has already given the industry measurable positives:

- Increased understanding and predictability—offering greater certainty and reduced risk
- Improved efficiency
- Improved integration and coordination—meaning fewer problems onsite
- Less waste
- Better value and quality
- Better buildings throughout their lifecycle

According to the U.K. government, early BIM demonstration projects have already achieved savings of around 20 percent during the construction phase, with some on course to achieve 33 percent savings over the life of the building.

BIM is far more than 3D CAD modeling. It requires changes to the definition of traditional architectural phases, more data sharing than the construction industry is used to, and a willingness to embrace partnering in an approach that collects all project-related information digitally. BIM is able to achieve this by modeling representations, specifications, and the critical paths of actual parts and components used in the construction process—representing a major shift from traditional computer-aided design.

There are four levels of BIM sophistication[3]:

- **Level 0:** This basic level involves separate sources of information in paper documents.
- **Level 1:** This level involves separate sources of information in semi-structured electronic documents, often involving 2D/3D CAD.
- **Level 2:** This level involves file-based electronic information with some automated connectivity. It will include post-construction information such as operation and maintenance of assets and the management activity for the life of the asset.
- **Level 3:** This level involves integrated electronic information with full automated connectivity. Level 3 BIM is a fully integrated and collaborative process that includes project lifecycle and facility management information enabled by Web services.

Another terminology commonly used is "BIM dimensions." Currently, these are defined as follows:

- **3D BIM:** This provides a visualization tool enabling designers and contractors to work together to identify and resolve problems with the help of the model.
- **4D BIM:** This is 3D BIM plus the construction workflow planning, scheduling and management. As the design is changed, advanced BIM models will be able to automatically identify those changes that will affect the critical path and indicate what the corresponding impact will be on the overall delivery of the project.
- **5D BIM:** This is 4D BIM plus the project's construction cost and requirements. With BIM, the model includes information that allows a contractor to accurately and rapidly generate an array of essential estimating information, such as materials quantities and costs, size and area estimates, and productivity projections. As changes are made, estimating information automatically adjusts, allowing greater contractor productivity.

The industry is already discussing 6D BIM, which is 5D BIM plus facility management.[4] The author believes that, extending this further, 7D BIM could be 6D BIM plus building analytics.

Clash detection

Clash detection is the process of finding where the BIM models "clash." Clash detection puts a value on the savings made from eliminating problems found during a review. Clash detection can be broken into three types:

- Hard clash
- Soft clash/clearance clash
- 4D/workflow clash

A hard clash is simply when two objects occupy the same space (e.g., a pipe going through a wall where there is no opening).

Soft clashes refer to allowable tolerances or space; for example, buffer zones between components left to provide space for future maintenance.

4D/workflow clashes refer to clashes in scheduling work crews, equipment/material fabrication delivery clashes, and other timeline issues.

BIM models

At the moment, BIM models cover the following areas:

- Architectural
- Structural
- Mechanical
- Electrical
- Plumbing

Each discipline creates a BIM model, and all models are integrated into a composite master model. As more and more business and building applications (such as voice, data, video, wireless and building control services) operate over one network infrastructure, the network infrastructure should be covered under the BIM models. After all, this network infrastructure is the superhighway for these applications and is commonly referred to as the fourth utility (water, mains power and HVAC are the other three utilities). This will enable better coordination between the M&E and the network design teams. Figure 1 shows some examples of BIM models.

