IMPACT OF THE U.S. NATIONAL BUILDING INFORMATION MODEL STANDARD (NBIMS) ON BUILDING ENERGY PERFORMANCE SIMULATION

Vladimir Bazjanac

Lawrence Berkeley National Laboratory, University of California, Berkeley, CA 94720, USA

ABSTRACT

The U.S. National Institute for Building Sciences (NIBS) started the development of the National Building Information Model Standard (NBIMS). Its goal is to define standard sets of data required to describe any given building in necessary detail so that any given AECO industry discipline application can find needed data at any point in the building lifecycle. This will include all data that are used in or are pertinent to building energy performance simulation and analysis.

This paper describes the background that lead to the development of NBIMS, its goals and development methodology, its Part 1 (Version 1.0), and its probable impact on building energy performance simulation and analysis.

KEYWORDS

BIM, national standard, data exchange, building energy performance, software interoperability.

INTRODUCTION

Information technology (IT) professionals who work in the Architecture/Engineering/Construction/ Operations (AECO) industry often define buildings as enormous collections of data. They treat buildings as data bases; data bases that they find mostly disorganized, with data that are often repetitive, inconsistent, contradictory, and prone to loss over the lifetime of a building. The need to organize, systematize and standardize buildings data, and to make them easily available, reusable and preserved has been long recognized by them.

Virtually every discipline in the AECO industry uses software in the conduct of its activities; this includes the building energy performance (BEP) simulation and analysis profession. Each is experiencing serious data exchange problems in the use of its software: inability to directly import data generated by other software (this often results in the need to manually reproduce already existing data that in turn results in errors, data omission and misinterpretation), inability to access already existing data, the resulting excessive cost and time needed for preparation of productive work, and delay in generation and delivery of results (Bazjanac 2002). This has lead to the formation of the International Alliance for Interoperability (IAI) and several other industry and professional consortia, the formulation of an open, object oriented, extensible lifecycle data model of buildings – Industry Foundation Classes (IFC) – and, ultimately, to the concept of Building Information Model (BIM).

Fundamentally, a BIM (defined as a noun), is an *instance of a populated data model of buildings* that contains multi-disciplinary data specific to a particular building, which they describe unambiguously. It contains all data that define the building and are pertinent from the point of view of more than one discipline. A BIM includes all relationships and inheritances for each of the building components it describes; in that sense it is "intelligent" (Bazjanac 2004).

From a general industry point of view, a BIM is a shared digital representation of a building and its physical and functional characteristics, based on open standards for software interoperability. It contains information supplied by *all* participants in building design, procurement and operation, and forms a reliable basis for decisions throughout its lifecycle (Figure 1). It facilitates effective collaboration by different stakeholders at all phases of that lifecycle.

The basis for the definition and population of any BIM is a data model of buildings that all BIM authors and users agree to apply in the case of a particular building. While proprietary data models of buildings (usually limited to data definitions that represent only a part of the building lifecycle) abound, only one data model of buildings is an *open* specification that covers the entire lifecycle and is also recognized by the International Standards Organization (ISO/PAS 16739): IFC, developed by the IAI (IAI 2003).

The IFC data model itself is too large to implement by any single industry software application. IFC compatible applications implement only those parts of the model that represent industry process or processes and discipline(s) they support. Such model parts are called "model views," and the IAI has developed a Model View Definition Methodology (MVD) to facilitate their definition (Hietanen 2006). Defining IFC model views involves first the definition of data exchange requirements; the methodology for that was defined as part of the Norwegian Information Delivery Manual project (IDM 2006).

