United States

NATIONAL BUILDING INFORMATION MODELING STANDARD

Version 1 - Part 1: Overview, Principles, and Methodologies

Transforming the Building Supply Chain Through Open and Interoperable Information Exchanges

National Institute of BUILDING SCIENCES

Facilities Information Council

National BIM Standard

Foreword

The construction industry is in the middle of a growing crisis worldwide. With 40% of the world's raw materials being consumed by buildings, the industry is a key player in global economics and politics. And, since facilities consume 40% of the world's energy and 65.2% of total U.S. electrical consumption, the construction industry is a key player in energy conservation, too! With facilities contributing 40% of the carbon emissions to the atmosphere and 20% of material waste to landfills, the industry is a key player in the environmental equation. Clearly, the construction industry has a responsibility to use the earth's resources as efficiently as possible.

Construction spending in the United States is estimated to be $1.288 trillion for 2008. The Construction Industry Institute estimates there is up to 57% non-value added effort or waste in our current business models. This means the industry may waste over $600 billion each year. There is an urgent need for construction industry stakeholders to maximize the portion of services that add value in end-products and to reduce waste.

Another looming national crisis is the inability to provide enough qualified engineers. Some estimate the United States will be short a million engineers by the year 2020. In 2007, the United States was no longer the world's largest consumer, a condition that will force United States industry to be more competitive in attracting talented professionals. The United States construction industry must take immediate action to become more competitive.

The current approach to industry transformation is largely focused in efforts to optimize design and construction phase activities. While there is much to do in those phases, a lifecycle view is required. When sustainability is not adequately incorporated, the waste associated with current design, engineering, and construction practices grows throughout the rest of the facility's lifecycle. Products with a short life add to performance failures, waste, recycling costs, energy consumption, and environmental damage. Through cascading effects, these problems negatively affect the economy and national security due to dependence on foreign petroleum, a negative balance of trade, and environmental degradation. To halt current decline and reverse existing effects, the industry has a responsibility to take immediate action.

While only a very small portion of facility lifecycle costs occur during design and construction, those are the phases where our decisions have the greatest impact. Most of the costs associated with a facility throughout its lifecycle accrue during a facility's operations and sustainment. Carnegie-Mellon University research has indicated that an improvement of just 3.8% in productivity in the functions that occur in a building would totally pay for the facility's design, construction, operations and sustainment, through increased efficiency. Therefore, as industry focuses on creating, maintaining, and operating facilities more efficiently, simultaneous action is required to ensure that people and processes supported by facilities are optimized.

BIM stands for new concepts and practices that are so greatly improved by innovative information technologies and business structures that they will dramatically reduce the multiple forms of waste and inefficiency in the building industry. Whether used to refer to a product – Building Information Model (a structured dataset describing a building), an activity – Building Information Modeling (the act of creating a Building Information Model), or a system – Building Information Management (business structures of work and communication that increase quality and efficiency), BIM is a critical element in reducing industry waste, adding value to industry products, decreasing environmental damage, and increasing the functional performance of occupants.

Foreword

The National Building Information Model Standard™ (NBIMS) is a key element to building industry transformation. NBIMS establishes standard definitions for building information exchanges to support critical business contexts using standard semantics and ontologies. Implemented in software, the Standard will form the basis for the accurate and efficient communication and commerce that are needed by the building industry and essential to industry transformations. Among other benefits, the Standard will help all participants in facilities-related processes achieve more reliable outcomes from commercial agreements.

Thus, there is a critical need to increase the efficiency of the construction process. Today's inefficiency is a primary cause of non-value added effort, such as re-typing (often with a new set of errors) information at each phase or among participants during the lifecycle of a facility or failing to provide full and accurate information from designer to constructor. With the implementation of this Standard, information interoperability and reliability will improve significantly. Standard development has already begun and implementable results will be available soon. BIM development, education, implementation, adoption, and understanding are intended to form a continuous process ingrained evermore into the industry. Success, in the form of a new paradigm for the building construction industry, will require that individuals and organizations step up to contribute to and participate in creating and implementing a common BIM standard. <u>Each of us has a responsibility to take action now</u>.

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Chapter 1.1 Executive Summary

National Building Information Modeling Standard™ Version 1 - Part 1: Overview, Principles, and Methodologies

Introduction

The National Building Information Modeling Standard (NBIMS) Committee is a committee of the National Institute of Building Sciences (NIBS) Facility Information Council (FIC). The vision for NBIMS is "an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format useable by all throughout its lifecycle."[1] The organization, philosophies, policies, plans, and working methods that comprise the NBIMS Initiative and the products of the Committee will be the National BIM Standard (NBIM Standard), which includes classifications, guides, recommended practices, and specifications.

This publication is the first in a series intended to communicate all aspects of the NBIMS Committee and planned Standard, which will include principles, scope of investigation, organization, operations, development methodologies, and planned products. NBIMS V1-P1 is a guidance document that will be followed by publications containing standard specifications adopted through a consensus process.

Wherever possible, international standards development processes and products, especially the NIBS consensus process, American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), and International Standards Organization (ISO) efforts will be recognized and incorporated so that NBIMS processes and products can be recognized as part of a unified international solution. Industry organizations working on open standards, such as the International Alliance for Interoperability (IAI), the Open Geospatial Consortium (OGC), and the Open Standards Consortium for Real Estate (OSCRE), have signed the NBIMS Charter in acknowledgement of the shared interests and commitment to creation and dissemination of open, integrated, and internationally recognized standards. Nomenclature specific to North American business practices will be used in the U.S. NBIMS Initiative. Consultations with organizations in other countries have indicated that the U.S.-developed NBIM Standard, once it is localized, will be useful internationally as well. Continued internationalization is considered essential to growth of the U.S. and international building construction industries.

BIM Overall Scope and Description

Building Information Modeling (BIM) has become a valuable tool in some sectors of the capital facilities industry. However in current usage, BIM technologies tend to be applied within vertically integrated business functions rather than horizontally across an entire facility lifecycle. Although the term BIM is routinely used within the context of vertically integrated applications, the NBIMS Committee has chosen to continue using this familiar term while evolving the definition and usage to represent horizontally integrated building information that is gathered and applied throughout the entire facility lifecycle, preserved and interchanged efficiently using open and interoperable technology for business, functional and physical modeling, and process support and operations.

[1] Charter for the National Building Information Modeling (BIM) Standard, December 15, 2005, pg.1. See http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Charter.pdf.

NBIM Standard Scope and Description

The NBIMS Initiative recognizes that a BIM requires a disciplined and transparent data structure supporting all of the following.

- A specific business case that includes an exchange of building information.
- The users' view of data necessary to support the business case.
- The machine interpretable exchange mechanism (software) for the required information interchange and validation of results.

This combination of content selected to support user needs and described to support open computer exchange form the basis of information exchanges in the NBIM Standard. All levels must be coordinated for interoperability, which is the focus of the NBIMS Initiative. Therefore, the primary drivers for defining requirements for the National BIM Standard are industry standard processes and associated information exchange requirements.

In addition, even as the NBIM Standard is focused on open and interoperable information exchanges, the NBIMS Initiative addresses all related business functioning aspects of the facility lifecycle. NBIMS is chartered as a partner and an enabler for all organizations engaged in the exchange of information throughout the facility lifecycle.

Data Modeling for Buildings

Key to the success of a building information model is its ability to encapsulate, organize, and relate information for both user and machine-readable approaches. These relationships must be at the detail level, relating, for example, a door to its frame or even a nut to a bolt, while maintaining relationships from a detailed level to a world view. When working with as large a universe of materials as exists in the built environment, there are many traditional vertical integration points (or stovepipes) that must be crossed and many different languages that must be understood and related. Architects, engineers, as well as the real estate appraiser or insurer must be able to speak the same language and refer to items in the same terms as the first responder in an emergency situation. Expand this to the world view where systems must be interoperable in multiple languages in order to support the multinational corporation. Over time ontologies will be the vehicles that allow cross communication to occur. In order to standardize these many options, organizations need to be represented and solicited for input. There are several, assumed to be basic, approaches in place that must come together in order to ensure that a viable and comprehensive end-product will be produced.

The Role of Interoperability

Software interoperability is seamless data exchange at the software level among diverse applications, each of which may have its own internal data structure. Interoperability is achieved by mapping parts of each participating application's internal data structure to a universal data model and vice versa. If the employed universal data model is open, any application can participate in the mapping process and thus become interoperable with any other application that also participated in the mapping. Interoperability eliminates the costly practice of integrating every application (and version) with every other application (and version).

The NBIM Standard maintains that viable software interoperability in the capital facilities industry requires the acceptance of an open data model of facilities and an interface to that data model for each participating application. If the data model is industry-wide (i.e. represents the entire facility lifecycle), it provides the opportunity to each industry software application to become interoperable.

Storing and Sharing Information

One of the innovations, demonstrated by some full-service design and engineering firms and several International Alliance for Interoperability (IAI) demonstration projects, has been the use of a shared repository of building information data. A repository may be created by centralizing the BIM database or by defining the rules through which specific components of BIM models may be shared to create a decentralized shared model. As BIM technology and use matures, the creation of repositories of project, organization, and/or owner BIM data will have an impact on the framework under which NBIMS operates. Owners are likely to create internally as-built and as-maintained building model repositories, which will be populated with new and updated information supplied via design/construction projects, significant renovations, and routine maintenance and operations systems.

Information Assurance

The authors caution that, while a central (physical or virtually aggregated) repository of information is good for designing, constructing, operating, and sustaining a facility, and the repository may create opportunities for improved efficiency, data aggregation may be a significant source of risk.

Managing the risks of data aggregation requires advanced planning about how best to control the discovery, search, publication, and procurement of shared information about buildings and facilities. In general, this is addressed in the data processing industry through digital rights management. Digital rights management ensures that the quality of the information is protected from creation through sharing and use, that only properly authorized users are granted access, and only to that subset of information to which they should have access. There is a need to ensure that the requirements for information are defined and understood before BIMs are built, so that facility information receives the same protection that is commonplace in world-wide personnel and banking systems.

Minimum BIM and the Capability Maturity Model

The NBIM Standard Version 1 - Part 1 defines a minimum standard for traditional vertical construction, such as office buildings. It is assumed that developing information exchange standards will grow from this minimum requirement.

The Standard also proposes a Capability Maturity Model (CMM) for use in measuring the degree to which a building information model implements a mature BIM Standard. The CMM scores a complete range of opportunity for BIMs, extending from a point below which one could say the data set being considered is not a BIM to a fully realized open and interoperable lifecycle BIM resource.

The U.S. Army Corps of Engineers BIM Roadmap[2] is presented as a useful reference for building owners seeking guidance on identifying specific data to include in a BIM from a design or construction perspective.

[2] See https://cadbim.usace.army.mil/default.aspx?p=s&t=19&i=1 for the complete roadmap.

NBIM Standard Process Definition

Proposals for the processes the NBIMS Committee will employ to produce the NBIM Standard and to facilitate productive use are discussed. A conceptual diagram to orient the user is provided. Components of this diagram correspond to section 5 chapters.

Both the process used to create the NBIM Standard and the products are meant to be open and transparent. The NBIMS Committee will employ consensus-based processes to promote industry-wide understanding and acceptance. Additionally, the Committee will facilitate the process whereby software developers will implement standard exchange definitions and implementations tested for compliance. Finally, the NBIMS Committee will facilitate industry adoption and beneficial use through guides, educational activities, and facilitation of testing by end users of delivered BIMs.

The Information Exchange Template, BIM Exchange Database, the Information Delivery Manual (IDM), and Model View Definition (MVD) activities together comprise core components of the NBIM Standard production and use process. The Information Exchange Template and BIM Exchange Database are envisioned as web-based tools to provide search, discovery, and selection of defined exchanges as well as a method of providing initial information necessary to propose and begin a new exchange definition discussion. The NBIMS workgroup formation phase teams will use the IDM, adapted from international practices, to facilitate identification and documentation of information exchange processes and requirements. IDM is the user-facing phase of NBIMS exchange standard development with results typically expressed in human-readable form. MVD is the software developer-facing phase of exchange standard development. MVD is conceptually the process which integrates Exchange Requirements (ERs) coming from many IDM processes to the most logical Model Views that will be supported by software applications. Implementation-specific guidance will specify structure and format for data to be exchanged using a specific version of the Industry Foundation Classes (IFC or ifc) specification. The resulting generic and implementation-specific documentation will be published as MVDs, as defined by the Finnish Virtual Building Environment (VBE) project,[3] the Building Lifecycle Interoperability Consortium (BLIS),[4] and the International Alliance for Interoperability (IAI).[5] The Committee will work with software vendors and the testing task team members to plan and facilitate implementation, testing, and use in pilot projects. After the pilot phase is complete, the Committee will update the MVD documents for use in the consensus process and ongoing commercial implementation. Finally, after consensus is reached, MVD specifications will be incorporated in the next NBIMS release.

NBIMS Appendices

Reference standards in the NBIM Standard provide the underlying computer-independent definitions of those entities, properties, relationships, and categorizations critical to express the rich language of the building industry. The reference standards selected by the NBIMS Committee are international standards that have reached a critical mass in terms of capability to share the contents of complex design and construction projects. NBIMS V1-P1 includes three candidate reference standards as Appendix documents: IAI Industry Foundation Classes (IFC or ifc), Construction Specifications Institute (CSI) *OmniClass*™, and CSI *IFDLibrary*™.

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[3] http://cic.vtt.fi/projects/vbe-net/
[4] http://www.blis-project.org
[5] http://www.iai-international.org

The IFC data model consists of definitions, rules, and protocols that uniquely define data sets which describe capital facilities throughout their lifecycles. These definitions allow industry software developers to write IFC interfaces to their software that enable exchange and sharing of the same data in the same format with other software applications, regardless of the internal data structure of the individual software application. Software applications that have IFC interfaces are able to exchange and share data with other application that also have IFC interfaces.

The *OmniClass*™ Construction Classification System (*OmniClass* or OCCS) is a multi-table classification system designed for use by the capital facilities industry. *OmniClass* includes some of the most commonly used taxonomies in the capital facilities industry. It is applicable for organizing many different forms of information important to the NBIM Standard, both electronic and hard copy. OCCS can be used in the preparation of many types of project information and for communicating exchange information, cost information, specification information, and other information that is generated throughout the facility's lifecycle.

IFDLibrary™ is a kind of dictionary of construction industry terms that must be used consistently in multiple languages to achieve consistent results. Design of NBIMS relies on terminology and classification agreement (through *OmniClass*) to support model interoperation. Entries in the *OmniClass* tables can be explicitly defined in the *IFDLibrary* once and reused repeatedly, enabling reliable automated communications between applications – a primary goal of NBIMS.

References

NBIMS References in this document represent the work of many groups working in parallel to define BIM implementation for their areas of responsibility. Currently there are four types of references.

- **Business Process Roadmaps** are documents that provide the business relationships of the various activities of the real property industry. These will be the basis for organizing the business processes and will likely be further detailed and coordinated over time. The roadmaps will help organize NBIMS and the procedures defined in the Information Delivery Manuals (IDMs).
- **Candidate Standards** are documents that are candidates to go through the NBIMS consensus process for acceptance as part of future NBIMS. It is envisioned that Part 2 or later releases of the Standard will incorporate these documents once approved.
- **Guidelines** have been developed by several organizations and include items that should be considered for inclusion in NBIMS. Since NBIMS has not existed prior to this, there was no standard from which to work, resulting in a type of chicken-or-egg dilemma. When formal NBIMS exists there will need to be some harmonization, not only between the guidelines and NBIMS, but also in relating the various guidelines to each other. While guidelines are not actually a part of NBIMS, they are closely related and therefore included as references.
- **Other Key References** are to parallel efforts being developed in concert with NBIMS. Not part of NBIMS, they may, in fact, be standards in their own right.

Chapter 1.2 How to Read Version 1 - Part 1 of the National BIM Standard

Introduction

This chapter is provided to help the reader understand how each element of Version 1 - Part 1 fits into the whole NBIMS. Each reader, regardless of previous experience or role in the capital facilities industry, is encouraged to read the Executive Summary and Table of Contents then scan through all sections of the publication. Readers need to be aware that this publication is not a manual on how to evaluate, select, or use Building Information Modeling (BIM) applications. It is a treatise on what is needed, why, and, most significantly, how to create a standard for exchanging open and interoperable building information. Readers will find sections introducing the overall BIM concept, the planned scope of the Committee's work, specific coverage of this and future Standard publications, and the differences between the National BIM Standard (NBIMS), the NBIMS Committee, and the NBIMS Initiative. The core of Part 1 is the discussion of processes and techniques which will be used to identify exchange candidates, create exchange definitions, evaluate products, and, in summary, make an open and interoperable building information exchange standard available to end users.

Relevance to Users

NBIMS V1 - P1 presents a comparatively expansive treatment of BIM. Rather than the usual focus on software products and case studies drawn from industry-specific implementations of BIM tools, this document presents the need for a lifecycle view of building supply chain processes, the scope of work necessary to define and standardize information exchanges between trading partners, suggestions for a methodology to address this work, and examples of work in progress that demonstrate appropriate principles and results. Recognizing that reading this document may present a challenge, *How to Read NBIMS V1 - P1* is intended to give the reader both a broad view of the content and link this broader view with specific content. It is hoped the document will achieve the goal of defining for all participants a shared set of facility lifecycle values even as readers continue to pursue essential individual professional or technical specialties.

Discussion: Background

Imagine for a moment all of the individual actors in all of the phases of a facility's lifecycle. Imagine that all of the actors, working in familiar ways within their own specialty areas, are able to gather information, explore options, assemble, test, and perfect the elements of their work within a computer-based model before committing their work to be shared with or passed on to others, to be built, or to be operated. Imagine further that when it becomes necessary to share or pass a bundle of information to another organization, which may or may not be using the same tools, or to move it on to another phase of work, it is possible to safely and almost instantaneously (through a computer-to-computer communication) share or move just the right bundle of information without loss or error and without giving up appropriate control. In this imaginary world the exchange is standardized across the entire industry such that each item is recognized and understood without the parties having to create their own set of standards for that project team or for their individual organizations. Finally, imagine that for the life of the facility every important aspect, regardless of how, when, or by whom it was created or revised, could be readily captured, stored, researched, and recalled as needed to support real property acquisition and management, occupancy, operations, remodeling, new construction, and analytics.

These scenarios are a highly compressed summary of the fundamental goals and challenges for the NBIMS Committee, the rationale behind the NBIMS Initiative, and the business solution the National BIM Standard will provide. They illustrate the need for the NBIM Standard to address the requirements of many types of users with hundreds of functional backgrounds and individual business viewpoints arising from the particular niche occupied within the building supply chain and throughout the lifecycle of a facility. To address the range of requirements, the NBIMS Committee, beginning with this publication, speaks to the business process aspects of open and interoperable[6] information exchange standards as well as supports the beneficial use of computer systems and business best practices in every aspect of the facility lifecycle.

