National Institute of
BUILDING SCIENCES

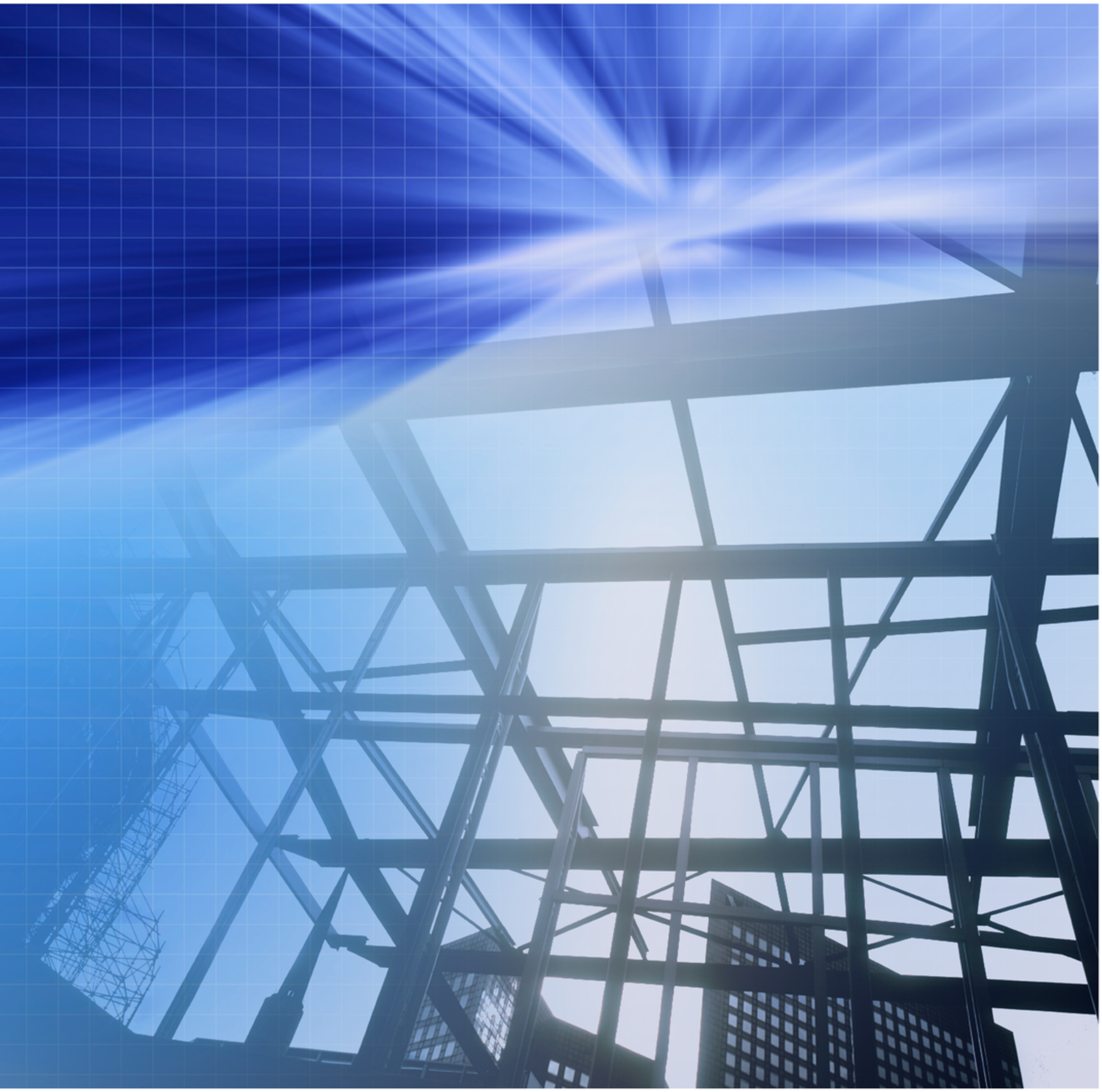
buildingSMARTalliance
National BIM Standard

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



An Authoritative Source of Innovative Solutions for the Built Enviroment

FINAL REPORT | DECEMBER 2007

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. Each of us has a responsibility to take action now.