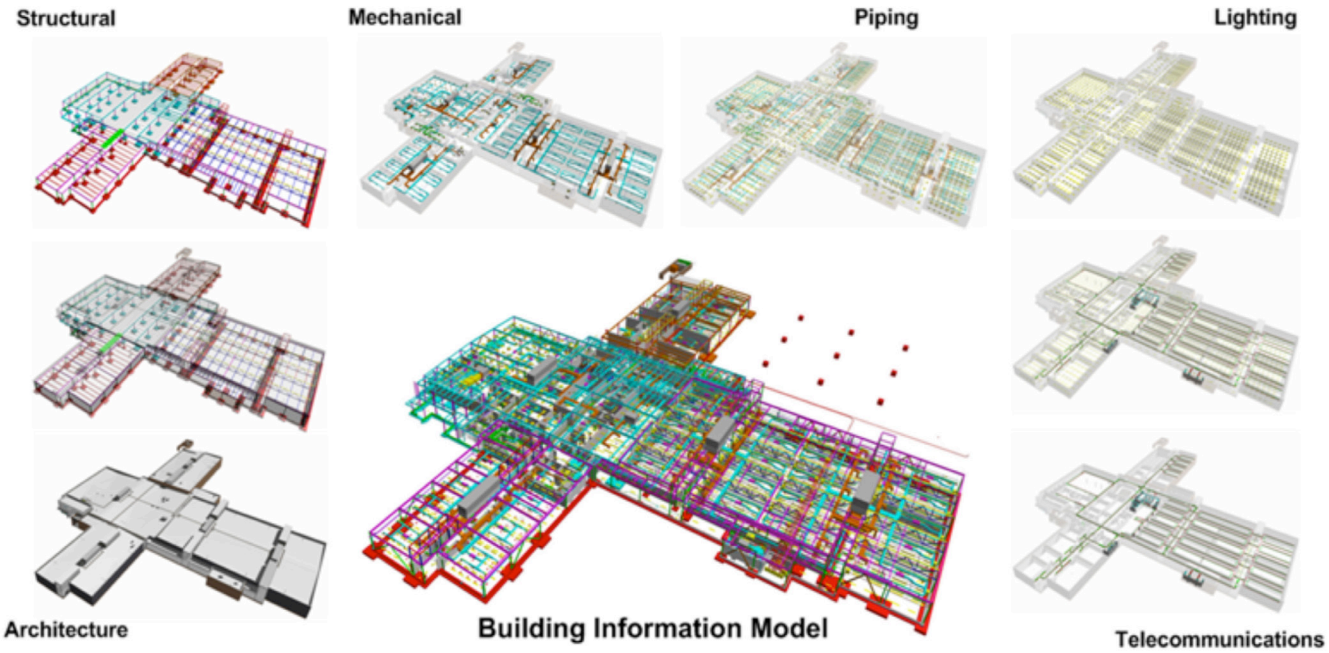

Figure 1: Examples of BIM models (courtesy of Jacobs Global Buildings)

BIM and space management

Using a BIM model for space management enables the facility team to allocate, manage, and track spaces and related resources within a facility. BIM permits the team to analyze the existing use of space, evaluate proposed changes, and effectively plan for future needs. Having accurate and detailed space information is especially useful for planning renovation projects, where some building segments will remain occupied and change during the construction phase. Existing workspace management systems should be integrated into BIM.

BIM and asset information management

Data from a BIM record model can be linked to a database of building assets to assist in maintaining and operating a facility more efficiently. These assets often include the building elements, systems, and equipment that must be maintained and operated efficiently to satisfy the facility users' requirements in a cost-effective way.

Asset management systems are used to support financial decision making, short-term and long-term planning, and maintenance scheduling. Using information in a BIM record model, facility managers can:

- Evaluate the cost implications of changing or upgrading building assets
- Track the use, performance, and maintenance of a building's assets for the owner, maintenance team, and financial department
- Produce accurate quantity takeoffs of current company assets for financial reporting and estimating the future costs of upgrades or replacements

BIM and facility management & building analytics

BIM can be used to track, update, and maintain facilities management information to support better planning, operations, and maintenance decision making throughout a building's lifecycle. Tracking performance data from the building systems and comparing these values to design model predictions enables facility managers to ensure that the building is operating to specified design and sustainable standards and identify opportunities to modify operations to improve system performance. Building designers can also use this data to validate and refine their prediction models and evaluate the impact of proposed materials and system changes to improve performance. Existing facility management systems should be integrated into BIM. This is where 6D BIM potentially fits.

Building analytics often focus on building energy use. However, sensor networks are becoming key ingredients of smart buildings and they provide insight into systems operation, building usage and location of occupants. When combined with building analytics, the data can be converted into business intelligence and allow for informed decisions on energy optimization, operational efficiency and space utilization. This is where 7D BIM potentially fits.