Discussion: Fundamental Concepts

Readers of V1 - Part 1 need to understand some fundamental concepts which form the philosophical basis of the Standard. These concepts reside at the core of the NBIMS Initiative and their influence permeates throughout the organizational, operational, and technical aspects incorporated into the Standard. The next few pages introduce these concepts at a high level and then direct readers to sections of the Part 1 document where these concepts are described in greater detail. For many readers, it will be helpful to return to these conceptual discussions after reading more detailed sections of the document.

The Facility Lifecycle Helix

Building processes extend throughout and, in many cases, beyond the life of a facility. The lifecycle is not a strictly linear process but is primarily a cyclical process which must have feedback and cycle-to-cycle knowledge accumulation and distribution capabilities. Figure 1.2-1 represents the business process lifecycle as a helix with a central knowledge core and external nodes representing process suppliers and external consumers. The information backbone (see Chapter 3.3 *Storing and Sharing Information*) at the core is made up of integrated repositories which provide historical and current data. Through analysis, backbone data can provide knowledge and alternative future projections.

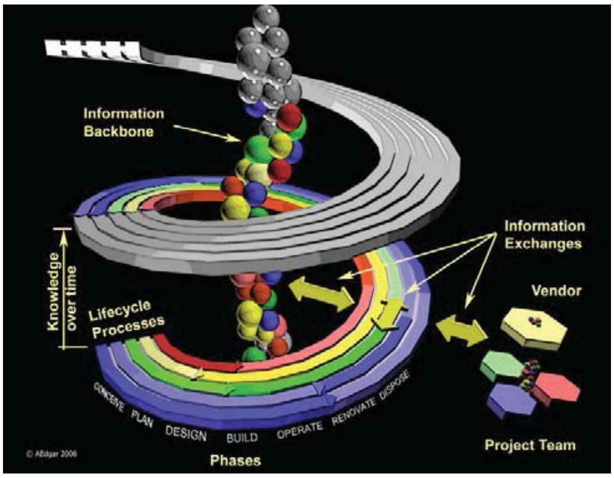

Figure 1.2-1 Facility Lifecycle Helix

Between these three elements, the process helix, the knowledge core, and external suppliers of products and services, are found information interchange zones. Information exchanges require exchange rules and agreements. One of the primary goals of NBIMS is to standardize these rules and agreements nationally, in alignment with international standards, and eliminate the need to redefine exchange agreements repeatedly for each project or new set of participants.

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[6] Interoperable: With respect to software, the term interoperability is used to describe the capability of different programs to exchange data via a common set of business procedures and to read and write the same file formats and use the same protocols. (Wikipedia: http://en.wikipedia.org/wiki/Interoperability)

Read Section 3 for fundamental information exchange concepts, information assurance, and information exchange requirements.

Coordination, Harmonization, and Integration

The Committee is committed to maximizing existing research and development through alliances, cross-representation, active testing and prototyping, and an open and inclusive approach to both membership and results. This requires knitting together the broadest and deepest constituency ever assembled for the purpose of addressing the losses and limitations associated with errors and inefficiencies in the building supply chain. The current Charter signatories (see http://facilityinformationcouncil.org/bim/members.php) represent most, if not all, of the end-user constituencies active in the building supply chain as well as most of the professional associations, consortia, and technical and associated service vendors who support them. Read Section 1 for more information on Committee goals and review the Appendix material where related initiatives, believed to be candidates for normative reference standards, are discussed in detail.

The Information Exchanges

Some of the most fundamental concepts in the Standard have to do with exchanging building model information. Together, these concepts can be thought of as a 'layer cake' with tiers as illustrated in Figure 1.2-2. Although each level in this diagram has its own characteristics and strategic importance, the 'layer cake' as a whole illustrates the framework for putting BIM standards to work. Throughout the Part 1 publication, readers will find references to this diagram as elements are discussed in greater detail.

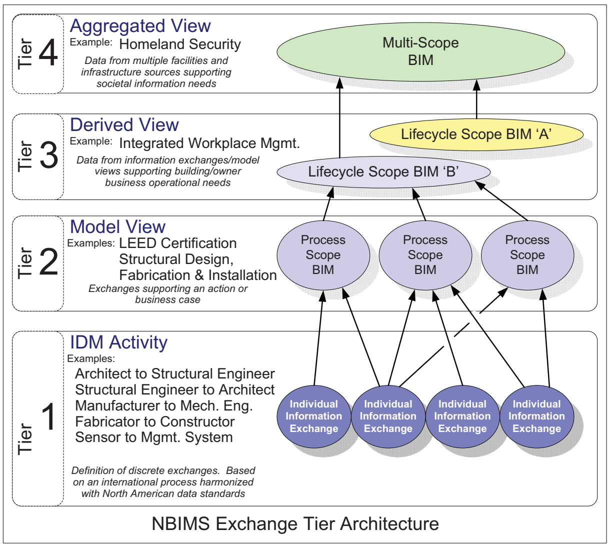

Figure 1.2-2 NBIMS Exchange Tier Architecture

The top layer (Tier 4) of the 'cake' can be thought of as the strategic goal for an entire organization in that it represents a common, overall picture of all facilities and ongoing operations as well as providing a basis for analysis and planning activities. At its most mature, Tier 4 should be derived from real-time access to live facilities models, project models (planned and in-construction phases), and operations applications; all based on NBIM Initiative concepts. This is an ideal that organizations will work to achieve over a period of time (see *Evolution and Maturity* below and Chapter 4.2 *Capability Maturity Model*). Less mature Tier 4 capabilities will likely rely on stored or standardized linked data that is supplied from project BIMs and links to compatible operations systems. For example, *References* lists a link to the U.S. Coast Guard's efforts to achieve a BIM-based Tier 4 capability.

Tier 3 describes the aggregation of information for a particular legal or operational purpose, such as for individual facilities or a group of facilities on a campus. Because this is the predominant focus for owners or building-specific management, it is likely to be the focus for project BIM development and BIM systems for operations. Multiple Tier 3 BIMs contribute to a Tier 4 capability, which provides an overall view of assets in an organization.

In Tier 2, information is aggregated to support a specific task or requirement such as energy analysis, cost estimating, or structural analysis. In the Model View Definition (MVD), model exchange specifications based on exchange requirements are constructed to support the view requirement and typically do not need to represent an entire facility. Multiple Tier 2 Models can be combined to provide a Tier 3 facility BIM.

Tier 1 contains the most basic information building blocks, definitions for individual information exchanges between two parties, and the reference standards that control how information will be organized and described. To be useful, the exchange definitions in Tier 1 should be readable by people and suitable for incorporation in specifications to be implemented in software. The method NBIMS plans to use to identify and build Tier 1 exchange requirements is the Information Delivery Manual (IDM) methodology.

Section 5 discusses the methodologies that will be used to create the NBIM Standard, including workgroup formation, definition of requirements and creation of modeling specifications as well as steps that can be taken during of deployment of certified software and its use in exchanging BIM data.

Evolution and Maturity of the Standard

The Committee realizes and embraces the fact that achieving the highest ideals in NBIMS development and use will be an evolutionary process. Starting with fundamental criteria and a process for initiating a standard BIM exchange, Section 4 describes a minimum definition that meets the NBIMS criteria (Chapter 4.1 - *BIM Minimum*), how BIM data is structured and the significance of using a standard schema regardless of content or maturity, and helps users set goals and evaluate progress (Chapter 4.2 - *Capability Maturity Model*).

Discussion: How NBIMS V1 - Part 1 is Organized

Part 1 is written and organized to address varying degrees of familiarity with facility lifecycle information management concepts and supporting technologies. Throughout Part 1 the authors have endeavored to provide the following.

- A philosophical basis for the Initiative and Standard elements
- A recommendation and/or instructions for how the Standard should be evolved
- Examples that meet the Standard or are works-in-progress. Readers should keep in mind that these examples represent a response to particular business situations and there are usually many ways to accomplish the Standard concept.

This publication groups major conceptual topics into logical sections and orders these more or less in a sequence that parallels how the Committee proposes to develop and mature NBIM Standard candidates.

- Section 1 introduces the Part 1 document and provides a guide for readers.
- Section 2 is a Prologue to the Standard's discussions and recommendations. This section summarizes fundamental NBIMS Committee and philosophical concepts incorporated into the NBIMS Initiative, including the overall scope of industry transformation, current initiatives, the Committee's approach to NBIMS now and projected into the future, a discussion of the scope of NBIMS, and a specific description of the coverage of Part 1 with projections for future versions.
- Section 3 introduces fundamental information exchange concepts: how BIM information will be stored in operational and project settings, the importance of achieving

interoperability and maintaining open, rather than proprietary, systems environments, and the conceptual case for a secure and coordinated facility lifecycle information resource available to all credentialed stakeholders.

- Section 4 progresses from concepts and conceptual requirements to those that are proposed for the NBIM Standard. Specifically, Section 4 describes the Standard relative to information exchange content in chapters that define the minimum characteristics required of a BIM, how the data should be structured, and a proposal for the BIM Maturity Model, which will establish a method of measuring individual BIMs against a set of ideal characteristics.
- From the introductory paragraph of Section 5, it is clear that NBIMS focuses on the information exchanges between all of the individual actors in all of the phases of a facility lifecycle. NBIMS will be an industry-wide standard for organizing the actors, work phases, and facility cycles, where exchanges are likely and, for each of these exchange zones, stating the elements that should be included in the exchange between parties. Section 5 provides a conceptual framework for information exchange concepts, describes the need for standard packages of information between, for example, an Architect and a Structural Engineer during a design development phase and the concept of a shared repository of facility lifecycle information. Section 5 describes the proposed 'factory' process for developing NBIM Standard products including IDMs and MVDs. NBIM Standard products will also include classifications, references, and guides.
- Having presented the process proposed for creating the NBIM Standard in Section 5, this document provides References with links to important case studies of initiatives that are closely related to the NBIM Standard effort. Early Design and Construction to Operations Building Information Exchange (COBIE) are presented as existing initiatives describing approaches and elements that it is anticipated will be restated to meet the NBIM Standard. This is because NBIMS is prescribing a particular set of criteria for open and interoperable exchange along with a development and testing process that assures consistency.
- Many of the related standards and practices that may be incorporated into the National BIM Standard are already available or under development by consortia, professional and trade organizations, and institutions. Whenever possible NBIMS will work with these organizations to harmonize and incorporate these standards and practices. In some cases, NBIMS will have to create or sponsor the creation of wholly new standard elements as well as structures to facilitate development, maturing the standard, a standards repository, and library research and discovery capabilities.

  The References pages provide introductions to and links for more information for important concepts such as FIATECH's Capital Projects Technology Roadmap, significant ongoing projects which are consistent with the NBIMS Initiative, and likely candidates for harmonization and/or adoption. This Standard is being developed as part of a transformation in the building industry that includes sweeping changes in the way owners think about management of real property, how project teams are organized, and higher expectations for efficiency and quality even as delivery cycles are shortened. As a source of inspiration, the attached references discuss business management concerns including organizational changes, legal and insurance considerations, contracting, and related topics.

  Finally, because it is clear that traditional computer-aided drafting (CAD) will be a part of practice for the foreseeable future, References also introduces and provides a link to the important continuing role of the National CAD Standard (NCS) and the relationship NCS will have to 3D, 4D, and other virtual modeling and construction environments.

The NBIMS Initiative focuses in part on business requirements related to lifecycle building information models and providing both the requirements and detailed specifications for software developers to implement in applications. The Committee's purpose in segregating the NBIM Standard from the work of software developers allows individual software companies to prepare applications as they wish based on a single, open, and neutral exchange standard rather than supporting many, often proprietary, translators. This approach provides the means for many applications to contribute over the facility lifecycle, building on previous work and providing information to the next phase of work. Each application then is free to encapsulate best practices and deliver specific functionality to a user.

Discussion: Different Strokes for Different Folks

Throughout Part 1 existing practices are contrasted with desirable future practices in order to raise the quality of the industry and identify requirements all participants in facility lifecycle processes should adopt with regard to lifecycle building information management.

Readers will approach this publication from widely divergent viewpoints and interests. As was stated in the introduction, the Committee recommends that all readers at least skim the entire publication once because the content and approach are somewhat different from current industry dialogue and because the emerging best practices require a new emphasis on teaming and holistic awareness of all aspects of the facility lifecycle.

- Owners will use it to gain an understanding of what is possible from using BIM based on NBIM Initiative concepts and the NBIM Standard.
- Practitioners will use it to understand the details associated with implementing next generation BIM concepts.
- Product manufacturers will use it to prepare and position their products to add new value.
- Software vendors will use it to understand how to further incorporate BIM capabilities into their software products.
- Others involved with facility information will be able to use NBIMS to access information that will support their various endeavors.

Building Information Models are in an explosive growth mode currently and this first version of the National BIM Standard is intended to help provide direction and, frankly, add some quality control to what is produced and called a BIM. This effort is certainly not intended to slow the process of BIM implementation.

Tasks to Complete

NBIMS V1 - P1 is intended to be a very open and democratic document and the Committee invites participation and suggestions by all as to how future plans may need to be altered and enhanced. In addition to being a statement of principles, this is intended to be a tool for practitioners to use in establishing building information models for their facilities.

One may conclude after reading this document that there is a long journey ahead; however, one must take the first step and this is that first step. Imperfect as it may be, the creation of a National Building Information Model Standard should do nothing to slow the explosive growth of BIMs in the industry, only make them more usable and sustainable and provide the software vendors supporting the facility industry a consistent target for their BIM development efforts.

Chapter 2.1 Building Information Model Overall Scope

Introduction

The scope of Building Information Modeling (BIM) directly or indirectly affects all stakeholders supporting the capital facilities industry. BIM is a fundamentally different way of creating, using, and sharing building lifecycle data. The terms Building Information Model and Building Information Modeling are often used interchangeably, reflecting the term's growth to manage the expanding needs of the constituency.

What Is the Focus of NBIMS to the Scope of BIM?

The NBIMS Initiative categorizes the Building Information Model (BIM) three ways, as **product**, as an IT enabled, open standards based deliverable, a **collaborative process**, and a **facility lifecycle management requirement**. These categories reflect the make-up of the participants in the NBIMS Initiative and support the creation of the industry information value-chain, which is the ultimate evolution of BIM. This enterprise (industry wide) level scope of BIM is the area of focus for NBIMS, bringing together the various BIM implementation activities within stakeholder communities.

The methodologies used by NBIMS are rooted in the activities of the International Alliance for Interoperability (IAI), the Information Delivery Manuals (IDM), Industry Foundation Dictionaries (IFD), and the development of North American (NA) Information Exchanges that define user requirements and localized content supporting the NA approach to the various building lifecycle processes.

BIM supports a re-evaluation of IT use in the creation and management of the facility's lifecycle. The stakeholders include real estate, ownership, finance, all areas of architecture, engineering and construction (AEC), manufacturing and fabrication, facility maintenance, operations and planning, regulatory compliance, management, sustainment, and disposal within the facility lifecycle. With society's growing environmental, sustainment, and security mandates the need for open and re-useable critical infrastructure data has grown beyond the needs of those currently supplying services and products to the industry. First-responders, government agencies, and other organizations need this data, too.

As an IT and business enabler, BIM cuts across the traditional information silos supporting our growing integrated information requirements versus our current data abundance. The reality of what BIM does for the industry grows exponentially when it is understood that BIM uses machine interpretable data that is visually represented by intelligent virtual products (window) and entities (wall) of that data. In a virtual model this data has a geo-spatial context which allows additional analytical capabilities. It moves the industry forward from current task automation of project and paper-centric processes (3D CAD, animation, linked databases, spreadsheets, and 2D CAD drawings) toward an integrated and interoperable workflow where these tasks are collapsed into a coordinated and collaborative process that maximizes computing capabilities, web communication, and data aggregation into information and knowledge capture.

All of this is used to simulate and manipulate reality based models to manage the built environment within a fact based repeatable and verifiable decision process that reduces risk and enhances the quality of actions and product industry wide.

Background

The Building Information Model (BIM) as a technology is not new to the capital facilities industry. BIM under different names such as product model, virtual building, and intelligent object model have been in use for over twenty years. The rapid emergence of BIM as a topic of discussion and wide interest was facilitated by the National Institute of Standards and Technology (NIST) report on the failure of the current process (2D and non-integrated data) and tools (desk top application CAD) to adequately support information discovery and use within the capital facilities lifecycle. The cost of our current process' failure to adequately support the industry information exchange and workflow needs is $15.8 billion yearly.[7]

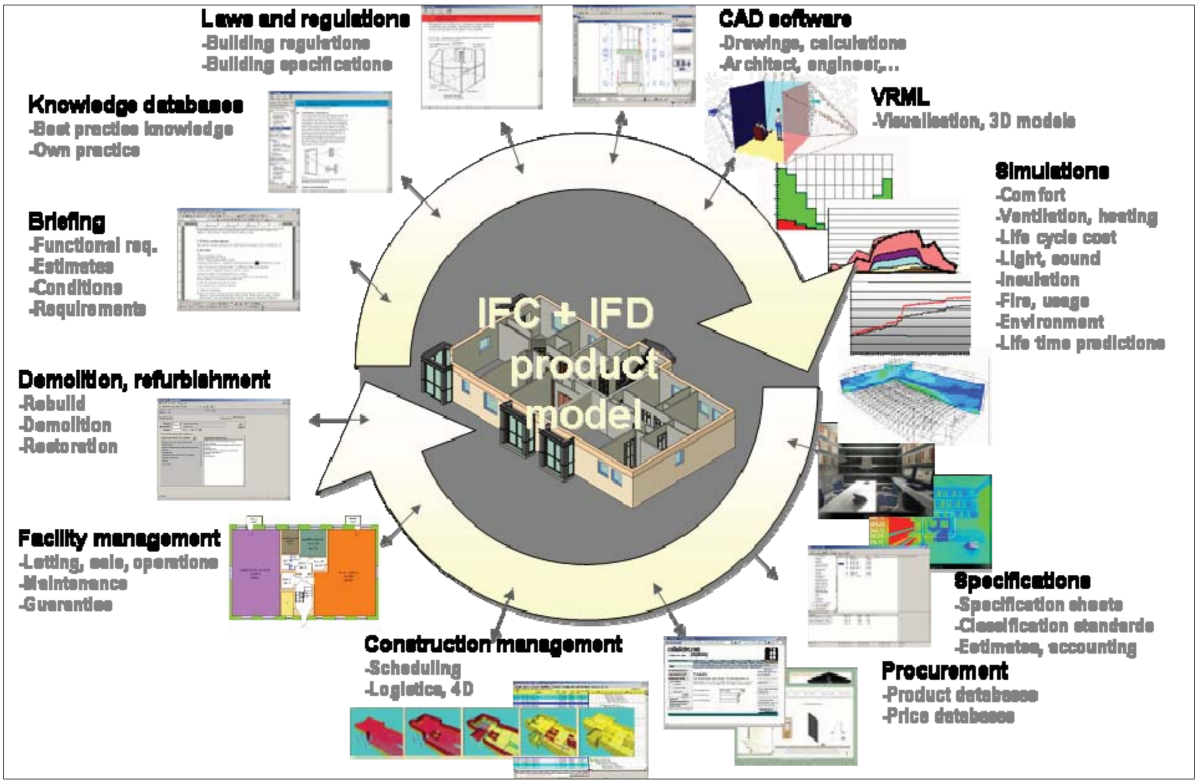

Figure 2.1-3 IAI Nordic Chapter 2000 BIM Product Model

The development of new and multi-source BIM authoring and analysis tools is both evolutionary and opportunistic. Simulation and object based modeling used earlier in manufacturing are a source of theories in the AEC industry's move to BIM. This growing awareness and availability of new tools has helped the industry know that mimicking a paper-centric process on a computer (2D CAD) is not efficient and does not use the technology to its fullest capacity. Data aggregation capabilities, Geospatial Information Systems (GIS), web communication, and data warehousing will have the same profound process change on the capital facilities industry as in other industries.