David A. Harris, FAIA
President
National Institute of Building Sciences

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.

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[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*™.

[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.

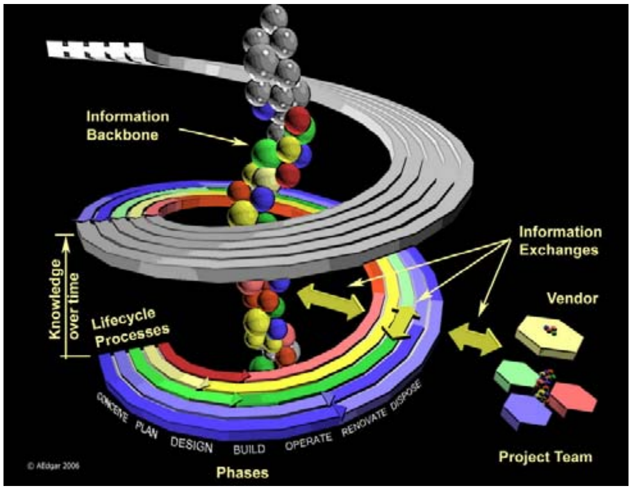

Figure 1.2-1 Facility Lifecycle Helix

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.

[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.

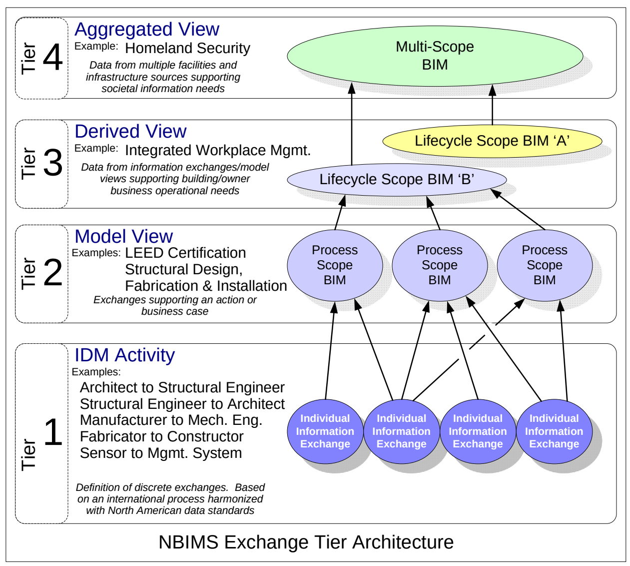

Figure 1.2-2 NBIMS Exchange Tier Architecture

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]