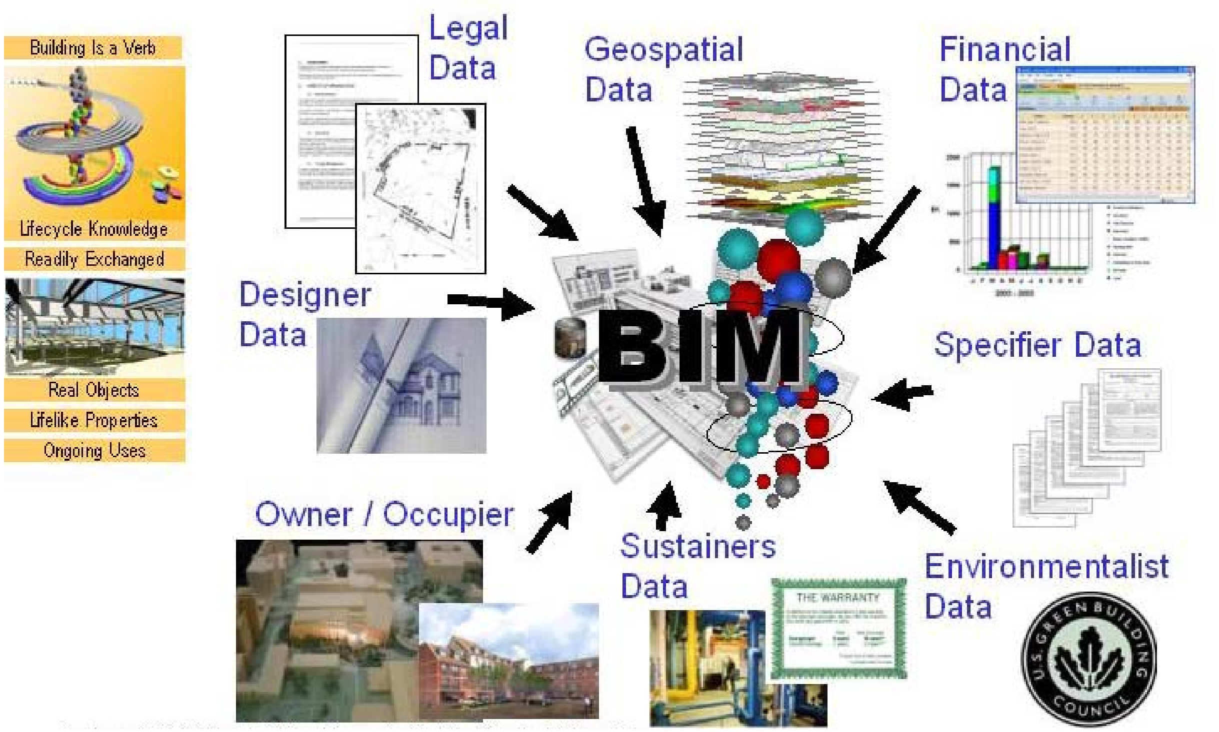

Figure 1. BIM concept (by courtesy of NBIMS Committee)

To actively involve all segments of the AECO industry in data exchange and sharing, the IAI formally started the "buildingSMART" Initiative and then formed the buildingSMART Alliance (IAI 2006). The alliance plans to act as a focal point for improving efficiency of building procurement and operations by establishing consortia arrangements for conducting research in the field, by conducting forums and workshops, by disseminating information, by reviewing relevant work performed by others, by developing and recommend standards, guidelines and certification programs, by stimulating innovation in the industry, and by promoting increased understanding and communications within the industry. Specifically, it plans to facilitate quantitative simulation and analysis of building energy performance, indoor air quality, safety aspects and security performance of various design concepts. It seeks input from participants from all segments of the AECO industry, including BEP (Figure 2).

The U.S. General Services Administration (GSA) was the first to formally adopt BIM as part of its building delivery process. The Office of the Chief Architect (OCA), a part of the GSA Public Building Service, (PBS) launched a National 3D-4D BIM Program (GSA 2003), which will require inclusion of an IFC based BIM in all Final Concept (i.e. end of schematic design) submissions. It also funded the definition of the GSA "spatial validation view" of IFC, convinced the major model based CAD vendors to implement the view, and published the GSA BIM Guide (GSA 2006). GSA plans to expand its use of BIM by defining IFC views that will support cost estimating *and BEP* in all of its projects in the future.

It is becoming increasingly clear that, as they "discover" it, BIM means different things to different participants in AECO industry processes. To bring common order, common understanding and common practice to BIM, the National Institute for Building Sciences (NIBS) started the National BIM Standard (NBIMS) project through its Facilities Information Council (FIC). NIBS was authorized by the U.S. Congress in 1974 and provides an authoritative source of advice for both the private and public sectors with respect to the use of building science and technology, and is the obvious best "home" for the project. The project, started in late 2005, will standardize the types and format of all data that define a building, from its conception throughout its lifecycle, and are used in performing business and industry processes and functions from initial design through building demolition (NBIMS 2007). This will inevitably include all data that are used in BEP simulation and analysis.

NBIMS DEVELOPMENT GOALS

The goals of NBIMS are to define information exchange requirements for the entire building lifecycle, to define the resulting data sets and formats for a standardized national BIM, to organize lifecycle information so it is useful, current and accessible to all segments of the AECO industry, and to provide an environment for longevity of that information.