BIM standards and COBie

U.S. national BIM standard (NBIMS-US™)

In the U.S., the national BIM standard (NBIMS-US™) was published by the buildingSMART alliance® (a council of the U.S. National Institute of Building Sciences) at the end of 2007. Since then, it has undergone several revisions. The finalized NBIMS-US™ V3 was released in July 2015. NBIMS-US™ is supported by many software vendors and several big design firms and construction companies. This standard is based on Industry Foundation Class (IFC or ifcXML), which is an ISO standard (IS 16739) for sharing data information, and PDF/E (IS 24517) for geometry (including 3D). It also includes embedding IFCs in the PDF. The IFC openBIM format was originally developed by the buildingSMART alliance to facilitate interoperability in the architecture, engineering and construction industries and is an object-based file format tied to a specific data model.

U.K. PAS/BS 1192 series

In 2007, the U.K. published the BS 1192 standard—Collaborative Production of Architectural, Engineering and Construction Information. This standard forms the basis for achieving Level 1 BIM. Recently, the U.K. BIM Task Group—in collaboration with the Construction Industry Council—published three additional BIM standards:

- PAS 1192-2:2013—Specification for information management for the capital/delivery phase of construction projects using building information modeling
- PAS 1192-3:2014—Specification for information management for the operational phase of assets using building information modeling
- BS 1192-4:2014—Collaborative production of information—Part 4: Fulfilling employer's information exchange requirements using COBie—Code of practice

PAS 1192:2 specified an information management process to support BIM Level 2 in the capital/delivery phase of projects—setting out a framework for collaborative working on BIM-enabled projects and providing specific guidance for information management requirements associated with projects delivered using BIM.

PAS 1192:3 acts as a partner to PAS 1192:2 and supports the Level 2 BIM objective by setting out a framework for information management for the whole lifecycle of asset management. It offers guidance on the use and maintenance of the asset information model to support the planned preventative maintenance program and the portfolio management activity for the life of the asset. It addresses the operational phase of assets irrespective of whether these were commissioned through major works, acquired through transfer of ownership, or already existed in an asset portfolio.

BS 1192-4 defines a methodology for the exchange of information throughout the lifecycle of a facility. It defines expectations for the design and construction project phases prior to handover and the subsequent in-use phase. This code of practice helps the portfolio managers, asset managers and facility managers specify their expectations while helping information providers—including the lead designers and contractors—prepare concise, unambiguous and accessible information. The use of COBie ensures that information can be prepared and used without the need for knowledge of the sending and receiving applications or databases. It ensures that the information exchange can be reviewed and validated for compliance, continuity and completeness.

Since BIM is a collaborative approach based on shared information models—and enabled by Web services—there is a need to address cyber security in the implementation of the collaborative processes and systems. The British Standards Institute and the U.K. industry[5] are currently developing a BIM security standard that will eventually be published as BS 1192-5.

COBie

COBie stands for "Construction Operations Building Information Exchange" and was a specification developed by the U.S. Army in 2007. It specifies how information may be captured during design and construction and provided to facility operators. It is a data schema for holding and transmitting information around handover to support the client's ownership and operation of a facility (both new and existing). Thus, COBie has two main purposes: as a data exchange format and as a checking tool in the design process.

The original document was revised by the U.K. government in 2012 to include energy and CO2 impact on building constructions. The process for importing data from BIM models has been extended to four data drops during the delivery stage of the project to manage cost and carbon1:

- Data drop 1: This deals with models that represent requirements and constraints
- Data drop 2: This deals with models that represent outline solutions
- Data drop 3: This deals with models that represent construction information
- Data drop 4: This deals with models that represent operation and maintenance information

The revised document is the COBie-UK-2012. The objective of this document is to explain the organization of the COBie worksheet and identify who provides what information within the requirement as the project proceeds from planning, to design, to commissioning, to occupancy, to handover.

COBie is simply a subset of the integrated BIM focused on the owner. COBie can be exported to BIM and vice versa.