[7] http://www.bfrl.nist.gov/oae/publications/gcrs/04867.pdf

Parallel activities that have shaped the industry's move to BIM include the Lean Construction Council's adaptation of manufacturing principles to construction, the IAI and buildingSMART®, CURT and COAA whitepapers on owner needs, OSCRE business re-engineering efforts in Real Estate, and the activities of the various stakeholder organizations. The entire country was affected by 9/11, understanding how important facility data could be in an emergency situation. All of these factors and the entering of major data companies into the capital facilities marketplace have increased BIM awareness.

Relevance to Users

To be successful this re-engineering effort must be coordinated at a facility lifecycle level rather than sub-optimized within the current industry and software vertical divisions or stovepipes. Major benefits of BIM are communication and the value of the information created by the BIM process. When BIM is done in a collaborative environment where analytical, decisional, and documentation activities are coordinated within the framework of a data model, then risks inherent in today's industry are reduced, while new revenue and service opportunities are developed.

This more holistic view will allow a better understanding of the information exchanges and data re-use opportunities that can be automated within collaborative workflows based on open data standards.

Relevance to the National BIM Standard

The promise of BIM rests upon the use of open and interoperable standards used within well defined and understood workflows. Communication of any kind relies upon rules. Language and text require the rules to be known for there to be comprehension. This is even more important in a machine-to-machine exchange of information.

The scope of BIM requires a high level of communication and interoperable data to support its fullest capabilities. The NBIMS Initiative is the response to this need.

Discussion

The NBIMS Initiative as an activity supports buildingSMART. NBIMS identifies business driven information requirements and business processes that can be automated in BIM technologies promoting continuity and information re-use throughout the entire facility lifecycle.

All major industry stakeholders support these changes, and the National Institute of Building Sciences (NIBS) represents the neutral environment where all stakeholders can come together to develop this industry level value-chain.

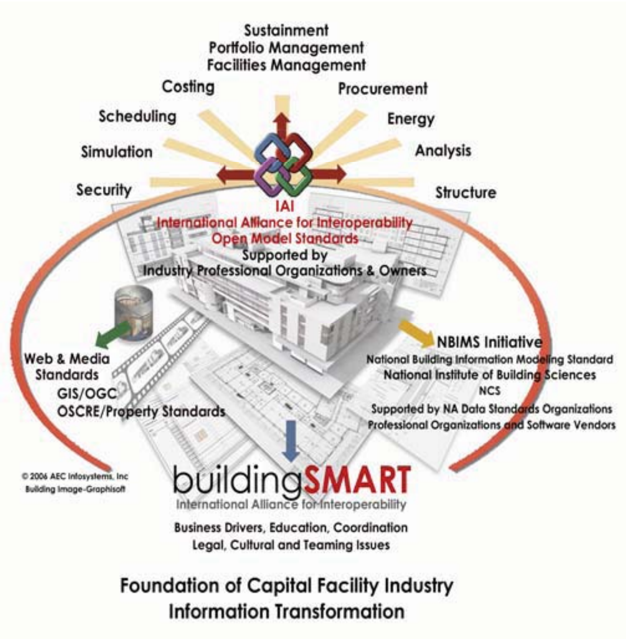

Figure 2.1-2 buildingSMART® Construct
(Courtesy of AEC Infosystems and Graphisoft)

This activity is similar to the changes in aviation, automotive, communication, and shipping that have moved the productivity of these industries forward, even as construction has lost productivity. Therefore, these changes have a high probability of assuring an increase in productivity in construction and providing the ability to make better decisions concerning infrastructure planning, design, construction, and management.

From a technology and process perspective, Building Information Modeling (BIM) plays a pivotal role in buildingSMART success.

BIM Scope

BIM overall scope is broad and can be described within the relationships of three categorizations of BIM. The first and most recognizable is **BIM as a product** or intelligent digital representation of data about a capital facility. BIM authoring tools[8] are used to create and aggregate information which, before BIM, had been developed as separate tasks with non-machine interpretable information in a paper-centric process.

The second is **BIM as a collaborative process** which covers business drivers, automated process capabilities, and open information standards use for information sustainability and fidelity.

Finally **BIM as a facility lifecycle management tool** of well understood information exchanges, workflows, and procedures which teams use as a repeatable, verifiable, transparent, and sustainable information based environment used throughout the building lifecycle.

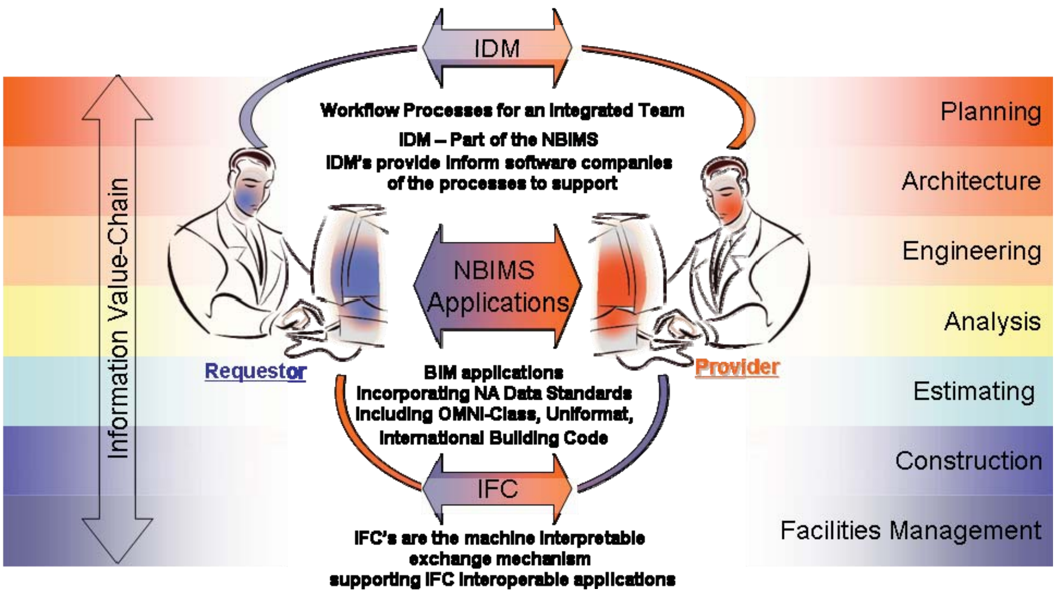

Figure 2.1-3 NBIM Standard Definition (Product, Process Supporting Collaboration)

[8] BIM authoring tools: Tools that generate original information and digital representations or intelligent virtual models.

A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward.

A basic premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a facility to insert, extract, update, or modify information in the BIM to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability. The National BIM Standard promotes the business requirement that this model be interoperable based on open standards.

BIM Implementation Requirement

Standardizing the meaning of shared data elements has been more challenging in our fragmented process than creating the actual physical structures the data supports.

BIM product, process, and collaborative environment require the industry to come together to agree on definitions and rules for commonly used terms and calculations, such as space, dimensions, product data classifications, and object element definitions. Much of this work has been completed by the IAI and is supported by the Industry Foundation Classes (IFC or ifc). Many software applications support IFC today, and it is projected that their number will double in the next three years.

Additional work supporting the process and collaborative environment are the Industry Foundation Dictionary (IFD) and Information Delivery Manuals (IDM). NBIMS represents the North American part of these activities.

North American BIM Localization

While the IAI and IFC as a mechanism to share data is internationally recognized, the data shared must be localized to the specific building environment. For example, in North America we use CSI *OmniClass*™ and *UniFormat*™ classifications, while another country would use its equivalent classification scheme. The IFC allow the transfer of this information as a machine interpretable exercise.

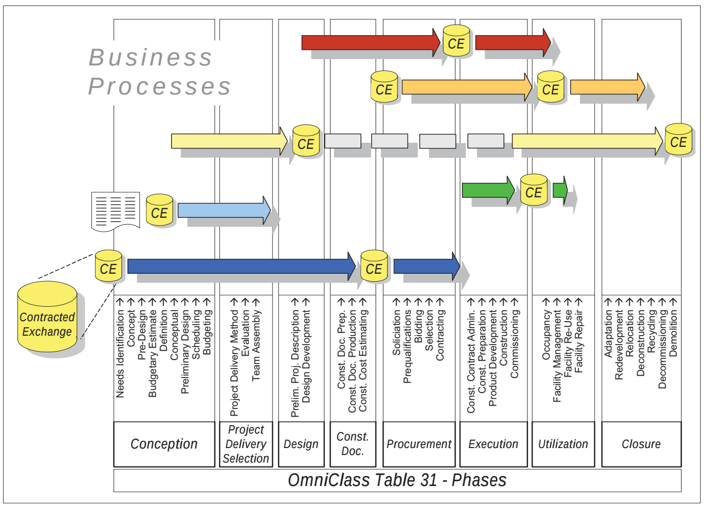

Figure 2.1-4 Business Processes

Part of the NBIMS work on IDM, Model Views, and Information Exchanges supports the North American implementation needs of this international effort. The NBIMS Initiative aligns with the international effort since construction is a global enterprise.

The NBIMS Initiative defines these information needs between and within a collaborative BIM environment and identifies the North American Information Standard or body responsible for this information. Product Object Manufacturers are supporting NBIMS so that BIM objects can be robust enough to support the BIM process.

Outcome of NBIMS Initiative

The outcome of NBIMS activity will be a publicly available, open Enterprise Data Warehouse of the shared data, rules, definitions, metadata, information exchanges, and IDM useful to all stakeholders in the capital facilities industry and IFC based software developers. This Enterprise Data Warehouse available on the NIBS website will support the rapid implementation of BIM by reducing the risk and overhead of process change. It will provide a transparent method of work. The software developers in the NBIMS Initiative will be able to implement consistent, open, and transparent workflows based upon business needs, information re-use, and facility lifecycle needs.

Areas of Immediate Activity

Starting in 2006, the NBIMS Committee first looked at what the industry as a whole needed and what activities were already underway in some form. The Committee also looked at what information exchanges could be better supported in existing IFC software if the industry defined its information exchange requirements.

While these areas of development may have industry or government participation or sponsorship, these activities include public sector committees and input. These activities are not accepted as an NBIMS until it goes through a consensus process and any harmonization activities necessary to support the wider standard use. Some areas where work is in development are listed below.

- *Space*. Candidate is the work by GSA to be harmonized with OSCRE and BOMA definitions for consensus on Space rules and definitions.
- *Construction Operations Building Information Exchange* (*COBIE)*. Work sponsored by NASA on the information exchange between construction and owner for facilities management.
- *Early Design*. IAI development team description of information needs for IFC deployment.
- *Portfolio Management.* IAI development team description of information needs for IFC deployment.
- *Energy Analysis*. Definition of BIM information exchange for Energy Analysis done by Lawrence Berkley Labs, DOE, and software vendors (proprietary xml).
- *Steel.* Harmonization of CIS/2 with IFC done by Georgia Institute of Technology, NIST, and related software vendors.
- *LEED*. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ of the U.S. Green Building Council.
- *IFDLibrary™*. Construction Specifications Institute.
- *Construction Data Dictionary*. Construction Specifications Institute.
- *Automated Code Checking.* International Building Code.
- *Structural Concrete Harmonization*. Funded by the Charles Pankow Foundation.
- *Wall Standards Exchanges.* And other coordination view definitions.
- *Product Manufacturer Exchanges.* BIM World, Object Development Corporation.
- *Costing View.* BLIS, update to costing model view definition.
- *Planning.* U.S. Coast Guard Shore Facility Capital Asset Management, defining the information sets for decision support.
- *BIM/GIS integration.* OGC.
- *Asset lifecycle*. Information needs for lifecycle asset management.

- Other international activities are reviewed for use by NBIMS. These include: MEP, Environmental Impact, and Model Checking.

The Information Exchange and IDM activity is both a bottom-up activity, using the National Information Exchange Template, and top-down, coming from industry committees. Each activity supports the other.

Stakeholders in BIM Use and Information

- *Owners*. High level summary information about their facilities.
- *Planners*. Existing information about physical site(s) and corporate program needs.
- *Realtors*. Information about a site or facility to support purchase or sale.
- *Appraisers*. Information about the facility to support valuation.
- *Mortgage Bankers.* Information about demographics, corporations, and viability.
- *Designers*. Planning and site information.
- *Engineers*. Electronic model from which to import into design and analysis software.
- *Cost and Quantity Estimators*. Electronic model to obtain accurate quantities.
- *Specifiers*. Intelligent objects from which to specify and link to later phases.
- *Attorneys and Contracts*. More accurate legal descriptions to defend or on which to base litigation.
- *Construction Contractors*. Intelligent objects for bidding and ordering and a place to store gained information.
- *Sub-Contractors*. Clearer communication and same support for contractors.
- *Fabricators*. Can use intelligent model for numerical controls for fabrication.
- *Code Officials*. Code checking software can process model faster and more accurately.
- *Facility Managers*. Provides product, warranty, and maintenance information.
- *Maintenance and Sustainment*. Easily identify products for repair parts or replacement.
- *Renovation and Restoration*. Minimizes unforeseen conditions and the resulting cost.
- *Disposal and Recycling*. Better knowledge of what is recyclable.
- *Scoping, Testing, and Simulation*. Electronically build facility and eliminate conflicts.
- *Safety and Occupational Health*. Knowledge of what materials are in use and MSDS.
- *Environmental and NEPA*. Improved information for environmental impact analysis.
- *Plant Operations*. 3D visualization of processes.
- *Energy and LEED*. Optimized energy analysis more easily accomplished allows for more review of alternatives, such as impact of building rotation or relocation on site.
- *Space and Security*. Intelligent objects in 3D provide better understanding of vulnerabilities.
- *Network Managers*. 3D physical network plan is invaluable for troubleshooting.
- *CIOs*. Basis for better business decisions and information about existing infrastructure.
- *Risk Management*. Better understanding of potential risks and how to avoid or minimize.
- *Occupant Support*. Visualization of facility for wayfinding (building users often cannot read floor plans).
- *First Responders*. Minimize loss of life and property with timely and accurate information.

Summary

The overall scope of BIM is yet to be defined. Today we know that BIM is changing the process, product, and delivery requirements of the capital facilities industry. BIM is a use of various technologies that maximize computing capabilities to aggregate, analyze, and automate tasks previously done in a labor intensive manner that tends to be more risk prone. These 2D based processes have led to a societal loss approaching $15.8 billion annually due to poor data interoperability.

As more applications and web services are developed for the capital facilities industry there will be a greater need to incorporate referenced data into the systems that require this data to manage intelligent operations for analysis and decision support. The NBIMS Initiative has the role of developing the structure and workflow of this data so that it can be incorporated into software products used by the industry.

Next Steps

Broad action requires broad participation and the NBIMS Initiative will continue to gain support from the industry it is mandated to serve.

Upon industry review of the NBIMS Version 1 - Part 1 the NBIMS Committee and Task Teams will continue their work, while new committees and workgroups will form to take on future tasks.

The international buildingSMART® alliance represents the construction industry’s movement to adopt new technologies, industry enterprise workflows, and emerging communication capabilities in its method of work. This encompasses all aspects of the building lifecycle including procurement of work and metrics to evaluate change.

Chapter 2.2 Introduction to the National BIM Standard Committee

Introduction

The genesis of the NBIMS Committee, the vision and mission of the NBIMS Initiative, and plans for the NBIM Standard and development activities are explained in this chapter. In addition, this chapter describes how NBIMS is organized, how it will function, and plans for relationships to other U.S. and international initiatives, standards development organizations, and established standards development methodologies, and the scope and nature of the NBIM Standard.

Background

National BIM Standard (NBIMS) Committee is a committee of the National Institute of Building Sciences (NIBS) Facility Information Council (FIC). The vision for NBIMS is "an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format useable throughout its lifecycle by all."[9] The organization, philosophies, policies, plans, and working methods comprise the NBIMS Initiative and the products of the Committee will be the National BIM Standard (NBIM Standard or NBIMS), which includes classifications, guides, practice standards, specifications, and consensus standards.

The National Institute of Building Sciences (NIBS) was authorized by the U.S. Congress in recognition of the need for an organization that could serve as an interface between government and the private sector. NIBS is a non-profit, non-governmental organization bringing together representatives of government, the professions, industry, labor, and consumer interests. Within NIBS, the Facility Information Council (FIC) mission, since 1992, has been "to improve the performance of facilities over their full lifecycle by fostering a common, standard, and integrated lifecycle information model for the Architecture/Engineering/Construction and Facilities Management industry."[10] The NBIMS Initiative and NBIM Standard will promote and enable the free flow of graphic and non-graphic information among all parties to the process of creating and sustaining the built environment and will work to coordinate U.S. efforts with related activities taking place internationally.

A charter for the NBIMS Committee was developed in late 2005. Signatories to the Charter agree to participate in the Committee to produce the United States National Building Information Model Standard as a full partner in this development. The Charter provides full original copyright protections for individual contributions; however, members agree that the work of the Committee shall be shared freely with the other members of the team and the work of the Committee, as a collection, shall be copyrighted by NIBS. The copyright is not for gain but for protection of the development teams' efforts from uncontrolled external use.