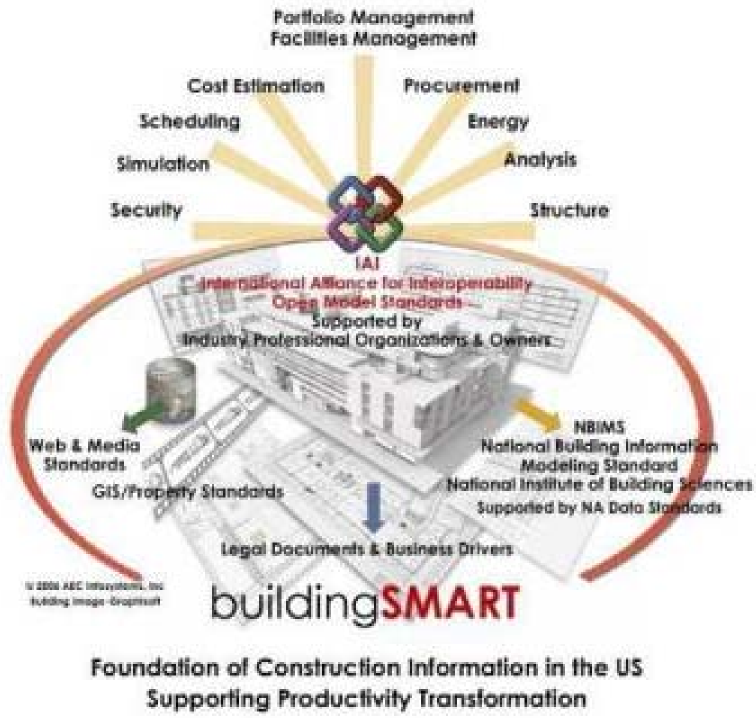

Figure 2. buildingSMART Alliance diagram (by courtesy of buildingSMART)

NBIMS will provide a framework for a comprehensive data base and building modeling that will enable comparative evaluation of all costs, including productivity of housed operations and their impacts on the enterprise, health and the environment. In doing so, it will reference other industry standards, as appropriate. It will also provide the information which is necessary for implementation of NBIMS in industry software. NBIMS is based on the IFC data model of buildings.

NBIMS METHODOLOGY

The methodology of NBIMS development is quite simple and can be detected in the NBIMS organizational chart (Figure 3). The various Task teams develop the standard. The Scooping Team develops the NBIMS "road map" and defines the NBIMS content. The Model View Team then develops exchange requirements and IFC model views for the defined content. The Development Team creates the corresponding IFC based Information Delivery Manuals. The Testing Team identifies "best practices" and provides the specifications to test commercial-off-the-shelf (COTS) and other software. The Business Process Integration Team generates building lifecycle legal and business documentation. The Communication Team distributes information about NBIMS activity. The development process by the different teams is concurrent and intensely interactive; all teams prepare technical packages for industry review and adoption.

NBIMS development plan calls for two parts of the standard. A draft of Part 1- Overview, Principles and Methodology, Version 1.0, was released for public comment in March 2007; the final version is expected in July 2007. Part 2 Version 1.0, the technical standard specification, is scheduled for release in December 2007. Several subsequent versions of both parts of the standard will be released later.

All releases of the standard will be subject to balloting and consensus. Each release of the standard is first prepared in draft format, which is submitted for industry review. Received comments and public discussion are, as appropriate, reflected in the revised proposal which is then submitted for balloting. When consensus is reached, the document is published as a standard.

CURRENT STATUS – PART 1

Part 1, Version 1.0 was made available for industry review as scheduled. It is a 161-page document that contains five sections of text and illustrations, a section with appendices and a large section with references (NBIMS 2007). The document is a non-technical description of the overall standard, the methodologies of development, and its intended use. Industry review and commenting were completed in two months; the resulting changes to the draft document will take another two months before it is formally released to the public.