BIM adoption

According to McGraw-Hill Construction2, BIM usage is accelerating powerfully, driven by BIM mandates from the U.S., U.K. and other government entities.

In the U.S., the General Services Administration (GSA)—an agency that manages all federal buildings—has been requiring BIM since 2003.

In Europe, BIM adoption is as follows:

- U.K.: Level 2 BIM mandatory for all government projects by 2016. Intent to implement Level 3 BIM by 2025.
- Norway: Statsbygg (civil state client) mandated BIM use for the lifecycle of their buildings.
- Finland: Senate Properties (state property services agency) has required the use of BIM for its projects since 2007.
- Denmark and Sweden: Many public and government projects require the use of BIM.

- Germany: BIM is used mainly in projects driven by a few private, institutional clients. The State of Bavaria is piloting BIM.
- The Netherlands: The Government Buildings Agency (RGD) mandated the use of BIM by 2011.
- France: BIM is used mainly in projects driven by a few private, institutional clients.

In the Asia/Pacific (APAC) region, BIM adoption is as follows:

- Singapore: The Building and Construction Authority mandated the use of BIM for projects of more than 20,000 square meters after 2013.
- Malaysia: BIM is mainly a private initiative driven by the larger property developers and contractors.
- South Korea: The South Korean government has been gradually increasing the scope of BIM-mandated projects since 2010.
- China: BIM is used mainly in projects driven by a few private, institutional clients. Legal requirements in the construction industry work against collaboration. RFP for design and construction are required to be separate. However, according to Beijing Tsinghua University, the Chinese government is strongly supporting BIM and BIM will be the future IT solution in China.
- India: Large construction companies in sectors such as hotels and airports are starting to implement BIM.
- Australia/New Zealand: BIM is used mainly for commercial and government building projects.
- Japan: BIM is used mainly for commercial building projects.

BIM and CommScope

So what is CommScope doing regarding BIM? The first step taken by CommScope was to link our eCatalog products to the Autodesk desktop tool using their "AUTODESK SEEK" interface. The first phase has been completed. See the link below.

http://seek.autodesk.com/search/manufacturer:CommScope?source=SearchBox&locale=en-us

The CommScope imVision® solution provides the capability to discover end devices connected to the network and to identify their location within a building. This real-time data could greatly improve BIM asset information management.

The CommScope Redwood® intelligent LED lighting system—together with its high-density sensor network and space utilization analytics tool—could enable BIM with effective space management by analyzing occupancy patterns and integrating with reservation scheduling software. In addition, COBie-UK-2012 requirements for reducing energy and CO2 impact of the facility may be achieved through Redwood's Building Intelligence Platform_____, which delivers reduced energy consumption over traditional building lighting systems.

Conclusion

There is no doubt that the future of architecture and the construction industry is digital—and BIM is the future of design and long-term facility management and building analytics. It is government led and technology driven and it is implementing change across all industries. However, there is still much confusion on how it should be utilized and implemented. BIM is a digital model that helps everyone understand the building. However, it is a new technology introduced into an industry typically slow to adopt change. Nevertheless, BIM will grow to play a crucial role in building design and documentation.

BIM reduces errors in transfer of information and helps build better value constructions. By identifying clash detection, BIM prevents errors creeping in at the various stages of development and construction.

In addition, BIM offers a detailed computer visualization of each part and assembly in relation to the total building. As hardware, software and cloud applications herald a greater capability to handle increasing amounts of data and information, the use of BIM will become even more pronounced than it is in current projects.

Finally, BIM will be a key driver for the smart/intelligent green building concept.

[1] UK BIM Task Group: www.bimtaskgroup.org

[2] McGraw-Hill Construction, SmartMarket Report 2014—The Business Value of BIM for Construction in Major Global Markets: How Contractors Around the World Are Driving Innovation With Building Information Modelling

[3] UK HM Government: Digital Built Britain—Level 3 Building Information Modelling—Strategic Plan

[4] www.vicosoftware.com/6d-bim-models

[5] The Institution of Engineering and Technology: Accelerating the Adoption of Building Information Modelling (BIM) in the Built Environment

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