Wherever possible, international standards development processes and products, especially the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), and International Standards Organization (ISO) efforts, will be recognized and incorporated so that NBIMS processes and products can be recognized as part of a unified international solution. Industry organizations working on open standards, such as the

[9] Charter for the National Building Information Model (BIM) Standard, December 15, 2005, pg.1. See http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Charter.pdf.
[10] *Ibid.*

International Alliance for Interoperability (IAI), the Open Geospatial Consortium (OGC), and the Open Standards Consortium for Real Estate (OSCRE), have signed the Charter in acknowledgement of the shared interests and commitment to creation and dissemination of open, integrated, and internationally recognized standards. Nomenclature specific to North American business practices will be used in the U.S. NBIMS Initiative. Consultation with organizations in other countries has indicated that the U.S.-developed NBIM Standard, once it is localized, will be useful to other countries as well. Continued internationalization is considered essential to growth of the U.S. and international building construction activities.

Relevance to Users

The NBIMS Initiative has many constituencies representing widely divergent professions, functions, and interests relative to the NBIM Standard. These constituencies can be summarized as follows.

- **Building Information Users** and **Building Information Modelers** will both determine the information that is required to support business needs and employ that information to carry out business functions.
- **Standards Providers** create and maintain standards for building information and building information data processing.
- **Tool Makers** develop and implement software, integrate systems, and provide technology and data processing services.

The NBIMS Committee recognizes that it is vitally important that all of these constituencies recognize, understand, and ratify the value of both the NBIMS Initiative and the NBIM Standard. This is the intent with which this chapter describes the makeup and functioning of the NBIMS Committee, the desired relationship of the NBIMS Committee and NBIM Standard to other organizations and/or activities, including both building-industry and established standards-development groups, and the nature and scope of planned standards.

Relevance to the NBIMS Initiative

This chapter is, in essence, a guide for the NBIMS Initiative and its product, the NBIM Standard. It will be used to inform and increase the awareness of the NBIMS Committee, the NBIMS Initiative, and the NBIM Standard for committee members, the NBIMS community of interested parties, and those wishing to learn more about the Committee and its planned work.

NBIMS Vision, Mission, Scope, Goals, and Objectives

NBIMS is to accelerate the implementation of an industry wide, well-understood Building Information Modeling (BIM) Standard supporting the real property industry and reversing the productivity decline in the AEC industry.

> **Vision:** An improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format useable throughout its lifecycle by all.
>
> **Mission:** Improve the performance of facilities over their full lifecycle by fostering a common, standard, and integrated lifecycle information model for the Architect, Engineering, and Construction (AEC) and Facility Management (FM) industry. This information model will allow for the free flow of graphic and non-graphic information

among all parties to the process of creating and sustaining the built environment and will work to coordinate U.S. efforts with related activities taking place internationally.

NBIMS Goals, Objectives, Strategies Version 1.0		
Societal Drivers for Infrastructure & Environment **Overarching Principles** Sustainability, Security and Global Competitiveness **Overarching Goal** *Accelerate industry productivity with an industry wide, well understood and open Building Information Model (BIM) Standard.*		
2007- 2008 Goals	**Objectives**	**Strategies**
1. Overview and Methodology		
Goal 1. *Seek industry wide agreement for the mission, vision, guiding principles and set of goals, objectives and strategies for developing a National Building Information Model Standard (NBIMS) for the Capital Facilities Lifecycle.* (This includes all the stakeholders including Real Estate, AEC, Facility Operations and Maintenance, Owner, Insurance as well as other stakeholders requiring access to Capital Facility Lifecycle information. Example: First Responders, Financial, etc.)	1.1 Identify the stakeholders needing and affected by the NBIMS Initiative and gain their support and participation for its activities.	1.1.1 Create and distribute the NBIMS Charter and Version 1 of the NBIMS Overview and Methodologies for industry review and participation.
		1.1.2 Provide clear information on the opportunities for industry participation in NBIMS creation
		1.1.3 Work with all industry professional organizations and groups to raise awareness and support of the NBIMS value proposition at the Capital Facilities Lifecycle level.
Guiding Principle 1: *As providers and stewards of our nation's public and private capital facility assets, we are obligated to work together in the most sustainable (open & collaborative), cost effective (quality, time, resources) and efficient manner (interoperable information value-chain) possible to meet society's needs.*	1.2 Develop the broad coalition of stakeholders required to define this industry "standard of standards".	1.2.1 Develop relationships with industry knowledge groups and bring this knowledge to the NBIMS effort.
	1.3 Provide a forum and opportunity for discussions and working groups at the facility lifecycle level and promote a neutral environment for the creation of the NBIMS.	1.3.1 Reach out to groups that might be sub-optimizing BIM deployment within a specific or too narrow focus and provide a broader perspective whenever possible.
	1.4 Promote NBIMS vision and mission via a participatory communications plan and program of activities involving all stakeholders.	1.4.1 Utilize the NIBS website, WBDG industry journals, websites and industry forums to communicate and inform stakeholders of NBIMS and its progress.
	1.5 Create a publicly available warehouse to make available the collected IDM Information Exchanges, data requirements, model views, process and business knowledge that will support a well understood and uniform framework for BIM deployment.	1.5.1 Utilize the NIBS website, WBDG to provide industry access to, and participation in NBIMS. Provide web content in the most cost effective and efficient manner for industry use.
2. NBIMS Creation		
Goal 2. *Develop an open and shared National Building Information Model Standard that will reduce the overhead and risk to stakeholders requiring BIM implementation to improve mission and business execution.*	2.1 Develop clear workflows with open and standardized data and content requirements to eliminate the waste inherent in proprietary and closed systems, unclear workflows and non-standardized data within and between industry information silos.	2.1.1 As a business process enabler NBIMS shall identify open and efficient information workflows and the relevant data standards integrating stakeholders' requirements.
		2.1.2 Provide educational information on BIM implementation and the importance/use of open standards in any BIM based process.
	2.2 Identify immediate societal and user business-case driven processes needed for NBIMS and act on these priorities.	2.2.1 Use the societal needs and industry identified challenges, and current work in progress as a departure point for NBIMS development.

Guiding Principle 2: *The Initiative should provide and promote a neutral forum for all stakeholders to come together and formulate reference models, best practice and accompanying open information standards and workflows that contribute to the collective for modernizing the way we build and manage capital assets.*	2.3 Rely on NA and international "best practices" and standards of allied organizations so as not to re-invent strategies and tools for NBIMS activities.	2.3.1 Work with all industry and international standards organizations through NIBS, IAI/BuildingSMART, CSI, OGC, ASTM, OSCRE and others to support IDM activity. Share information, process, and product when applicable.
	2.3 Define the current and future forward scope of BIM as a product, process, and collaborative work environment.	2.3.2 Utilize the Information Delivery Manual Process (IDM) (IAI) to develop the information exchanges and well defined workflows to facilitate the discovery of capital facility information and its purpose during the building lifecycle.
3. Availability and Usefulness of Information in NBIMS		
Goal 3. Facilitate discovery and requirements for capital facility information within the facility lifecycle.	3.1 Seek industry consensus on information exchange content.	3.1.1 Implement an industry consensus process for Information Exchanges using IAI, ISO and other standards body's procedures.
Guiding Principle 3: *It should be easy to discover which information is available, to evaluate its fitness for purpose and to know what conditions apply for its use.*	3.2 Work with testing bodies to develop QA procedures.	3.2.1. Define testing, software reference, and the consensus processes that support interoperable software conformance.
	3.3 Provide a structure for ongoing NBIMS development that incorporates industry changes and new requirements.	3.3.1 Make as much of the NBIMS development and consensus activity and process Web/IT enabled.
4. Interoperability		
Goal 4. Develop and distribute NBIM knowledge that helps disciplines share information that is machine interpretable.	4.1 Address and participate in the harmonization activities between various standards bodies as needed to support BIM implementation.	4.1.1 Work with all industry and international standards organizations through NIBS, IAI/BuildingSMART, CSI, OGC, ASTM, OSCRE, BOMA and others to support data standard harmonization activities.
		4.1.2 Utilize and adapt existing information standards to support BIM processes.
Guiding Principle 4: *It must be possible to combine seamlessly building and site data from different sources and share it between many users and applications.*	4.2 Develop software schema to accelerate rapid software implementation of NBIMS exchanges in software.	4.2.1 Make the processes and content generated from the NBIMS activity available to all solution providers to support interoperable software conformance using open and interoperable standards.
5. Re-engineered Work Process		
Goal 5. Define a minimum BIM for specific purposes.	5.1 Utilize IDM and Model Views supporting facility lifecycle needs and define a minimum BIM for industry uses.	5.1.1 Provide Model Views supporting more universal BIM use cases.
		5.1.2 Develop a searchable website to allow users to review NBIMS for their specific use case.
Guiding Principle 5: *Infrastructure data content should be collected once is interoperable and re-usable, and maintained at the level where business execution and asset management can be done most effectively.*	5.1.1 Develop a BIM maturity model matrix for self-assessment of BIM capability.	5.1.2 Develop Web-enable tools to help the industry assess its BIMS capability or requirements.
6. Sustainment		
Goal 6. Provide for Information Assurance across the life cycle.	6.1 BIM – either in the form of models or in the form of elements of models will need to be associated with metadata that provides information about who created the information, how they created the information, why and when and the quality of the information that is offered.	6.1.1 Information assurance capabilities for software and systems will need to be developed at the conceptual and meta models levels so that software vendors may tie capabilities to requirements by user organizations.
	6.2 People that wish to use that information do so with the knowledge that the integrity of the source information is always protected.	6.2.1 The Federal Information Security Management Act is a foundation of Information Assurance approaches across the capital facilities industry.

Guiding Principle 6: *Building data needed for good public policy and corporate governance should be available on conditions that protect sensitive information, but otherwise do not restrict its extensive use.*	6.3 Open software standards for security are the preferred approach for protecting the integrity of sharable information.	6.3.1 Review OGC's GeoDRM process and other industry solutions.

Discussion: Makeup of NBIMS

"The National BIM Standard Committee shall be under the organizational structure of the National Institute for Building Sciences (NIBS), managed by the Facility Information Council (FIC). The National BIM Standard Committee shall have a Chair, Vice-Chair, Secretary and Treasurer elected by the National BIM Standard committee-at-large on an annual basis. There shall be an Executive Committee made up of the Chair, Vice-Chair, NIBS staff member supporting the committee, and representatives of the committee-at-large. The Executive Committee is established by the Chair and its purpose shall be the administration of the business affairs of the National BIM Standard Committee. Task groups may be established for specific purposes and durations as determined by the Executive Committee."[11]

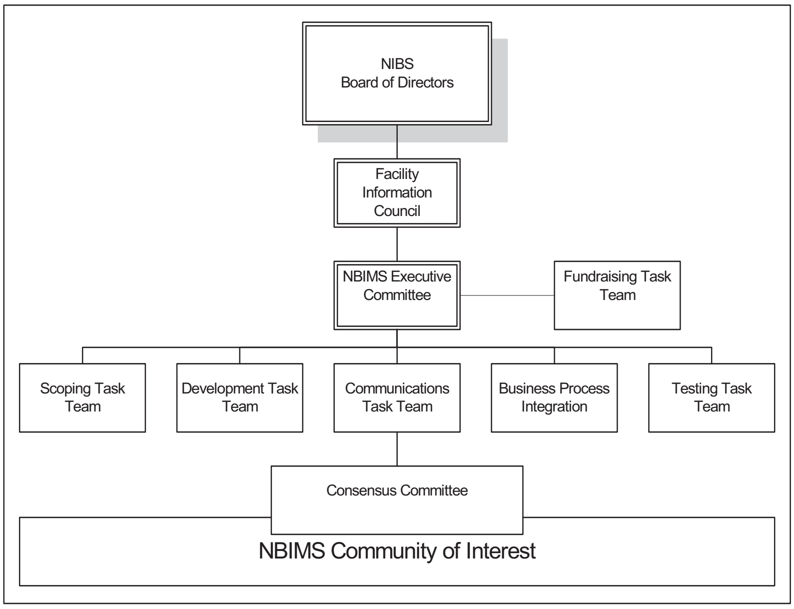

Figure 2.2-1 NBIMS Organization Chart

Discussion: Relationships to Capital Facilities Industry Organizations and Activities

The NBIMS Initiative supports and, in a significant way, enables the movement within the capital facilities industry to adopt new technologies, industry enterprise workflows, and emerging communication capabilities in its method of work. Although the NBIM Standard is focused on open and interoperable information exchanges, the NBIMS Initiative contributes to all aspects of the facility lifecycle including procurement of work and metrics to evaluate change. The NBIMS Committee is chartered to work to improve the exchange of information regarding facilities over their full lifecycle by fostering a common, standard, and integrated lifecycle information model for all organizations in the capital facilities industry.

The current Charter signatories represent most, if not all, of the identified facility lifecycle constituencies as well as most of the professional associations, consortia, and technical and

[11] *Ibid*, pg. 3.

associated services vendors who support them. (For a list of signatories, see the NBIMS website at http://www.facilityinformationcouncil.org/bim/index.php.) The Committee has significant representation from government owners, private and government practitioners, vendors, specialist professionals, private owners, AEC practitioners, property and facility managers, and real property professionals. As illustrated in Figure 2.2-1 and provided for in the Charter, the Committee is organized into task teams. Each task team is composed of committee members who volunteer to participate based on their interest and experience. Task team charges are available on the NBIMS website.

The NBIMS Committee will seek to create formal relationships with many organizations, some of which have already signed the NBIMS Charter and others who have yet to be contacted. To date, support for Committee activities has primarily been provided through in-kind contributions of time and other resources, except for direct financial support from NIBS and a grant from the Charles Pankow Foundation related to pre-cast concrete design.

NBIMS membership is free. The Committee actively invites organizations who recognize the value, both to the industry as a whole and to their organizations directly, to provide both in-kind contributions and sustaining funding to support specific projects and administrative costs.

The National BIM Standard will maintain a relationship with the buildingSMART alliance™ in order to ensure coordination of our efforts with the rest of the construction industry. The NBIMS Committee will be a key project identified by the Alliance.

Discussion: 'Information Users' and 'Information Modelers'

The envisioned NBIM Standard implementation model incorporates the notion that much of the interaction between the Standard and end-users will occur transparently as owners and practitioners simply use applications that support the Standard to carry out daily operations and projects. By using applications that support the Standard and by contracting for Standard-based exchanges, end users become 'Information Modelers' building the facility information backbone for their organizations and connecting the organizational backbone to external information sources such as projects and vendors.

The next level of interaction between practitioners, software developers, and the Standard is envisioned to be via an Exchange Database accessible via the web through which proposed and existing exchange definitions will be available for research and application uses. Front-line information users such as owners and practitioners will play a pivotal role as they identify needed exchange definitions, research the availability of Standard definitions, and then specify use of the Standard in contracted exchanges and internal operations. Where existing Standard definitions are not yet available or need improvement, a simple form will be available to define the need and initiate the development process. In this way, end users may be thought of as Information Modelers. (Section 3 - *Information Exchange Concepts* and Section 5 - *NBIM Standard Development Process* discuss these concepts in greater detail.)

Discussion: Relationship of NBIMS to 'Tool Makers'

The NBIMS Committee does not intend to develop or implement software, integrate systems, or provide technology and data processing services. However, the NBIMS Initiative will support those who do through concept development, outreach, facilitation, and education, and by providing the NBIM Standard. The relationship between NBIMS and Tool Makers is seen as synergistic. Section 4 provides additional detail about planned information exchange contents and Section 5 provides additional detail about development and deployment of the Standard. In summary, the NBIM Standard will establish methods by which open and interoperable building information exchanges should be developed and described, the specification of exchange data sets consistent with and supportive of typical business processes, and specifications for incorporating the exchange data sets into software applications and integration solutions to be developed by others.

Discussion: NBIM Standard Workflow

Figure 2.2-2 illustrates the elements of the NBIM Standard Development and Use Process and provides a high level view of the workflow associated with producing Standard products. In general, Figure 2.2-2 illustrates the relationship between the main tasks of researching existing specifications and proposing new specifications, the specification development process, publishing NBIM Standard specifications, facilitating compliance certification, and deployment/industry adoption functions such as working with software developers, professional associations, educational institutions, and other organizations with which NBIMS will coordinate standard development and facilitate best practices for BIM use. Section 5 introduces individual elements in this diagram and chapters that contain more specific details and discussions.

Discussion: NBIM Standard Products

Section 5 describes planned NBIM Standard references and products in more detail and is summarized as follows.

- **Classifications.** Process elements and actors, content types and values, systems or services classified into groups based on similar characteristics such as origin, composition, or properties. An early example is *OmniClass*™ which is included in the Appendix as a reference standard.
- **Guides.** "A compendium of information or series of options that does not recommend a specific course of action."[12] Much of Version 1 - Part 1 of the Standard is a guide.
- **Specifications.** "An explicit set of requirements to be satisfied by a material, product, system, or service."[13] Version 1 - Part 2 will contain standard specifications.
- **Consensus Standards.** NBIM Standard Specifications will be developed, reviewed, and adopted through a series of consensus-based processes. Section 5 provides more information; however, the consensus voting process that has been successfully used to create the National CAD Standard is seen as a viable model for part of the NBIM Standard Development and Use Process as well.

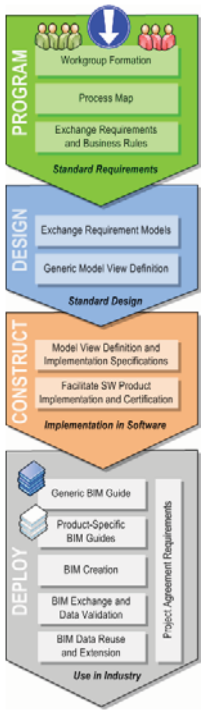

Figure 2.2-2 NBIM Standard Development and Use Process Overview

As noted in the definitions, it is important to understand that *NBIMS Version 1 - Part 1: Overview, Principles, and Methodologies* is a guide standard. This guide is an important part of the NBIM Standard and is being released to describe NBIMS Committee intentions, share details of the NBIMS Initiative, and invite public response. Readers seeking specifications should note that Part 2 is planned to be the first volume containing material that has been reviewed and adopted through a formal consensus-based process.

[12] *Form and Style for ASTM Standards,* ASTM International, October 2006, pg. vii.
[13] *Ibid.*

Chapter 2.3 Future Versions

Introduction

Primarily this section of *NBIMS Version 1 - Part 1* identifies what needs to be accomplished in order to issue Part 2. Also discussed are the process and timing that will be followed to achieve that goal and to issue future versions of the Standard. Most of this chapter is a compilation of information found and discussed in other chapters.