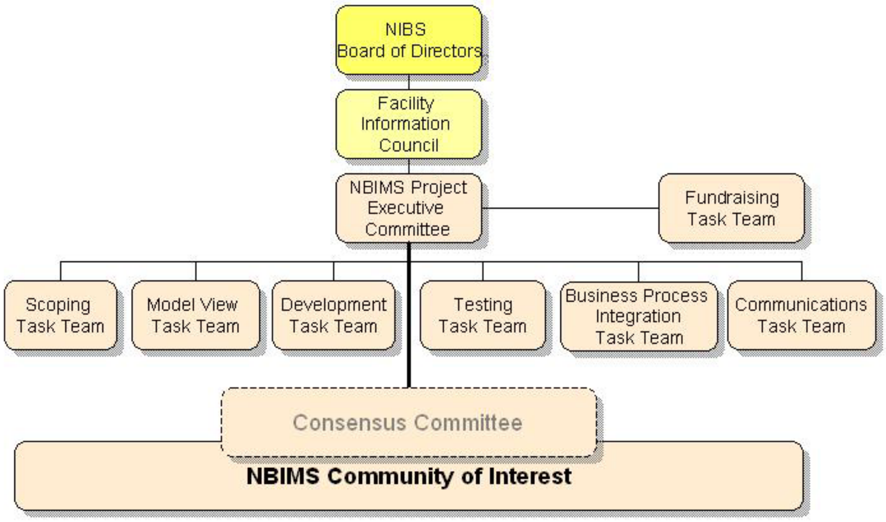

Figure 3. NBIMS organizational diagram (by courtesy of NBIMS Committee)

The first two sections of the draft document include an executive summary, instructions about how to read the standard, a discussion of the overall scope and potential of BIM, the description of the NBIMS Initiative and the project's relationship to industry product and tool makers, and a discussion of future versions of the standard. The latter includes a list of items that need standardization, and of associated priorities. Three additional versions of the standard are planned currently, with the next two releases planned to be published every other year, and the third in 2014.

The third section deals with data exchange and sharing. It explains concepts of information exchange from both theoretical and practical point of view. It discusses data models of buildings as part of business processes, approaches to managing different building classification formats, and the necessity for software interoperability. It explains the need for a common, coordinated project repository of the building's life cycle data, and discusses possible ways to control input and withdrawal of data from a shared repository.

The fourth section discusses the content of data exchange and sharing. It defines the concept of a "BIM minimum" and proposes a novel "Capability Maturity Model" (CMM). The former defines the minimum data sets and levels that make an initial BIM useful. The latter consists of a proposed methodology, borrowed from software engineering (SEI 1995), to relate the current "best business practices" to the functionality of a given BIM in any state of its development. It contains a matrix that matches 11 BIM data categories (from "data richness" to "information accuracy" to "interoperability/IFC support") to 10 levels of BIM data "maturity." The matrix has three levels of granularity: detailed technical information, summary of technical information, and high level overview. Applied to an individual BIM, the matrix can be interactively weighted to reflect the status and completeness of the BIM (i.e. each box in the matrix can be assigned a number from a point system); this provides a mechanism to rate BIM that will eventually lead to BIM certification.

The last section describes in some detail the NBIMS development process and its components. These include verification and testing of the technical standard, standardization of end user requests for data in the exchange, a data base of exchanged data, and instructions for software implementation (i.e. an explanation of data exchange requirements and model views). In addition, this section provides a summary of reference standards used in formulation NBIMS (IFC and OmniClass) and normative standards used when claiming compliance with NBIMS, and a discussion of implementation standards that will regulate specific data exchange.

The two appendices provide an example of an IFC model view (Early Design, developed using the MVD methodology), and a discussion of the COBIE project which defines the flow of information from building design through construction to building operation.

Part 1 of the standard is clearly a call for action to the AECO industry. It shows that tools exist that can dramatically reduce waste and inefficiencies in building planning, design, construction, and operations. This also applies to the use of energy in buildings. The industry needs to mobilize, adopt these tools and start using them regularly. A national effort like this should have a significant impact on U.S. competitiveness in the global market.

