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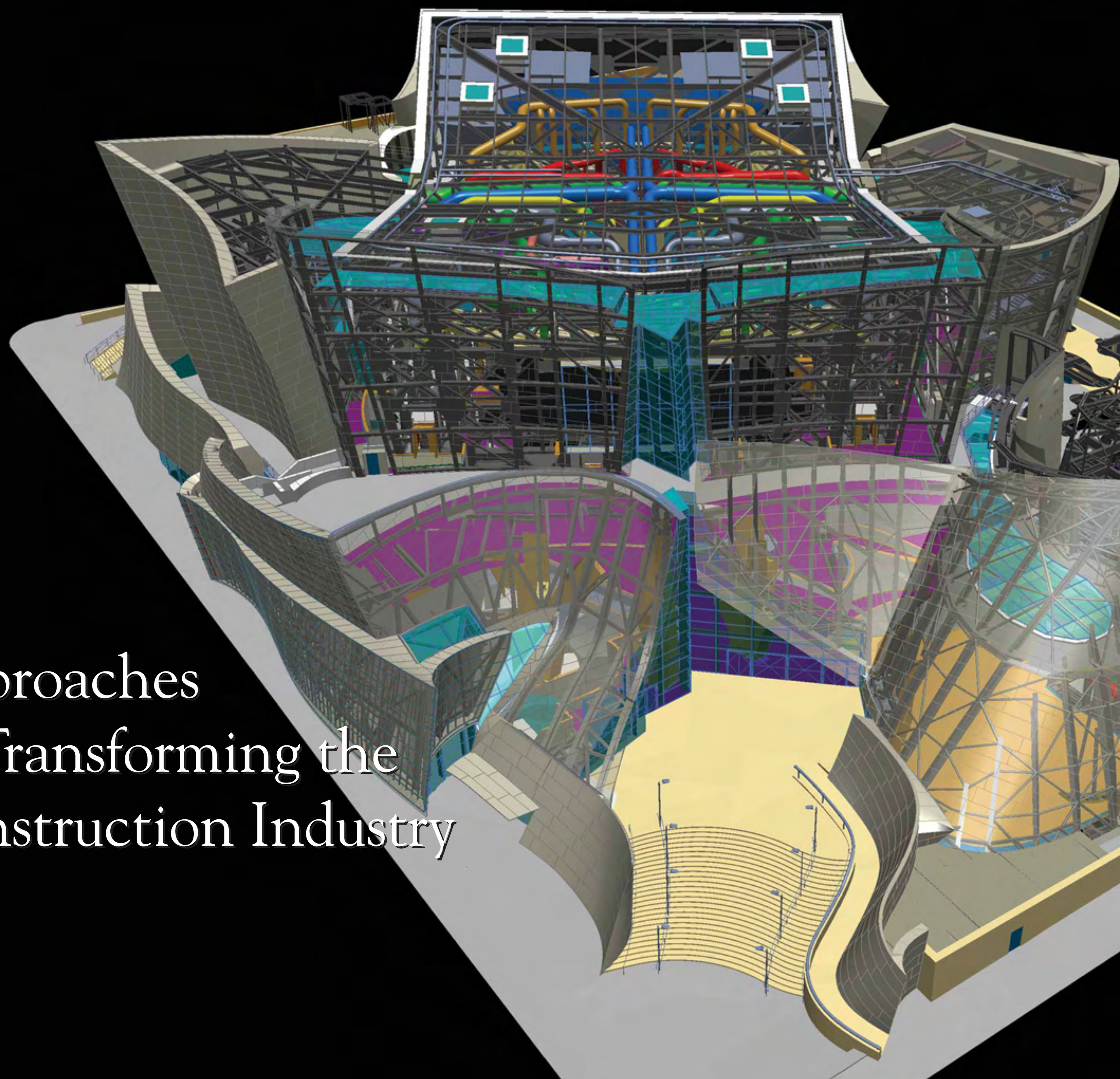


Approaches to Transforming the Construction Industry

Building Information Models and Model Views

By Richard See, Managing Director, Digital Alchemy

IN THE LAST FEW YEARS, we have seen a great deal of marketing and press about Building Information Modeling (BIM). By now, most people in the industry must have a vague understanding of what BIM is, but may find some additional background, some specific examples, and more detail about how BIMs will improve quality, reduce costs, and enable new business processes should be of interest to most.