Background

The *NBIMS Version 1 - Part 1: Overview, Principles, and Methodologies* is intended to first introduce the reader to a comprehensive Building Information Model (BIM) and all the possibilities it will bring to the capital facilities industry. The United States capital facilities industry is a long way from fully realizing all the opportunities of BIM and this chapter is intended to provide the roadmap that will be required for attaining the goals identified in the whole of this document. Figure 2.3-2 identifies major activities that are enabled by the Standard. The information presented below will discuss the tasks needed to achieve each of these high-level capabilities.

Relevance to Users

BIM is in use today and is flourishing, but it carries many of the problems of the past. These problems are primarily related to lack of sharing of information between lifecycle phases, since many practitioners are still only concerned with their phase of the project and fail to recognize their stewardship role in the overall lifecycle of the facility. In order for a BIM to be fully implemented and its potential fully realized, it must allow for the flow of information from one phase to the next, from inception onward. This can effectively only be achieved through open standards. Today, BIM is being defined by the capabilities that a specific vendor can provide and not by the requirements that design and construction professionals or, more importantly, the operators, sustainers, and owners of a facility need. Open standards are the only economical way all subject matter vendors can participate. A time when one vendor will be able to provide all the tools necessary for the capital facilities industry is not foreseen and is quite unrealistic.

The reader is encouraged to read the complete NBIMS document then return to this chapter, since it identifies the roadmap to achieve full realization of the opportunities BIM provides. It provides the timeline when users may expect certain capabilities to reach maturity.

There are many concerns on which the industry must come to a decision; many of these may require the formation of consortiums to accomplish the task. Funding will also be required, and finding resources interested in ensuring those capabilities exist may be a challenge. While a certain end state is desired, ensuring that all the pieces necessary to accomplish that end state may not have the level of interest needed to fund them. However, if the foundation capabilities are not in place and are not strong, then the final product will likely be inadequate and not attain the expected potential.

Relevance to the National BIM Standard

Accomplishing all the tasks identified in this section will be daunting and priorities are likely to change over time. The industry will not be able to boil the ocean; therefore, the process must be broken into small doable pieces that yield usable results and benefits as quickly as possible.

With many hands working toward a common vision these tasks can be accomplished as long as the goals are clearly stated and the relationships and prerequisites well understood. It is critical that active participation of practitioners remain high so that the final products do in fact support their requirements.

Discussion

Our ultimate goal is to improve construction productivity in the United States and to keep us competitive internationally. Many of the aspects of this overarching goal will be accomplished by a large consortium of players. The area that NBIMS is focused on is the design of the theory and structure for a new way of thinking about facilities and structures as information models. The industry is not just pushing a theory but is designing the process and structures for the information: using objects such as Industry Foundation Classes (IFC or ifc), using information exchanges such as Information Delivery Manual (IDM), using model views such as Model View Definition (MVD), and dictionaries such as International Framework for Dictionaries (IFD) to create and sustain a BIM.

The table (Figure 2.3-1) shows a desired extension to one originally provided by the Bureau of Labor and Statistics in 2004, which showed a declining productivity rate for construction, while other segments of the economy were improving at record rates. The NBIMS Initiative's goal is to implement some of the same techniques, used in other industries, in the capital facilities industry to achieve the similar productivity increases and to reverse the current downward trend. The rate of improvement will depend on how seriously the industry and the country view the crisis and come forward with the necessary resources. It is hoped that construction productivity can at least begin to show improvement before the end of this decade and follow our projections into the future.

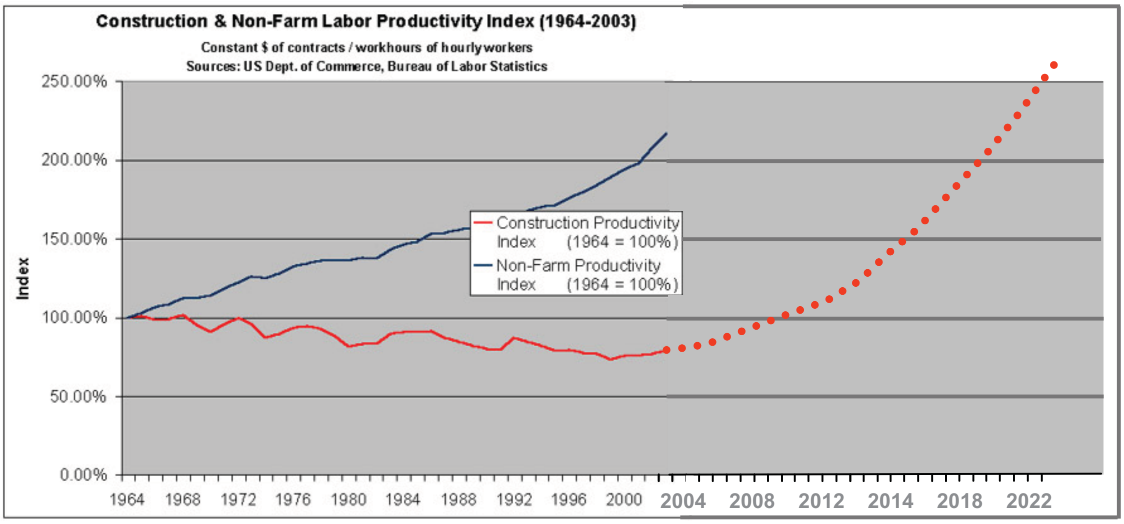

Figure 2.3-1 Construction Productivity (Historical information courtesy of Bureau of Labor Statistics; future projection courtesy of DKS Information Consulting, LLC.)

How soon the detailed roadmap presented below is accomplished will depend on how soon we lay the foundation needed to achieve it. While the NIST study[14] and others have identified the loss of billions of dollars a year from inefficient business practices, we have not been able to identify the specific sources of those dollars in order to be able to redirect them to solve the problem. The primary reasons are that the dollars are widely distributed and that most practitioners have an accepted way of doing business such that the imbedded waste and ways to improve are not readily seen. Hence, the industry makes small incremental improvements to inefficient processes instead of the substantive changes required that involve the entire capital facilities industry.

Next Steps

The next steps in the *NBIMS Version 1 - Part 1* are gleaned from each chapter and included here as a summary.

Supporting Tier 4

- Continued promotion of information relationships from the highest level, worldview, to the lowest level, object view, is required throughout the capital facilities industry to ensure that we maintain a continuum of information flow from the smallest to the largest pieces and vice versa. All parties involved must be supportive of the model at this level before there can be acceptance at more detailed levels. The NBIMS Initiative includes OSCRE, OGC, IAI, and many others who all need to become involved in order to reach industry wide consensus.

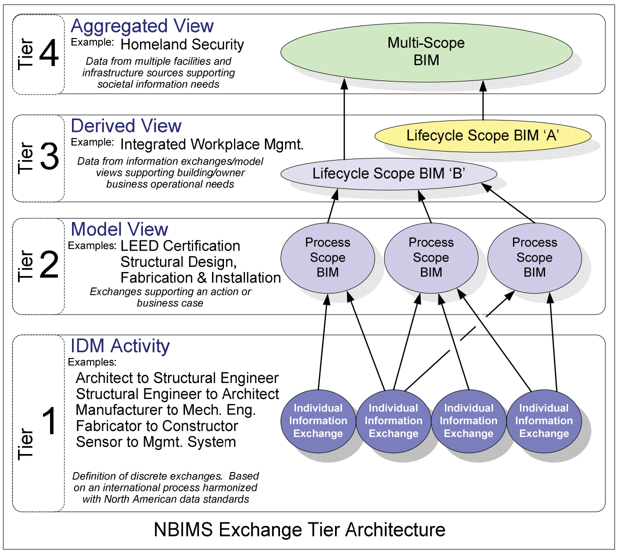

Figure 2.3-2 NBIMS Exchange Tier Architecture
(Courtesy D. Davis, AEC Infosystems)
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

- A key element of success will be implementing Information Assurance procedures so those who store information in the model and those who retrieve it are assured of the accuracy and security of the information. While commonplace in the banking and personnel industries, it is still relatively new concept in the capital facilities industry. Work must be done to ensure industry wide implementation so that trust can be ensured.

Supporting Tier 3

- Research is required to evaluate the current level of capability of BIMs in use in the industry today and to continue evaluating the rankings proposed for the capability maturity model remains valid. There was concern that the bar may have been set too high for most current

[14] U.S. Department of Commerce, National Institute for Standards and Technology, "Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry." (NIST GCR 04-867, August 2004 at http://www.bfrl.nist.gov/oae/publications/gcrs/04867.pdf.

BIMs to be "certified" however, this proved not to be true. The chapter *BIM Minimum* will be revised as required over time to reflect the status of the industry.

- The *Capability Maturity Model* chapter has been coordinated with the *BIM Minimum* chapter to ensure that the certified level is in fact what is being described in that section. Many so-called BIMs in existence do not meet the NBIMS definition of a BIM, since they are really only intelligent drawings, visualization tools, or production aides. The current Capability Maturity Model gives the capital facilities industry a spectrum of tangible capabilities by which to determine the current maturity of a BIM and to provide higher levels on the spectrum as developmental goals. Future work will be done to improve the Maturity Model so that it mirrors the burgeoning BIM community.
- The governing body of NBIMS will need to certify BIMs and testing processes in order to build a database of best practices and to isolate areas of opportunity for improvements in the BIM community, as well as to provide a means and motivation for users to create reliable information that is stored in open and interoperable formats.
- The industry will need to implement Information Assurance procedures at all levels of BIM.

Supporting Tier 2

- Identify the maturity baseline in the industry as it stands today, determine the typical level of BIM in use, and validate that it meets the minimum identified in this document
- Continue developing a vision for more mature BIMs and develop a roadmap for raising the minimum BIM bar. Identify deadlines for achieving higher level and more mature implementation over the next 20 or more years.
- Implement Information Assurance procedures to support Tier 2.
- Identify existing BIM projects that qualify as candidates for inclusion in the standard (together with Scoping and Requirements Development).
- Evaluate candidates and create a plan for developing qualified candidates into a standard (together with Scoping and Requirements Development).
- Review and comment on IDM Process Maps (developed by Requirements Development).
- Review and comment on IDM Exchange Requirements (developed by Requirements Development).
- Facilitate review and feedback by software developers.
- Plan and manage a pilot implementation/use program (together with Testing).
- Incorporate lessons learned from implementations/use to update Process Map, ERs, and MVD (together with Requirements Development and Testing).
- Plan and manage the consensus process (together with Executive Committee).

Supporting Tier 1

- The IFC development work is currently being done overseas. While there are links to chapters developing IFC worldwide, there is currently very little U.S. involvement. U.S. involvement in this effort must increase in order to develop IFC that will fully meet our future needs and to remain competitive.
- Software vendors continue to support open standard IFC in their products at various speeds. Each product has varying levels of success at importing and exporting IFC due to their internal configuration. Continued focus on the benefits of the IFC based neutral file format used to communicate between products needs to be maintained. This is the basis for the NBIMS open standards approach.
- Implementing Information Assurance procedures:

  - Review the OGC GeoDRM Reference Model from the perspective of information exchanges in BIMs.
  - Identify and document use cases.
  - Make plans to participate in future OGC Interoperability Programs.
- The need for *UniFormat*™ harmonization, along with enhancement, and coordination of other *OmniClass*™ tables must continue.
- Work with and further support OSCRE efforts to link the planning, design, and construction activities to the owners, operators, investors, and tenants of facilities.
- Provide continuing education for practitioners in all aspects of the real property industry.
- Support software vendor implementation of the ontologies and taxonomies.

Schedule

Several related documents will be produced over time in addition to and supporting the National BIM Standard. One such document is the Generic Implementation Guidelines. Although not a direct part of NBIMS, they will be based on NBIMS and therefore updates to NBIMS should be followed by the generic implementation guidelines. The Generic Implementation Guidelines are the common elements that would be used by all. Individual companies and organizations will augment the Generic Implementation Guidelines with their own unique requirements, but these should be limited in nature as they are somewhat duplicative.

It is estimated that new versions of NBIMS will be issued on the following schedule. The Generic Implementation Guidelines should follow these documents by three to six months.

- NBIMS V1 - Part 1 December 2007
- NBIMS V1 - Part 2 July 2008
- NBIMS V2 July 2009
- NBIMS V3 July 2011
- NBIMS V4 July 2014

A new version will be issued every three to five years after NBIMS has reached some level of dynamic equilibrium.

Industry will be solicited to participate in a consensus process for the items needing standardization identified in the section below. Those products ready for submission to the consensus process will be incorporated into the next version. *NBIMS V1 - Part 2* will include items undergoing this process.

Items Needing Standardization

The following are items that have been identified throughout the document as needing to be standardized in future versions of NBIMS.

Chapter 3.1 Introduction to Exchange Concepts

- More BIM packages need to incorporate NBIMS structured content so that property sets are interoperable.

Chapter 3.2 Data Models and the Role of Interoperability

- *OmniClass* tables need to be accepted as standards for use in NBIMS.

- The NBIMS Hierarchical Relationship needs to be accepted as a standard.
- Completion of the work involved with NWI 241 to harmonize IFC and ISO 15926. It is anticipated that this will be coordinated through a FIATECH project.
- Consensus on the hierarchy from worldview to detailed facility or structure view. (July 2008 as part of NBIMS V1 - Part 2)
- Overall consensus on use of a procedural lifecycle roadmap for the capital facilities industry using one of the existing best practice examples as its basis. (NBIMS V2)
- Incorporation of the accepted procedural best practice into software. (NBIMS V3)

Chapter 3.3 Storing and Sharing Information

- Information sharing strategies and standards for manufacturers and suppliers to ensure models are sustainable.
- Defining information structures related to activities included in a model.
- Defining how models will support sensor networks for real time facility operations.
- Strategies to incorporate server and web based service oriented architectures.

Chapter 3.4 Information Assurance

- Establishment of Information Assurance procedures in new models.
- Encryption-at-rest measures shall be initiated.
- Encryption-during-transmission shall be implemented.
- Building IA procedures into the management of the entire facility lifecycle.
- Metadata concerning who entered the information into the BIM and the level of quality of that information.

Chapter 4.1 BIM Minimum

The minimum BIM is an outcome of the current level of standardization available; however, agreement needs to be reached as to what a minimum standard entails.

Chapter 4.2 Capability Maturity Model

- The Capability Maturity Model will need to be accepted by the industry, whether or not it can be standardized remains in question.
- It is anticipated that the certification levels will be adjusted annually based on some established criteria. Such criterion may be based on the winners of several BIM related awards that occur annually such as the AIA TAP BIM Awards, the FIATECH CETI Awards, and others established by the industry.

Chapter 5.1 Overview of Exchange Standard Development and Use Process

No specific items needing standardization have been identified for this section.

Chapter 5.2 Workgroup Formation and Requirements Definition

No specific items needing standardization have been identified for this section.

Chapter 5.3 User-Facing Exchange Models

- Development of ERMs for the end user processes selected for V1. (See Chapter 5.2)

- Development of one or more generic MVDs (depending on the number of high level exchange scenarios that the ERMs span, e.g. architectural design to structural design, architectural design to HVAC design).
- Review and comment on these MVDs by industry associations and vendors.

Chapter 5.4 Vendor-Facing Model Definition, Implementation, and Certification Testing

- Since this document is focused on defining the processes and tools by which a Version 1 National BIM Standard will be developed and NOT on the actual standard, there are no MVDs included in this document. MVDs will be developed in future releases of the actual standards document.
- Identify existing BIM projects that qualify as candidates for inclusion in the standard (together with Scoping and Requirements Development).
- Evaluate candidates and develop a plan for developing qualified candidates into a standard (together with Scoping and Requirements Development).
- Review and comment on IDM Process Maps (developed by Requirements Development).
- Review and comment on IDM Exchange Requirements (developed by Requirements Development).
- Develop Model View Definitions (as defined in the MVD Development Process section).
- Facilitate review and feedback by software community.
- Plan and manage a pilot implementation/use program (together with Testing).
- Incorporate lessons learned from implementations/use to update Process Map, ERs, and MVD (together with Requirements Development and Testing).
- Plan and manage the consensus process (together with Executive Committee).
- Generate and publish V1 NBIMS documents (together with all committees).

Chapter 5.5 Deployment

- Develop example Project Agreements between parties to exchanges.
- BIM creation in which certified software is used to author building information models.
- Data validation in which delivered BIM data is checked for compliance with the Project Agreement.
- BIM use in which delivered BIM data is imported and used in certified software by exchange parties to accomplish project objectives.

Chapter 5.6 Consensus-Based Approval Methods

- The consensus process must be developed and deployed.

Appendix A IAI Industry Foundation Classes (IFC or ifc)

- The IFC continue to be developed and expanded and new versions will be issued. NBIMS will continue to adopt the work of the ISO and the IAI International as the IFC are incorporated into software. IFC are at the Publicly Accepted Standard (PAS) stage (ISO/PAS 16739) and as such are not yet an ISO standard, although they are headed in that direction.

Appendix B CSI OmniClass™

- The fifteen *OmniClass* tables should be accepted as industry standards.
- Tables 11, 12, 13, 14, 22, 31, 32, 33, 34, and 41 are ready to be submitted to the consensus process in 2007.

- Table 21 is undergoing harmonization and will be ready for consensus in 2008.
- Table 23, 35, 36, and 49 will be ready at a future date.
- We will use a modification of the NIBS consensus process to incorporate these documents.

Appendix C CSI International Framework for Dictionaries (*IFDLibrary*™)

The *IFDLibrary* partners have a number of projects underway that are starting to address working with the IFD and integrating it with the IFC model to support interoperability. North America is currently pursuing the following projects.

ICC SmartCodes. The primary project CSI is pursuing as an initial test case is supporting the International Code Council (ICC) SmartCodes project. ICC has identified terms from the energy code and identified their relevant properties. This work is captured in spreadsheets to develop the input tool and access to the API. With the energy code complete, we will move on to support other parts of the International Building Code.

NBIMS. Once the toolset and procedures are established, CSI plans to make them available to support all projects looking to achieve interoperability through using the IFC model and IDM process definitions. Initial work with the development committee on the *Product Property Sets for Specifiers* project is expected to utilize the IFD to establish the requirements for specifications by project phase.

Additional Standards Efforts

- Readers of this document who represent widely used domain standards (i.e. normative standards) are encouraged to undertake NBIMS projects to help define those information exchanges needed for their specific communities. Readers of this document who utilize local standards are asked to participate in relevant NBIMS projects to identify the extent to which requirements defined by their standards may be represented in the NBIMS open-standards framework.
- NBIMS encourages software vendors to participate in the discussion of this methodology to provide an open framework for their interoperability projects. Such a framework will reduce the cost of vendor participation in NBIMS and ultimately provide critically needed end user functionality that increases the ease of use of each participating software system.