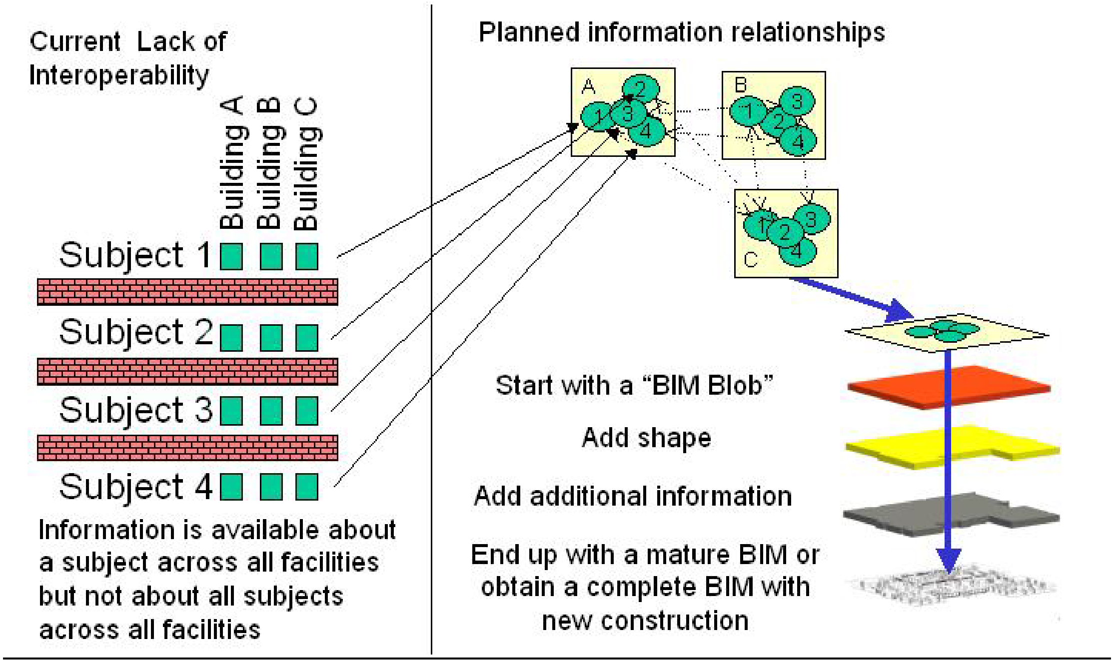

Figure 4. Process of populating a BIM with data *(by courtesy of NBIMS Committee)*

NBIMS IMPLICATIONS ON BEP SIMULATION AND ANALYSIS

BEP simulation and analysis play a very important role in making buildings energy efficient and operating them in a way that saves energy. Using BEP simulation and analysis tools is very inefficient and cumbersome today and suffers from lack of seamless and effortless data exchange (see the Introduction above). BEP simulation and analysis clearly have a role in the process of properly and fully populating and using BIM – under the process of "adding additional information" (Figure 4). Building energy professionals must participate in the NBIMS definition process if BEP simulation and analysis are going to play a role in building procurement and operations in the future.

The current practice of BEP simulation and analysis is rather chaotic. No *commonly agreed to rules* exist for data collection, data transformation, verification of model quality or almost anything else. The quality of developed and used simulation model depends on data available at the given stage of the project, the knowledge and experience of the modeler, available resources, and various other external conditions and pressures. Data gathering, the modeling process and the quality of the resulting simulation and analysis are different in every project.

NBIMS has a chance to change that and bring order and consistency to the practice of BEP simulation and analysis. For BEP simulation tools to be part of tool suites that are almost automatically used on all building design, construction and operations projects, they will have to use *the* definitive source for all applicable input data: a project BIM that meets NBIMS. Software implementation rules and guidelines, contained in NBIMS, will apply to BEP simulation tools too; this will have a direct impact on parts of all currently available BEP simulation tools. A BEP view of IFC will have to be developed and will become a national standard; this will include definitions of all will exchange data. A large amount of information about the energy performance of a given building, generated in BEP simulation and analysis, will have to be placed back (per NBIMS rules) into the related BIM for reuse by other downstream software.

NBIMS Part 2 Version 1.0 – the technical specification of the standard – is already under development. LBNL already initiated its work on Part 2: data type and set definitions to support BEP simulation and analysis tools. NBIMS will send out the draft specification for industry review as soon as the draft is ready in the fall of this year. In addition, LBNL is planning to initiate a BEP simulation view of IFC, and is developing rules of data set reduction and simplification, and data translation and interpretation applicable to BEP simulation and analysis (Bazjanac and Kiviniemi 2007).

The current content of NBIMS indirectly provides for the use of multiple data models of buildings (including proprietary and non-object oriented models). Part 2 will have to address and resolve the harmonization of such models with IFC. It will also need to define a methodology and provide means for identifying authoritative sources of information, and ensure their accuracy and integrity.

CONCLUSION

NBIMS is likely to be the catalyst in changing the current AECO industry processes and modes of operation. It will hopefully bring much needed order and standardization to the definition and use of data about buildings and their performance throughout the industry. If BEP is going to be automatically considered in building procurement and operations in the future, BEP simulation and analysis professionals will have to actively participate in this change. NBIMS "call to arms" is particularly relevant to this constituency.

NBIMS will inevitably have a significant impact on the future practice of BEP simulation and analysis and its tools. It will regulate sources and quality of data used in BIM based simulation and analysis; it will regulate some of the information generated in simulation and analysis that must be entered back in the associated BIM, and will also make the generated performance data more accessible and usable to others who need them in building procurement and operations.

NBIMS is likely to become the basis for all kinds of building rating systems, from BIM maturity and completeness to LEED to buildings' true sustainability. By participating in NBIMS development, the BEP simulation and analysis constituency can also lay foundation to an eventual fair and meaningful U.S. building energy efficiency rating system.

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