This is the first in a two-part article that will provide background about the evolution of building modeling concepts and systems, why product neutral BIMs are important, and how such BIMs will enable intelligent data sharing and enable the AECO industries to realize the kinds of efficiencies and quality improvements enjoyed by manufacturing industries today. Part I of this article provides background on building modeling, the larger context of product models, and initiatives to define a global standard for BIMs. Part 2 of this article will introduce the notion of Model Views, which are much like database views, how these views are defined, and how they will ensure predictable interoperability experience when used for exchange of BIM data between applications.

EARLY BUILDING MODELING SYSTEMS

The notion of building modeling is not new. As early at the mid 1970's the UK government funded research in this area that ultimately led to early building modeling systems including BDS (Building Design System) and RUCAPS which were used by early adopters in the UK and U.S. through the mid 1980s. Even these first generation building modeling systems included some of the concepts central to today's BIM authoring software. Concepts including parametric element definition, building element libraries, multiple representations (graphic and analytic), and drawings as view or graphic reports generated from an integrated building model.

RUCAPS was replaced by a second generation building modeling system called SONATA in 1986 and saw much wider adoption, particularly in the UK, although it was limited by the fact that it required a workstation computer when other drafting oriented CAD systems would run on personal computers. However, in this same timeframe, a PC based building model system, ArchiCAD, was maturing and beginning to build a user based that continues today.

In parallel, the GLIDE (Graphical Language for Interactive Design), GLIDE-II, and CAEADS (Computer Aided Engineering and Architectural Design System) systems were developed by the CAD-Graphics Laboratory at Carnegie-Mellon University. Although not released as commercial products, they introduced more advanced solid modeling geometry for use in designing buildings and integrated database techniques to support more sophisticated models and extending the association of data with geometric representations[1]. These techniques were later adopted or emulated in commercial products.

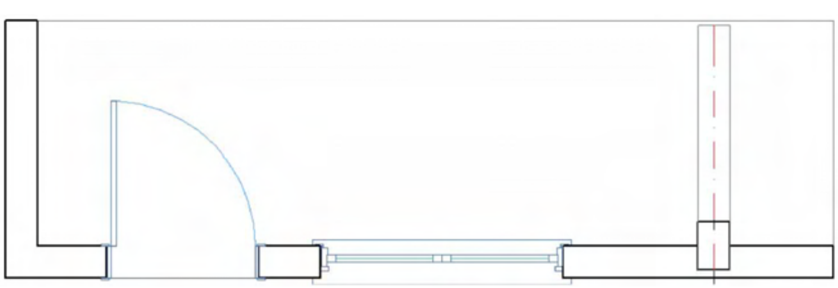
These early systems were generally developed by people in the building industry that had a vision of using the computer to prototype buildings as assemblies of building elements rather than using the computer to create the same design drawings that had been used to describe buildings for centuries.

PRODUCT INFORMATION MODELS

Throughout the 1980s, similar modeling initiatives emerged in various manufacturing and more specialized construction industries. Common interests and needs in these groups and projects eventually led to the formalization of the concept of Product Information Models and development of STEP (the Standard for the Exchange of Product Model Data) and ISO standard 10303.[2] STEP has vigorously supported and widely adopted in the automotive, aerospace, process plant, and ship building industries, where the benefits of Product Information Modeling (improved information sharing, efficiency, and quality) have been widely observed and reported in the past decade.

One perspective is that the concept of Product Information Models, as introduced by STEP, formalized, harmonized, and standardized of concepts developed in many of the earlier projects and products (some of which are cited above). A Product Information Model can be thought of as a database of the product to be manufactured. That database can include a wide array of information about the product, including geometry, material, manufacturing and assembly techniques, tolerances, costs, and even information to support supply chain management, or it

An example of a 2D image.



may include only some of these. The significant improvement of Product Information Models (and the pioneering products mentioned above) over previous product representations is that they are integrated information sets, which means data is referenced rather than repeated. This elimination of redundancy and reuse of data can/should lead to improved consistency, accuracy, efficiency, and quality—all of which lead to better products and productivity.