Priorities

While the above items all need to be completed in order to achieve our comprehensive BIM goals, the list below identify the most critical and specific items that can begin standardization processes or that require specific support for the consensus processes either underway or soon to be underway. They are listed in no specific order since each should be investigated in detail to understand the level of effort that will be required to prepare them for balloting and consensus. It is hoped that a significant portion of the list will be addressed in Part 2, but that is yet to be determined. This will be a significant role for the consensus committee of NBIMS.

- Develop standardized Model View Definition and conduct consensus process.
- Establish standard information assurance procedures for a new model.

- Publish V1 NBIMS Model View Standard in conformance with IAI International.
- Initiate standard encryption-at-rest measures for NBIMS based products.
- Support *OmniClass*™ table 21 harmonization efforts to prepare for consensus.
- Implement standard encryption-during-transmission measures for NBIMS based products.
- Build standard IA procedures into the management of the entire facility lifecycle.
- Develop standard audit trail and quality indicators for BIM.
- Continue support for standard IFC development.
- Conduct consensus process to standardize the information exchange template.
- Conduct consensus process for *OmniClass*™ tables 11, 12, 13, 14, 22, 31, 32, 33, 34, and 41.
- Conduct consensus process for the hierarchical relationship.
- Support completion of the work involved to harmonize IFC (ISO/PAS 16739) and ISO 15926.
- Conduct consensus on use of a procedural lifecycle roadmap for the capital facilities industry using one of the existing best practice examples as a basis.
- Incorporation of the accepted procedural best practice into software.
- Conduct consensus to standardize minimum BIM.
- Conduct consensus process to make Early Design a standard part of NBIMS.
- Conduct consensus process to make COBIE a standard part of NBIMS.

Chapter 3.1 Introduction to Exchange Concepts

Introduction

BIM is an emerging process supported by a broader toolset and data standards for the creation and use of project and building lifecycle information. The changes in the tools support new processes allowing professionals to integrate intelligent[15] and standardized data, graphics, databases, web services, and decision support methodologies changing the human-computer-interaction and richness of data supported in the process.

For users, BIM integrates or even eliminates lower value and/or traditionally separate tasks and makes higher value activities such as simulation and other forms of analysis cost effective for all scale projects. It supports information sharing and distribution across a broader spectrum of professions through information exchanges and offers the possibility of knowledge bases for buildings as part of its data aggregation.

These changes do not come out of a box; it is not a simple upgrade of software. For BIM to be **effective** in achieving the goals of integrated project information and be **efficient** as a delivery process, the industry has identified a series of objectives to support the creation of standardized information exchanges, information exchange content, and updates to data standards to support robust sharing of data within an industry information value-chain. (See Figure 3.1-1)

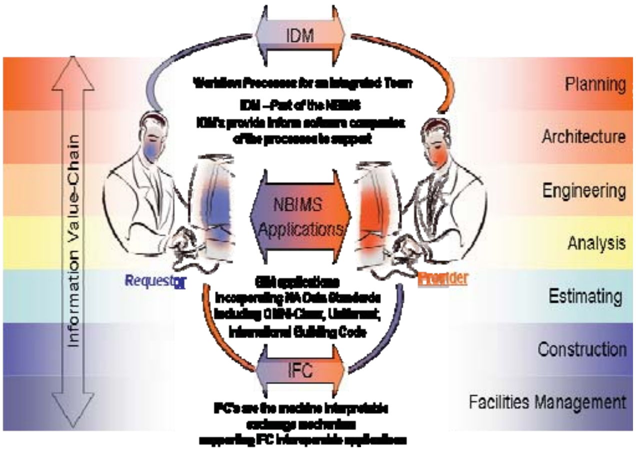

Figure 3.1-1 Relationships and Enablers of the Information Value Chain

This chapter covers information concepts and the content and delivery standardization areas needed to support industry goals and NBIMS as a North American activity aligned with international interoperability goals.

Background

CAD drafting took almost twenty years to implement and forced a standardization of machine interpretable exchanges for lines, arcs, circles, and text when it became obvious that this was necessary to share an electronic version of paper based documentation. Being on the same software product was not the solution as team members trying to share CAD files with different layer names and line weights had problems sharing files when the content did not align.

In order to share the right information at the right time and with the right stakeholders a clear set of standards for the sharing of construction documents was needed. This was the genesis for the

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[15] Intelligent data in this context defines data which is machine-interpretable (not requiring human interpretation or interaction) and exists in relationship to graphical and non-graphical data within the project data structure.

National CAD Standard. Software companies that supported this standard could share information and the ROI to users of CAD became a functional reality.

The issues experienced with CAD are compounded in BIM due to the expansion of information sharing needs and process changes. Technology has once again outstripped the process and standards in place, and NBIMS is part of an international effort to implement expanding technologies in a more cost effective way for all parties involved.

Lessons learned from CAD implementation and automation successes in similar industries suggest that well understood information exchanges aligned with decision and communication requirements throughout a project lifecycle are required to effectively implement the goals of BIM.

Best practices for BIM require more robust data standards, content requirements, and machine interpretable data exchanges to reduce the human capital needed to share information.

BIM Implementation Requirement

BIM product, process, and collaborative environments require the industry to agree on definitions and rules for commonly used terms and calculations, such as space, units of measure, product data classifications, and object element definitions. Fortunately, much of this work has been completed by the International Alliance for Interoperability (IAI) and is supported in the Industry Foundation Classes (IFC or ifc). Several applications support IFC today and the number continues to grow.[16] In addition, work supporting classification of the built environment and processes for agreeing to information exchange requirements are available in Industry Foundation Dictionary (*IFDLibrary*™) and Information Delivery Manual (IDM) methodology. The NBIMS Committee envisions adopting these as normative references for the NBIM Standard.

Relevance to Users

Building modeling, as enabler and catalyst for virtual design and engineering, integrated practice concepts, and lean construction concepts, is already demonstrating significant productivity gains over traditional processes, even with a limited amount of data integration. In the future, highly integrated data exchanges will support new opportunities for business process re-engineering with associated gains in industry productivity. Owners and practitioners are beginning to understand that much more substantial gains are possible as interoperability increases.

Relevance to the National BIM Standard

The core of the National BIM Standard is development and deployment of standardized information exchange specifications. Partnering and coordination of industry initiatives is designed to reduce the time and resources expended to accomplish the task. Similarly, adoption of and participation in international standards development activities is designed to reduce duplication and achieve a localized solution that is consistent with international solutions.

Discussion

While the IAI and IFC schema are internationally recognized, the shared data or content must be localized to the specific building context. For example, North America uses CSI *OmniClass*™ and *UniFormat*™ classifications, while in the United Kingdom similar functionality is implemented

[16] See Appendix A, IAI Industry Foundation Classes (IFC or ifc).

in *Uniclass*. The IFC schema allows the transfer of this information as machine-interpretable in either case.

As part of the NBIMS Committee work on exchange specifications, use of, for example, IDM (to discover and document requirements), MVD (to create reusable encodings for software implementation), and *IFDLibrary* (a consistent semantic dictionary) supports the North American implementation requirements for this international effort.[17] The NBIMS Committee efforts align with the international effort because the building industry is a global enterprise.

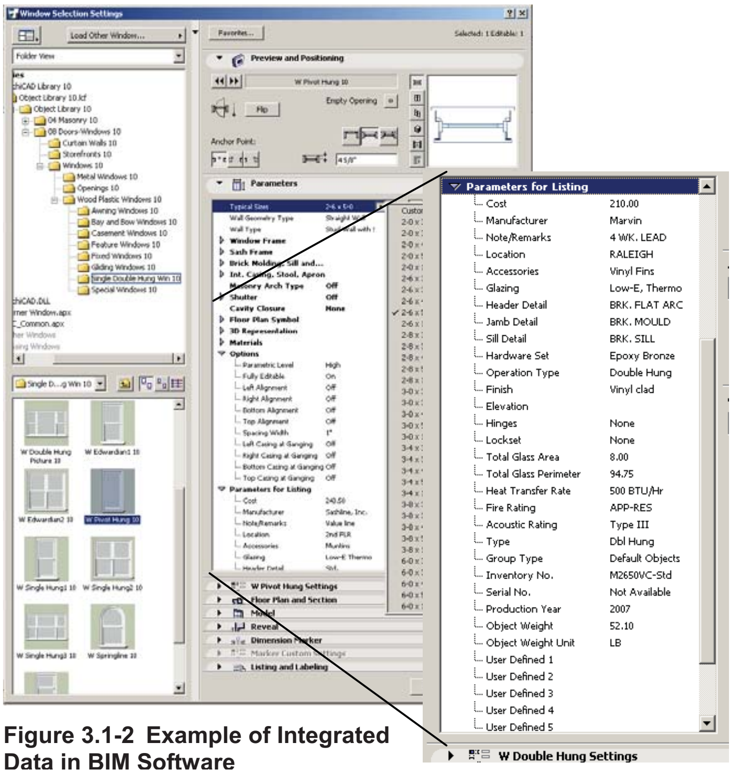

Figure 3.1-2 Example of Integrated Data in BIM Software

The overall schema for building information can be prescribed but, at a granular level and depending on the circumstances, the exchange of information about any object will change depending upon the context. For example, the superset of information for a door might include many physical and performance characteristics, such as size, material, color, glass area, handing, installation recommendations, ID tag, energy efficiency, manufacturer name, serial number, warranty, and cost, but, during early design, only the size, handing, and ID tag might be required. The NBIMS effort will define these information needs within a BIM context and identify the North American Information Standard or body responsible for this information.

Product Object Manufacturers are supporting NBIMS so that BIM objects can be robust enough to support the BIM process, their libraries broadly reusable, and the results are predictable and reliable when objects are placed into a model.

Summary

Exchanging information accurately and efficiently between project stakeholders is as essential to project success as managing the information within a stakeholder organization. Unambiguous, machine-interpretable exchanges of BIM information offer powerful benefits to the building industry, but they require several types of well-defined and broadly adopted standards to be effective. NBIM Standard specifications will be primarily concerned with the exchanges of information between parties, but content and semantic reference standards will also be included. Wherever possible, NBIMS will make use of available international reference and methodology

[17] See Section 5 for more on the tools and methodologies to be used in the NBIMS Production and Use Process.

standards. It will also participate in development of standards appropriate to North American contexts.

Chapter 3.2 Data Models and the Role of Interoperability

Introduction

A key to the success of building information modeling is an ability to organize and relate information consistently for use by both people and software. Information structures must have the capacity for details (such as the relationship between a door and hardware) and aggregation into broad representations (such as enterprise views of asset holdings). The built environment contains a large universe of materials. There are many traditional domains and, in fact, many different languages that must be understood and related to each other. Architects and engineers, as well as a real estate appraiser or insurer, must be able to communicate content and intent meaningfully within their own business domain and still share content and intent with other domains as diverse as that of the first responder to an emergency situation. For multinational corporations these challenges are compounded by the need to operate in multiple languages.

The participation of many organizations will be required to achieve the degree of agreement and standardization needed to develop shared ontologies.[18] Some of these ontologies are already available, more are in development, and still others exist as concepts.

This chapter presents information on data modeling in the building industry, data structures, ontologies, and standards that contribute to effective building information modeling and the role of interoperability in achieving the goals of efficient exchange of building information model data.

Background

The capital facilities industry domains have grown increasingly more technically sophisticated, but these domains remain relatively fragmented both in terms of processes and data processing automation. Passing information from one domain to another typically involves manual processes including re-creation of data, imperfect translators, or proprietary and specific software integrations. To compare datasets without actually exchanging data, specialty software is available that is able to manipulate and compare multiple data formats without translating data between them. These approaches offer some benefits but are limited and inefficient in that they cause significant waste, re-work and, perhaps most importantly, are inadequate for use in emergency situations. A more efficient approach would be to develop a coordinated, industry-wide shared language and data structure that each domain could use for its own purposes and a method of passing information from party to another in an automated and loss-less manner. Finally, in addition to immediate uses of coordinated information, shared languages and data structures also make it possible to plan for and rely on using, re-using, and re-purposing data across multiple lifecycle phases, which is critical for long-term goals such as life safety and environmental conservation.

The NBIMS Initiative hopes to influence new best practices even as it facilitates and/or provides enabling capabilities in the form of semantic standards, data schemas, hierarchal content

[18] Ontology is a study of conceptions of reality. Here ontology refers to the study of realities of basic categories and relationships of entities and types of entities in the built environment. Entities in the built environment are often categorized in terms of 'people or organization,' 'places and things,' and 'time or phases,' among others.

classification systems, building information exchange requirements, and building information encodings for implementation into software.

Rather than imposing another layer of requirements on the industry, the NBIMS Committee would like to make it possible to remove layers of inefficiency and re-work in favor of creating, using and providing information as a natural by-product of typical business activities. Data standards, building information modeling practices, and interoperability during exchanges are critical to this goal.

Relevance to User

Thankfully, users do not have to start from the beginning in this endeavor nor, in many cases, will end-users have to know the details of the standards and practices built into the software they will use daily. Some of the standards to be incorporated into interoperable software already exist and are continuing to evolve, such as those provided by the Construction Specifications Institute (CSI), the International Code Council (ICC), the U.S. Green Buildings Council (USGBC), Open Geospatial Consortium (OGC), the Open Standards Consortium for Real Estate (OSCRE), and the International Alliance for Interoperability (IAI). Some are new, next-generation standards, such as *OmniClass*™ from CSI and *IFDLibrary*™ from a consortium including IAI and CSI, and the National BIM Standard, which will publish encodings to be incorporated by software vendors into a wide variety of applications.

It is necessary that knowledgeable users participate in identifying the requirements for NBIM Standards. This is described in Section 5, but it is enough for now to know that end-users will not need to be skilled in standards development or software programming to participate. Data modeling and interoperability capabilities will be applied after the fact to the requirements established by practitioners. This chapter is provided for those who would like to know a little more about existing ontologies, how they will be incorporated NBIMS to achieve interoperability, and how new ontologies will be created to meet emerging requirements.

Relevance to National BIM Standard

The National BIM Standard will consist of specifications and encodings to define the requirements for exchanges of data between parties using building information modeling processes and tools. The NBIMS Committee will then facilitate implementation of these specifications and encodings by software developers into software used in BIM-based processes. Standardized, open-source classifications and data structures will be required to accomplish this.

Standardized classifications include ‘classes' such as walls, doors, furniture, and phases of work, job types, or many other concepts. Classifications also organize concepts such as accounting codes, personnel types, space use types, and work order priority codes. Many classifications such as *MasterFormat*™ and *UniFormat*™ [19] have existed for some time. Many needed classifications, such as wall types, exist within individual companies but have not yet been standardized across the industry.

Building information modeling data structures known across the industry have been primarily developed by the companies or products with which they are associated; some examples are Autodesk's AutoCAD® .dwg and Revit® .rvt, Bentley's MicroStation® .dgn, and Graphisoft's ArchiCAD® .gsm. Recently, new schemas associated with domain-specific data and intended to

[19] Trademarks of the Construction Specification Institute (CSI). See also www.csinet.org.

support narrowly defined exchanges of information between applications rather than the applications themselves have begun to emerge. These include CIS/2,[20] CIMSteel Integration Standards, from the Steel Construction Institute and gbXML[21] from the USGBC. Classifications of concepts exist within each of these data structures, but, typically, they vary from application to application or between domains, such as between building and geospatial domains.

The NBIM Standard will be defined to support exchanges between software applications so as not to be dependent on data structures used within an individual application. As an exchange standard, NBIMS will specify an open and freely available data structure and each software developer will be responsible for creating and/or receiving a correctly structured exchange data set. End-users should only have to be able to operate the certified software.

The data structure is only one-third of the matter. Creating an exchange standard that is interoperable requires that the information be semantically understandable and data content fit into classifications that are controlled. Local interoperability is achievable on an ad hoc basis by agreeing to parameters for a project or within a single domain. The benefits of this approach can be significant but are limited to a single project or series of projects using the ad hoc approach. Industry-wide interoperability, with its associated benefits, requires industry-wide standards.

The Role of Interoperability

Software interoperability is seamless data exchange at the software level among diverse applications, each of which may have its own internal data structure. Interoperability is achieved by mapping parts of each participating application's internal data structure to a universal data model and vice versa. If the employed universal data model is open, any application can participate in the mapping process and thus become interoperable with any other application that also participated in the mapping. Interoperability eliminates the costly practice of integrating every application (and version) with every other application (and version).

The NBIM Standard maintains that viable software interoperability in the capital facilities industry requires the acceptance of an open data model of facilities and an interface to that data model for each participating application. If the data model is industry-wide (i.e. represents the entire facilities lifecycle), it provides the opportunity to each industry software application to become interoperable.

Interoperability vs. Integration

Software interoperability, as discussed above, is seamless data exchange between diverse application types which each may have its own internal data structure. **Software integration** is a special case of interoperability where the same data model is used in separate applications or where specific integration between two applications has occurred. In this way, interoperability is achieved within a limited group of applications. (The group typically consists of applications that each serves a different discipline, industry process, or business case.) By agreeing to share a data model or do specific integration, software developers seek a market advantage. Data sets are directly imported and/or exported, or application interfaces access the data file directly. Traditionally, integrated data models and applications are both proprietary. If the original data format changes for any reason, all integrated applications must be re-integrated. An individual organization may support dozens of proprietary data formats, each of which must be integrated with the others. In a typical organization this may require maintaining hundreds of integrations or,

[20] See www.cis2.org.
[21] See www.gbxml.org.

just as commonly, avoiding integration by separating functional operations and relying on manual re-keying of information.

Discussion

The NBIMS Committee believes that achieving broad and lasting efficiency in the capital facilities industry requires software interoperability through exchange definitions, adoption of an open exchange data model, and a common interface to the exchange data model for use by any participating application. If the exchange data model is industry wide (i.e. represents the entire facilities domain), it provides the opportunity for each software application serving the industry to become interoperable. In contrast, integration excludes interoperability with applications that do not share the (proprietary) data model and thereby limits the flexibility and efficiency of the industry.

Data models establish the relationships between various data objects and the associated data elements in a format that ensures that data is only entered once and therefore has to be maintained in only one location. The open exchange data model will serve several roles.

- A structure for people to find items for use in data exchanges. NBIMS will use Information Delivery Manuals (IDMs) to organize data required for a specific type of exchange. The data required by an IDM is, by definition, a subset of the entire facilities data model.
- Normalizing (i.e. organizing data so it only occurs once in a database) for efficient data maintenance.
- Common definition of data elements with synonyms to support various business contexts where the same type is used but is known by a different name.
- A directory structure for the storage of collected information so that as data is collected it can be efficiently stored.