BUILDING INFORMATION MODELS

Building Information Models or BIMs should be thought of as the building industry's application of Product Information Modeling concepts where the product is a building.

Early implementations of BIM have been very "geometry centric", but this is beginning to expand now to inclusion of properties for use in analysis applications like energy use simulation, quantity take-off, cost estimating, construction planning and various types of engineering analysis.

As with Product Models, a BIM can be thought of as a database of the building project. The information in this database will someday span the full range of data we now manage for building projects, but as an integrated data set. As such, BIMs are multi-representational, multi-dimensional, and integrate the information created by many industry domains.

Figure 2 is a simple example of BIM objects, properties, and relationships.[3]

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Figure 2 – A simple example of BIM objects, properties and relationships.[3]

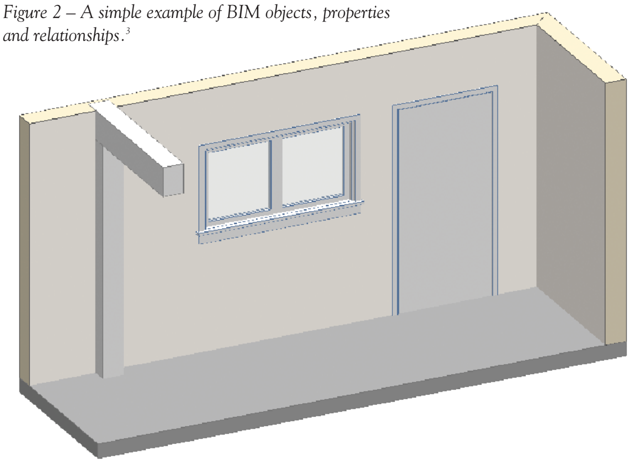
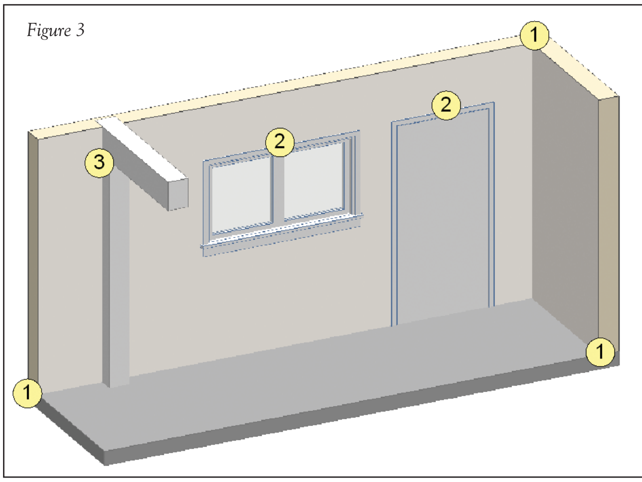


Figure 3



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Objects

BIM Models contain many types of objects. The most commonly understood are object representing the physical elements of the building. Our small example includes:

- Wall;
- Door;
- Window;
- Column;
- Beam; and
- Floor slab.

But BIM models also include many other object types that define abstract concepts and relationships like: relationships (for example connection and adjacency), object type definition (for example wall type and door type), hierarchies (for example containment), grouping (for example zones and systems).

2D geometry

2D Plan drawings are generated as geometric views or reports of the "plan" shape representations of the objects in the model. It is important to note that the "plan" representation uses industry standard symbolic graphics (e.g. door swing) whereas the "3D" representation uses 3D physical geometry. The image on page 20 shows two separate representations of a single object.

3D geometry

3D views are generated as geometric views of the "3D" shape representation.

Properties

Properties are attached to BIM objects to identify or describe them in some way. The range of possibilities for these properties is as wide as all the contexts in which they will be considered in a project, from design through construction and operation. Typically such properties are initially defined in a BIM authoring applications and can then be used by analysis and simulation applications to assess design performance (for example, thermal, structural, and quantity/cost).

Relationships

Capture and management of relationships is a key area in which BIMs improve upon processes and software tools used in the past because they enable a higher level of model analysis than properties only. For example, adjacency and connection relationships between spaces are what enable automated egress checking in a building model.