The basis for communication will be an agreed upon and controlled vocabulary. A controlled vocabulary is a list of terms that have been enumerated explicitly. In an open standard, this list is freely available but controlled by a ‘vocabulary registration authority’ for the benefit of all. All terms in a controlled vocabulary should have an unambiguous, non-redundant definition. This is a design goal that may not always be true in practice. It depends on how strict the controlled vocabulary registration authority is regarding registration of terms. At a minimum, the following two rules should be enforced.

- When the same term is commonly used to mean different concepts in different contexts, its name is explicitly qualified to resolve this ambiguity. (For example, address may be qualified for home address or office address.)
- When multiple terms are used to mean the same thing, one of the terms is identified as the preferred term in the controlled vocabulary, and other terms are listed as synonyms or aliases. (For example, in the U.S. a preferred name might be elevator with a synonym being lift; whereas, in the U.K. the opposite might be true.)

A taxonomy is a collection of controlled vocabulary terms organized into a hierarchical structure. Each term in a taxonomy is in one or more parent-child relationships to other terms in the taxonomy. There may be different types of parent-child relationships in a taxonomy (for example, whole-building, natural and real property, or type-instance, such as space or level), but good practice limits all parent-child relationships to a single parent of the same type. Some taxonomies allow poly-hierarchy. However, poly-hierarchy is not expected to be supported by NBIMS.

CSI is developing a thesaurus for the capital facilities industry, and it is envisioned that it will eventually be incorporated into NBIMS. A thesaurus is a networked collection of controlled vocabulary terms. This means a thesaurus uses associative relationships in addition to parent-child relationships. The expressiveness of the associative relationships in a thesaurus varies and can be as simple as 'related to term' as in term A is related to term B.

Commitments may be made to use a specific controlled vocabulary or ontology for a domain of interest. The NBIMS domain of interest ultimately encompasses all information views related to capital facilities. Enforcement of an ontology's grammar may be rigorous or lax. Frequently, the grammar for a light-weight ontology is not completely specified, that is, it has implicit rules that are not explicitly documented. It is important that NBIMS have a tight structure to the adopted ontology so as to minimize misinterpretation and to allow unambiguous understanding in software exchanges between the many domains and interests of the capital facilities industry. While vendors may use terms they created to help their marketing and branding, it is hoped that, in time, proprietary terms will be linked to the standard language presented in NBIMS.

Currently there are no software applications which can support the entire scope of endeavors in the capital facilities industry. It is likely there never will be. As the uses of BIM expand, the NBIMS Committee, through the NBIM Standards, hopes to create a capability where each party can choose software best suited to its own requirements confident that they will be able to freely collaborate with others and efficiently exchange data.

A meta-model is an explicit model of the constructs and rules needed to build specific models within a domain of interest. In the case of NBIMS the heart of the meta-model is in the Information Delivery Model (IDM).[22] A valid meta-model is an ontology, but not all ontologies are modeled explicitly as meta-models. A meta-model can be viewed from three different perspectives,

- as a set of building blocks and rules used to build models,
- as a model of a domain of interest, and
- as an instance of another model, and this where the model views come into play.

When modelers use a modeling tool to construct models, they are making a commitment to use the ontology implemented in the modeling tool. This model making ontology is usually called a meta-model, with 'model making' as its domain of interest.

One of the primary roles of NBIMS is to set the ontology and associated common language that will allow information to be machine readable between team members. Ultimately, these boundaries will encompass everyone who interacts with the built and natural environments. In order for this to occur, the team members who share information must be able to map to the same terminology. Common ontologies will allow this communication to occur.

[22] See Chapter 5.3, User-Facing Exchange Models.

NBIMS Exchange Tier Architecture

A natural hierarchy is emerging from the various aspects of BIM. As depicted in Figure 3.2-1, this hierarchy describes the following.

- **Aggregated View** shows the relationships at a world view.
- **Defined View** shows the relationships based on *OmniClass* table 31.
- **Model View** shows control to the access of information based on one's role in the model.
- **Information Delivery Manual (IDM) Activity** shows the flow of information supporting BIM.
    - **International Framework for Dictionaries (IFD)** allows IFC to be translated to other languages.
    - **Industry Foundation Classes (IFC)** show the molecular level of a BIM.

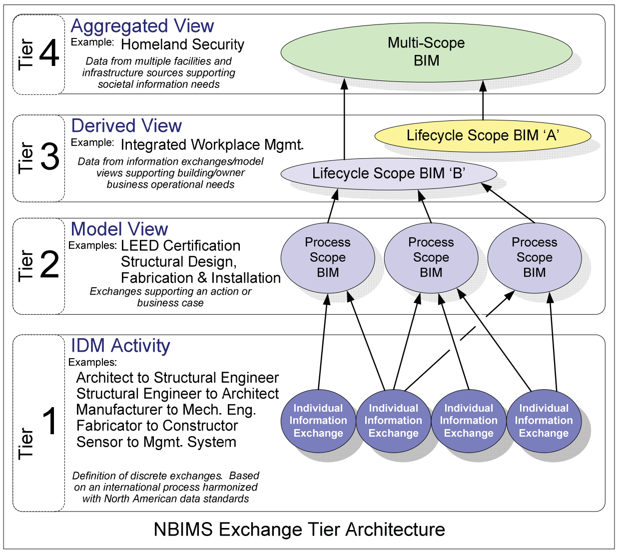

Figure 3.2-1 NBIMS Exchange Tier Architecture
(Courtesy D. Davis, AEC Infosystems)
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

Tier 4: Societal

Tier 4 concepts are depicted in Figure 3.2-2. This diagram describes a hierarchy above the building or structural level which is in alignment with the Federal Real Property Council (FRPC) ontology for facilities. Information above the facility level is aligned with and was developed by the Open Standards Consortium for Real Estate (OSCRE). Alignment of these primary defining bodies, as depicted, provides a continuum of information flow that has never before been clearly delineated for the capital facilities industry.

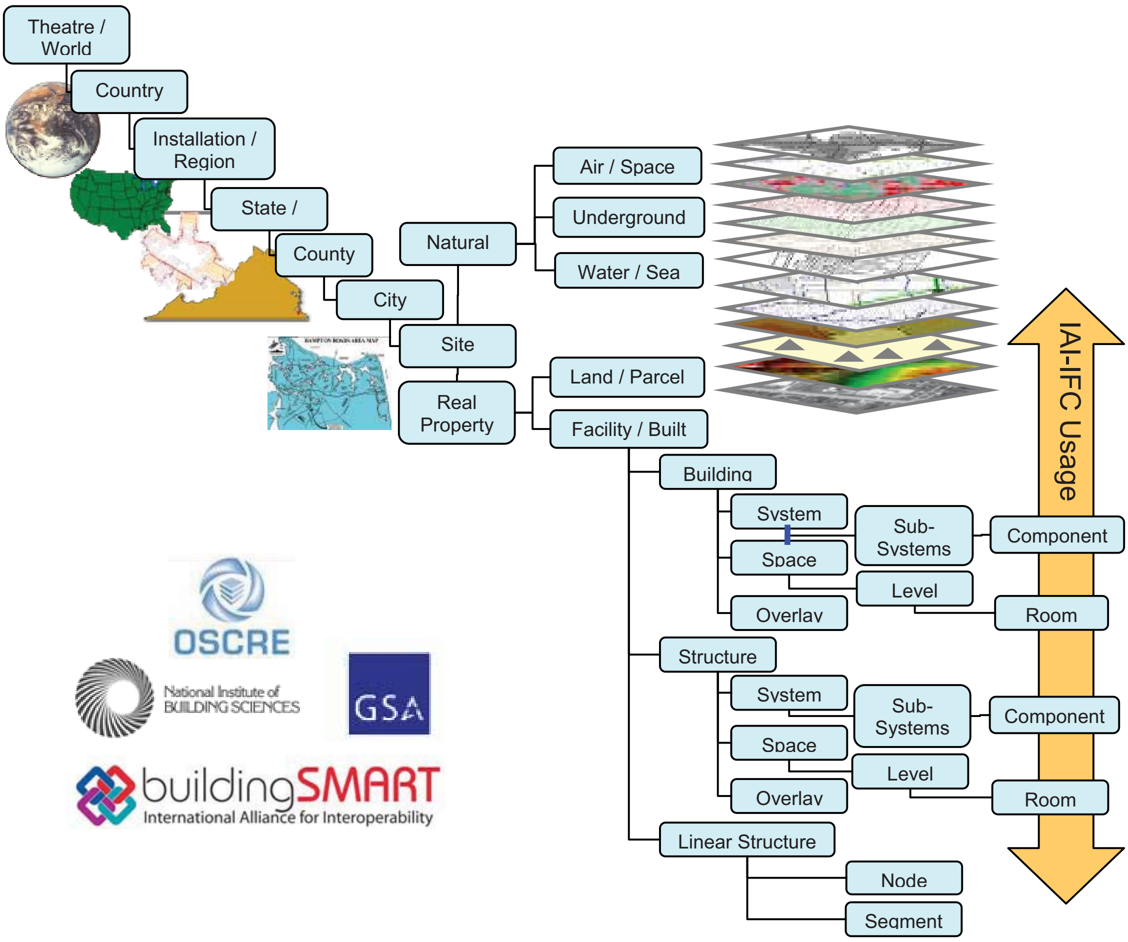

Figure 3.2-2 NBIMS Hierarchical Relationship
(Diagram courtesy DKS Information Consulting, LLC, OSCRE, GSA, and IAI International)

Figure 3.2-2 identifies how information can be rolled up from the smallest part of a facility or any part of the built environment to a world view or specific part of the world view. The information relationship potential depicted is the envisioned realm of the BIM as defined in the NBIMS Initiative. This range of informational interoperability is far beyond current professional norms and will challenge implementers as they define the relationship and ontological requirements of the capital facilities industry.

Also identified in Figure 3.2-2 are the relationships between the roles inside and outside facilities, which are traditionally depicted as separate domains. One of the roles of this new construct is to blur the lines that have been artificially established between those two domains and their associated technologies.

Here is a prime example of where these two worlds collide and technology can, in fact, help: Outside the facility engineers use a base-10 system of measurement, while inside the facility a base-12 system is used. The attempted conversion to the metric system in the early 90's in the United States, had it been successful, would have made this an easier transition. For today, one must still translate between measurement systems.

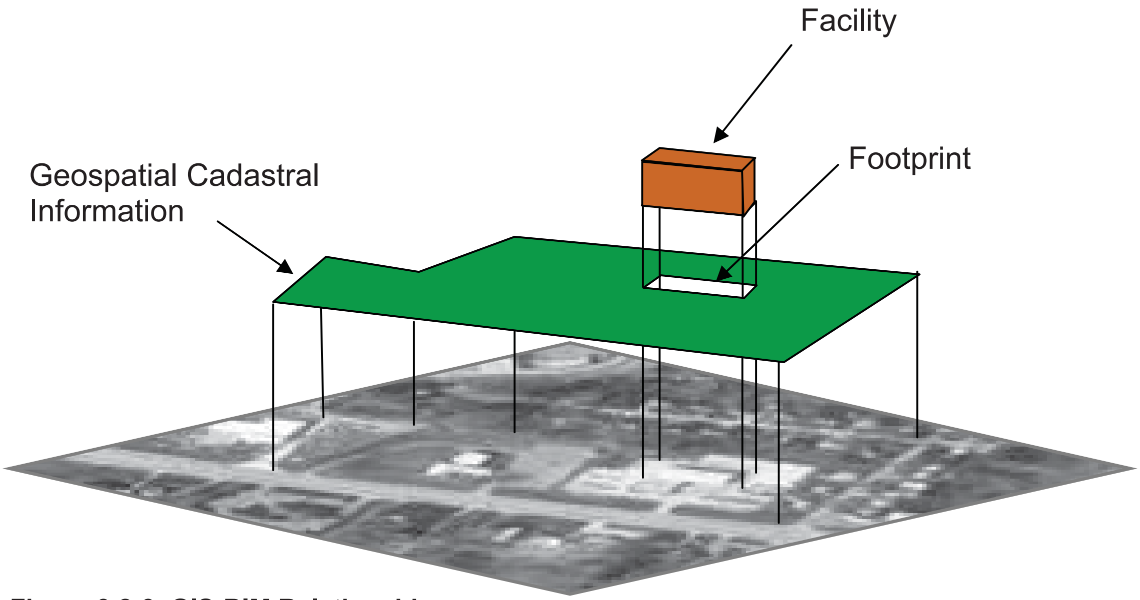

Figure 3.2-3 GIS-BIM Relationship (Diagram courtesy DKS Information Consulting, LLC)

While 'inside the building' and 'outside the building' will remain real boundaries environmentally, one must be able to easily share information between these two domains. Figure 3.2-3 identifies these primary relationships and how they are currently conceptualized. The difficulties associated with differing spatial data types are beginning to be addressed by the U.S. government in the form of executive orders. Executive Order 12906[23] and Circular No. A-16[24] establish requirements for geospatial information which include building footprints, and EO 13327[25] augments those with requirements for real property lifecycle information about the facility. The government appears measured in response to the intent and opportunities afforded by these executive orders; they are steps in the right direction to provide a foundation for interoperability.

Building Information Models will define what is inside a facility yet will need information defined in the geospatial world outside a facility in order to perform many types of analysis. The converse is true of GIS systems where information from inside a facility is needed to accomplish analysis, such as power distribution requirements. Three groups have taken on this challenge. The first is the International Alliance for Interoperability (IAI) Industry Foundation Classes (IFC or ifc) link to Geospatial Information Systems (GIS). The second is the Open Geospatial Consortium (OGC) Web Standard (OWS-4) specification which is investigating the relationship between GIS-BIM-CAD[26]. The third, the Open Standards Consortium for Real Estate (OSCRE), is developing standards to harmonize these interests in an effort to provide information to the ultimate beneficiaries, owners, operators, investors, and tenants of facilities.

[23] EO 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure, http://www.fas.org/irp/offdocs/eo12906.htm.
[24] Circular No. A-16, Coordination of Geographic Information and Related Spatial Data Activities, http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html.
[25] EO 13327, Federal Real Property Asset Management, http://www.ofee.gov/eo/13327.pdf.
[26] OGC OWS-4 Testbed Activity. http://www.opengeospatial.org/projects/initiatives/ows-4

Tier 3: Lifecycle

There are many lifecycles associated with each entity in Figure 3.2-2. The interaction of these lifecycles should be mapped using business process models. When one looks at a facility as depicted in Figure 3.2-3, the interactions between the worlds inside and outside a facility become a little more manageable. There need only be one information exchange, albeit a complex one, to act as the conduit to the geospatial world. It should be noted that only buildings or structure types of facilities are being incorporated in NBIMS at this point. A separate activity will be required to develop BIMs for linear structures (i.e. roads, power lines, utility lines, surface parking), largely due to the more integrated relationship between the geospatial world and linear structure itself. Once the building/structure relationships can be developed, then BIM concepts can more easily be applied to linear structures.

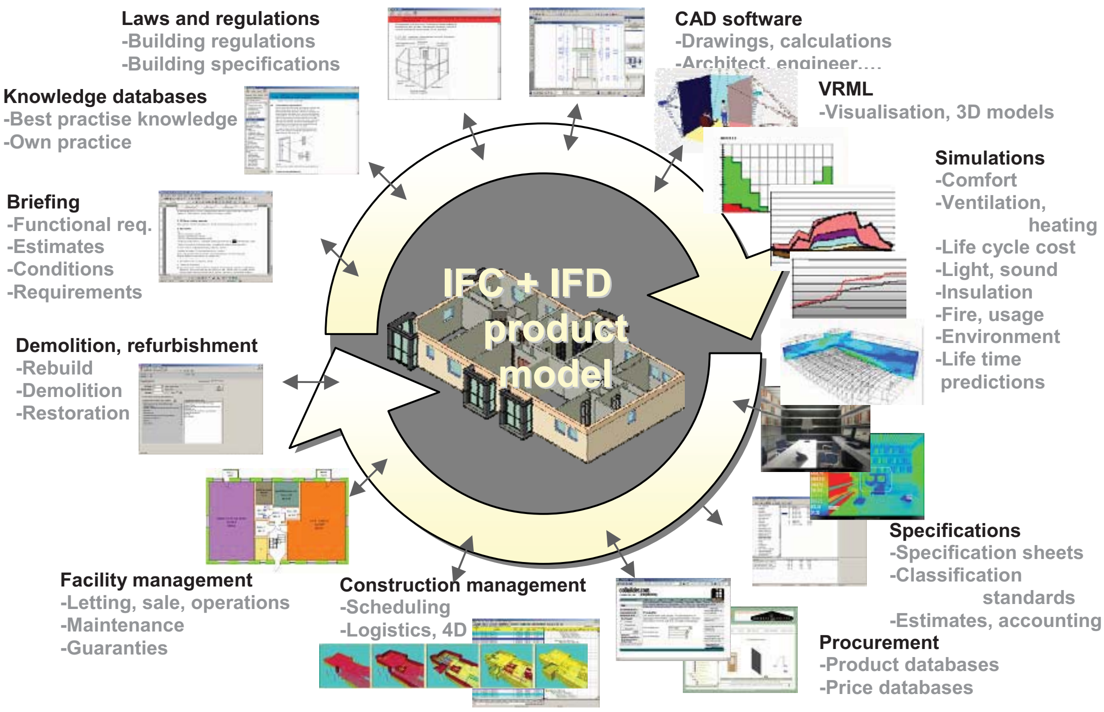

Figure 3.2-4 BIM Relationships (Drawing courtesy IAI International and AEC Infosystems, Inc)

In Figure 3.2-4, many facility lifecycle relationships are displayed. Systems, space, and overlays are depicted. Each system can operate dependently or independently of the other. The ontologies used are focused on the Construction Specifications Institute (CSI) *OmniClass* tables. There is significant discussion of the use of *OmniClass* tables in Appendix B.

It should be noted that in all the ontologies discussed the primary goal is to create user-facing requirements which may be mapped to Industry Foundation Classes (IFC or ifc) objects with associated characteristics for implementation in software. Figure 3.2-4 identifies many of the traditional functions and activities that occur during a facility lifecycle, which are all ontologically related in a BIM.