Our example includes all of the following relationships (See **Figure 3**):

Visible

1. Connection;
2. Voids (an opening in the wall); and
3. Supports.

Not Visible

1. Bounds (walls, floor bound space);
2. Contains (Project>Building>Story>bldg elements and space); and
3. Connects (space to door, window, and adjacent spaces).

Early implementations of BIM have been very "geometry centric", but this is beginning to expand now to inclusion of properties for use in analysis applications like energy use simulation, quantity takeoff, cost estimating, construction planning and various types of engineering analysis.

BIM STANDARDIZATION AND INTEROPERABILITY

Standardization is a logical step in the evolution and adoption of new technologies and processes as it can and should enable a next level of efficiency and adoption to industry.

Standardization for BIM logically followed the path taken for standardization of Product Information Models in STEP. This began in 1994, when a then fledgling AEC team (including the author) at Autodesk began development of a standard library of building model elements as the basis for interoperability between AEC add-ons to AutoCAD. Success in the initial prototyping eventually led to the formation of the Industry Alliance for Interoperability (IAI), which included 12 industry leading companies, led by Autodesk, that developed the original Industry Foundation Classes (IFC). IFC was introduced as the "common language for interoperability in the building industry" at the 1995 AEC Systems conference in Atlanta. All 12 companies demonstrated prototype applications (AutoCAD and Add-ons) that interoperated on a shared building model.

Seeing the industry excitement generated by the initial launch of IFC, the IAI member companies made the decision to open its membership to all companies in the building industry. By the end of 1995, there were several international chapters and hundreds of member companies in the renamed International Alliance for Interoperability (IAI). Several "Domain Teams" were also formed, to define the end user processes to be served by a first public release of IFC specifications for a standardized BIM.

Design and development of IFC by this larger, more international alliance was very much influenced by STEP and in fact, IFC makes use of many parts of the STEP standard, including: the EXPRESS modeling language, the STEP physical file format, and schemas for geometry and topology.

Release 1.0 of the IFC Schema for BIM was published by IAI in January 1997, IFC Release 1.5 followed in November 1997, and IFC Release 2.0 April of 1999. To date, there have been 7 releases of IFC, as described on the IAI web site (www.iai-international.org). The current release is IFC 2x3. Each of these, beginning with 2.0, could be exchanged between applications using the STEP physical file format (.IFC) or an XML data file format (.XML, .IFX).

Support for the proposed standard in software products lagged, as with any new standard, but began to accelerate quickly when government and large building owner organizations (e.g. US GSA) began to require the IFC BIM submissions in the past few years.

MODEL VIEWS FOR SPECIFIC EXCHANGE SCENARIOS

The IFC standard for BIMs is very large—so large that no single application will implement the entire schema other than model servers. As such, IFC can be thought of a framework for many common data exchange scenarios (e.g. the model subset shared by the architect with the structural and MEP engineers during conceptual design).

In 2000, the BLIS Consortium introduced a standard process and toolset for identifying these standard end user use cases, documenting requirements, and specification of implementation guidance as Model Views. These processes and tools were later improved to become the Information Delivery Manual (IDM) and Model View Definitions (MVD). Very recently, these processes and toolsets have been integrated. This integrated process will be proposed to the IAI in November 2007, as a standard methodology for requirements definition, IFC based solution definition, software implementation, and data validation in building industry projects.

The U.S. National BIM Standard (NBIMS) council in the National Institute of Building Sciences (NIBS) has adopted this process for development of a National BIM Standard. Once this standard is supported in shipping software applications, it will enable the industry to begin requiring use of standard data exchanges in projects and will ensure that these exchanges can be verified throughout the course of these projects. ■

Part 2 of this article will be released in the Spring 2008 issue of JBIM, will walk through examples of this standard BIM View development process and will also show how they can be used in building projects to enable new business processes that will improve data sharing, improve project efficiencies, improve construction quality, and reduce costs through error avoidance.

REFERENCES

[1] Building Product Models: Computer Environments Supporting Design and Construction—Eastman, 1999.

[2] ISO TC184/SC4 is responsible for the ISO 10303 (STEP) standard—www.tc184-sc4.org.

[3] Input from Jiri Hietanen—Research Scientist, Tampere University of Technology.