Tier 2: Model View

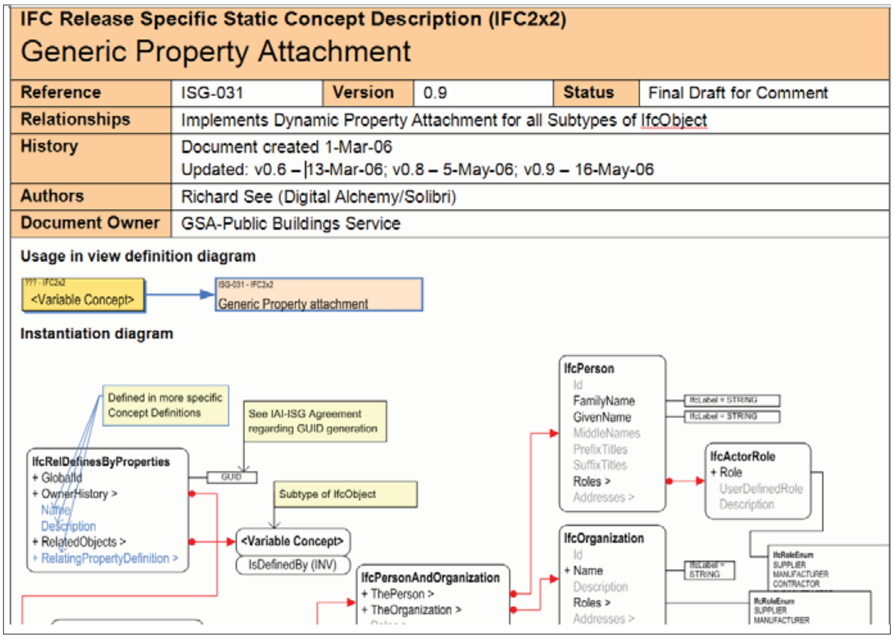

Figure 3.2-5 Model View (Diagram courtesy of Digital Alchemy and GSA)

Tier 2 of the diagram provides additional structure to the BIM. This level defines how each activity or group views the information in the model. For example, a designer may use a 3D model to examine and understand the relationships and potential conflicts as well as have the detailed information to perform site and system modeling and analysis, while a CFO may use only a spreadsheet *pro forma* to make the decisions necessary for involvement in the project. Later in the lifecycle, the facility operator will want a very different view of the model. The first responder or incident commander will again want a different view. All will be working off the same BIM. These views must be defined in the ontology. There are, likely over time, thousands of different views that will be defined. It will be important to coordinate these views into best practices so that each individual does not have to create his or her own view. (Individual views are certainly possible, but are neither cost effective nor desirable.) Therefore, it is recommended that practitioner representatives, such as associations, define these views.

Tier 1: Information Exchanges and Objects

Tier 1 of the layer organization is where all the pieces, necessary for BIMs to function and information to be logically related, are tied together.

Information exchanges, which are defined using Information Delivery Manuals (IDM), define the relationship between any two entities. While these information exchanges go on thousands of times a day, few are documented. Manuals of practice are often all that is available to provide these definitions. Industry needs to codify these exchanges so that all practitioners understand the relationship and the emerging best practice approaches to information exchange are recorded. It is critical that the purpose of these exchanges be identified to be included in the BIM, if appropriate. It is critical that the proper information be included for applications that may be desired later in the lifecycle. While a piece of information being shared may not initially be recognized as important in the present context, it may be of significant value later in the lifecycle. When information is not collected at an early phase of an activity, it may have to be collected later at an additional cost. In some cases, information may be very difficult to collect later and may require destructive means to do so.

In Figure 3.2-6, each information exchange is depicted as requiring a requestor and a provider. Information exchange agreements may be defined either when they occur or ahead of time. Once defined then they can be automated so that significant human interaction is not required and machine efficiencies can be applied. (These exchanges are beginning to be defined and are described in detail in Section 5.)

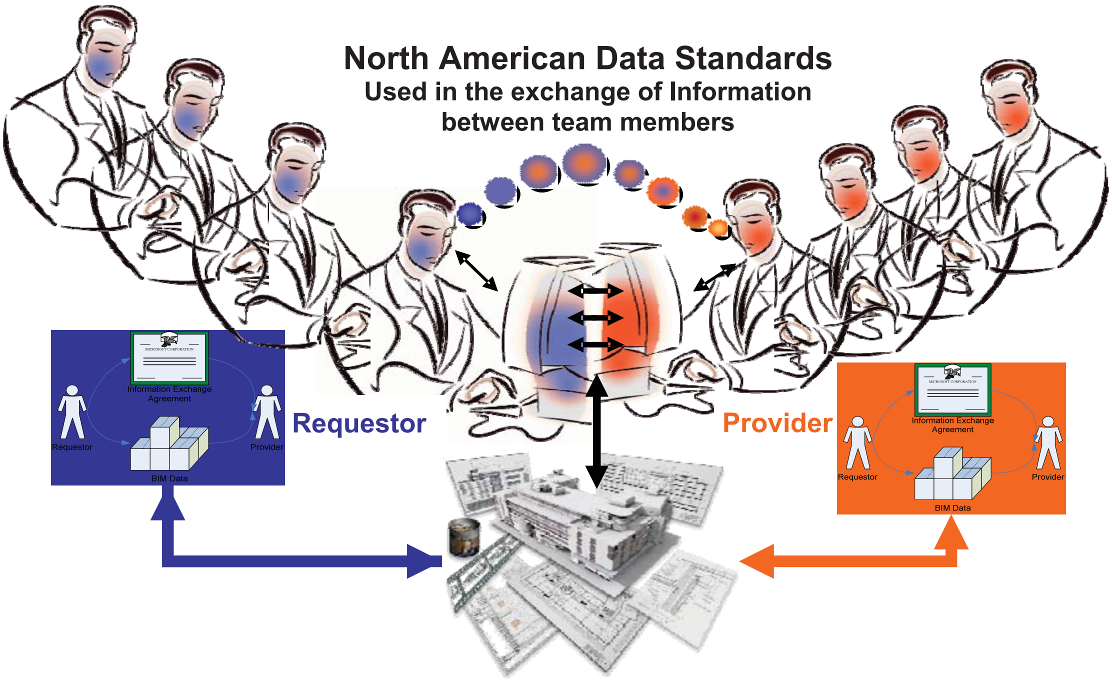

Figure 3.2-6 Figure Information Request and Delivery BIM Data Transferred by IFC (Figure courtesy AEC Infosystems)

One other aspect of information exchange being developed is the exchange of information internationally in various languages. Figure 3.2-7 identifies the dictionaries that are being defined to allow information to be translated between countries. The international structure of the IDM is being developed primarily in Norway where financial resources are being provided. The United States is participating on a volunteer basis in this important aspect of the BIM concept. While this effort is being accomplished primarily in Europe, it will benefit U.S. practitioners who compete in the world market.

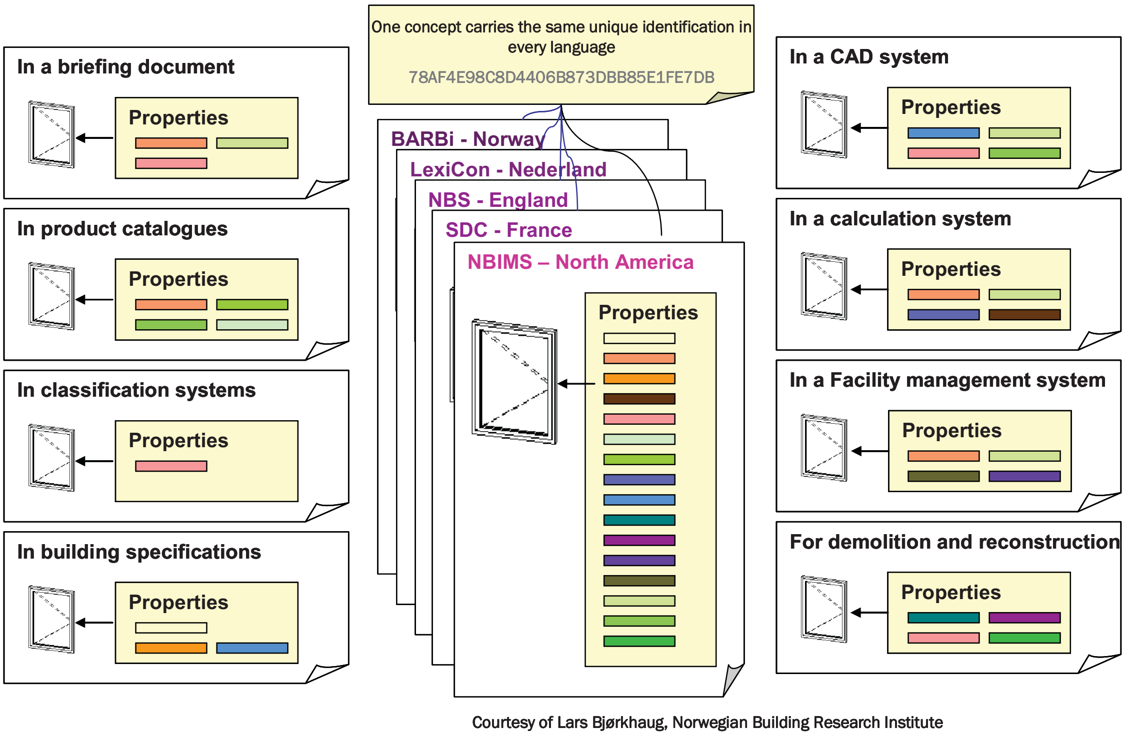

Figure 3.2-7 Relationship of IDMs to the International Dictionary (Courtesy Norwegian Building Research Institute)

IFC Reference Data Structures

One of the strengths of the international BIM effort is the IFC object based structure that is in use in many localities. The IFC Express-G models provide the necessary structure to ensure that information is relational and usable by machine.[27] Unfortunately, the number of practitioners who fully appreciate this structure is limited which has been a hindrance to forward progress in the adoption of BIM. This problem is comparable to adoption of other data structures such as the original *MasterFormat*™ or, more recently, migrating to the new *MasterFormat* or *OmniClass Table 22 – Work Results* from the more familiar 16 Division *MasterFormat*.

A sample of an IFC Express-G data structure is provided in Figure 3.2-8. In the current IFC representation model, each representation is included (or encapsulated, following the object-oriented principles) within the definition of an individual semantic object (being either a product occurrence, i.e. subtypes of IfcProduct) or a product type (or block, i.e. a subtype of IfcTypeProduct). Each geometric representation (IfcShapeRepresentation) is defined in its own object coordinate system, in the case of product occurrences. The object coordinate system is placed through a local placement (IfcObjectPlacement) either directly into the world coordinate system or through some intermediate object placements. Each semantic object can have zero, one, or many geometric representations; each being contained in a separate instance of IfcShapeRepresentation, but all are placed by a single instance of IfcObjectPlacement.

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[27] Inhan Kim, Thomas Liebich, and Seong-Sig Kim, *Development of a Two Dimensional Model Space Extension for IAI/IFC2.X2 Model*, July 2003

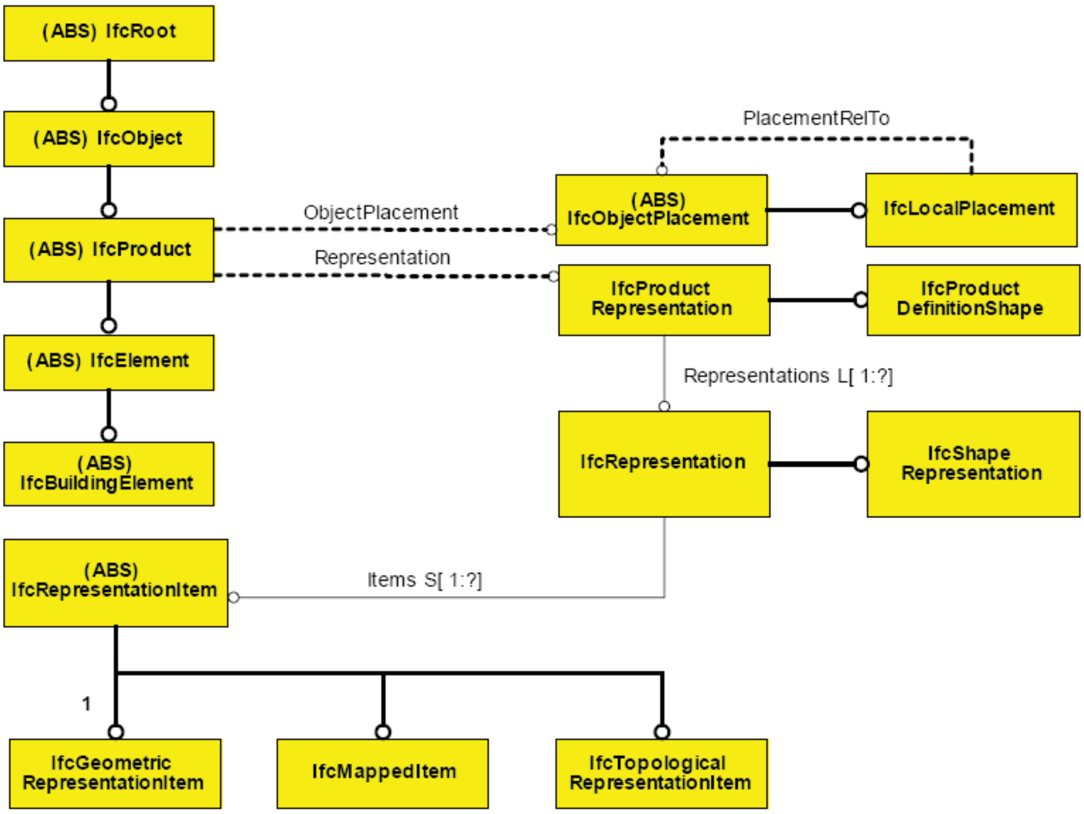

Figure 3.2-8 Representation of Data Structures in IFC 2x (Courtesy of IAI International)

Implementation Data Structures

There are many ways that data structures can be established to ensure data is collected during the normal business processes in place today. The NBIMS Committee is not looking to re-design business processes as much as to add awareness to points where data can be captured and integrated into the data stream. Having a data structure available at the various touch points with the business process is a critical aspect of BIM implementation. These data structures may be in all types of formats. They may be in Express-G as is the case with IFC, they may be in IDEF, or any countless others, but they should be in some recognized structure. They can even be in a format such as Microsoft® Access™ or as simple as a Microsoft Excel® spreadsheet, as examples. That is an implementation decision typically made by software vendors. Our purpose in NBIMS is to identify that a normalized data structure be used so that the data can be maintained and any changes be easily made.

Next Steps

The implementation of the ontologies and taxonomies presented in this document are in the very earliest stage of cultural acceptance in the capital facilities industry. At this early stage, there are several steps that must be taken to ensure a strong foundation for the NBIMS Initiative and NBIM Standards is created.

- Participate in making operational the NBIM Standard Production and Use Process as described in Section 5 of this document.

- Support buildingSMART alliance™ in industry-wide initiatives.
- Support CSI's work with *IFDLibrary*™.
- Work with and further support OSCRE's effort to link the planning, design, and construction world to facility owners, operators, investors, and tenants.
- Provide continuing education for practitioners in all aspects of the capital facilities industry.
- Support software vendor implementation of the ontologies and taxonomies.

Items Needing Standardization

Codification of the work in progress nationally and internationally is essential to further progress on BIM. In some cases, it will be a reaffirmation of the use of the ISO or PAS standards that are already in place. In other cases, it will be taking ontologies that exist in the capital facilities industry to a consensus level to ensure that all are speaking the same language.

The NBIMS Committee contributions to IDM, MVD, *IFDLibrary*, and IFC as normative reference standards supporting international efforts are being reciprocated. The fundamentals for data structures and ontologies are in place and have much agreement in the U.S. and internationally. There is still a significant amount of work to be accomplished to achieve sufficient agreement for implementation; thus, the following steps are required.

- Completion of the work involved with NWI 241 to harmonize IFC and ISO 15926.
- Consensus on the hierarchy from world view to detailed facility or structure view.
- Overall consensus on use of a procedural lifecycle roadmap for the capital facilities industry using one of the existing best practice examples as a basis.
- Incorporation of the accepted procedural best practice into software.

References and Links

Liebich, Thomas, (March 18, 2004) "IFC 2xEdition2 Model Implementation Guide Version 1.7" International Alliance for Interoperability http://www.iai-international.org/Model/files/20040318_Ifc2x_ModelImplGuide_V1-7.pdf.

The latest version of the DoD Business Enterprise Architecture can be found at http://www.dod.mil/bta/products/bea.html

[OWL] Web Ontology Language at http://www.w3.org/2004/OWL/.

[Wikipedia] While dictionary definitions provide the basis for the terminology Wikipedia was identified as the best and most comprehensive source for the discussion on ontologies and taxonomies, http://en.wikipedia.org/wiki/Ontology.

Chapter 3.3 Storing and Sharing Information

Introduction

A primary goal of NBIMS is to define the specifications required to exchange the information required for facility lifecycle business processes within the United States. Achievement of this goal is expected to result in improved operations, maintenance, and management of facilities. Reductions in the cost of planning, design, and construction will be direct benefits those who create and utilize building information models. Information exchanges implies stored information resources between which the exchanges occur. This section discusses stored information repositories, speculating on their characteristics, requirements for creation and maintenance, and use during short-term projects and long-term operations.

It should be stated emphatically in the introduction that we do not envision a single database for the repository, simply a central location where all software packages can come to seek related BIM information. It is hoped that this information source would implement standard database schema to ensure normalization of information so that information is only stored once and used many times. Each implementer may have his or her own approach, as this standard is not prescriptive in the solution, only identifying that the capability needs to exist.

Background

To create NBIMS, standards that address specific information exchange problems are created through an open collaborative process. Together these individual standards define a full set of common information created and shared by trading partners during the facility lifecycle. The compilation of these exchange packages results in the definition of a minimum BIM requirement. It is highly likely that software vendors who support NBIMS will eventually create software to support repositories of data that meet the NBIM Standard in addition to or as an alternative to proprietarily formatted repositories that do not support NBIMS information exchanges.

While the authors of this document cannot predict the future use or impact of NBIMS standards on process participants such as architects, engineers, constructors, operators, or owners, we have identified some key trends toward the potential application of model repositories. These are described in the paragraphs below.

The requirements for information storage and sharing cover three traditionally separate facets of the industry, Computer Aided Design (CAD), Computer Aided Facility Management (CAFM), and Geospatial Information Systems (GIS). A model view of a BIM could incorporate information from any or all of these technologies. Historically, they have not interfaced directly very well if at all. However, new concepts pretty much dismiss traditional CAD as being non-intelligent information. CAFM is integrated into the BIM. Therefore, we are really speaking of a geospatially located Building Information Model. IFC will provide a common format for CAD, CAFM, and GIS to communicate.

Relevance to Users

BIM technologies may be effectively used in many different ways by project stakeholders. How each of these stakeholders looks at the information will be defined in the model view. In addition, there may be important business drivers for implementing BIM differently during various project phases. This section provides a seed that can be used by the readers of this document to begin