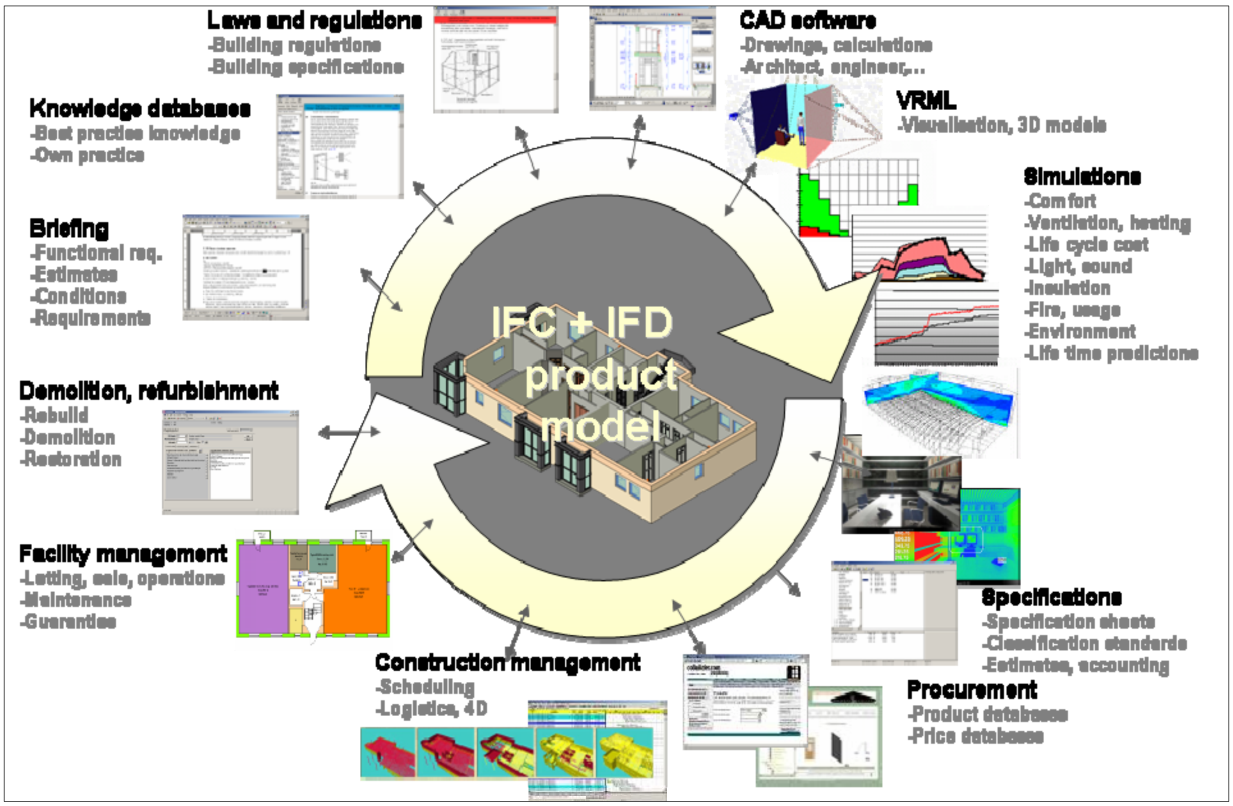

Figure 2.1-3 IAI Nordic Chapter 2000 BIM Product Model

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.

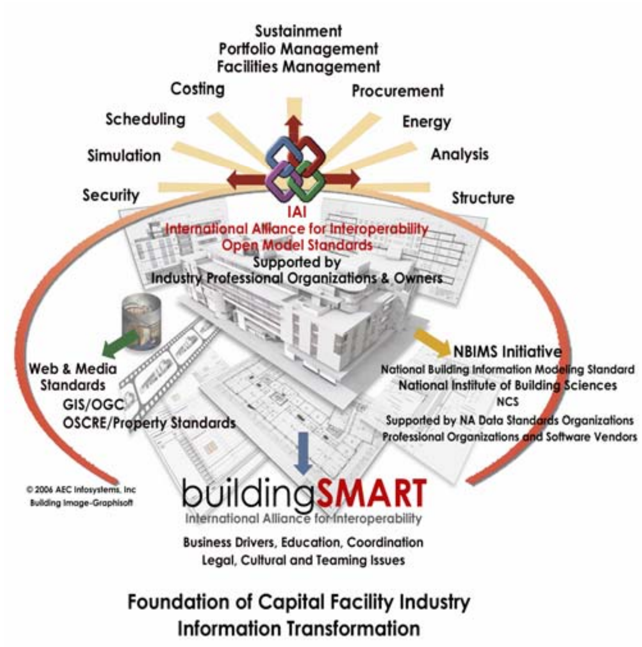

Figure 2.1-2 buildingSMART® Construct
(Courtesy of AEC Infosystems and Graphisoft)

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.

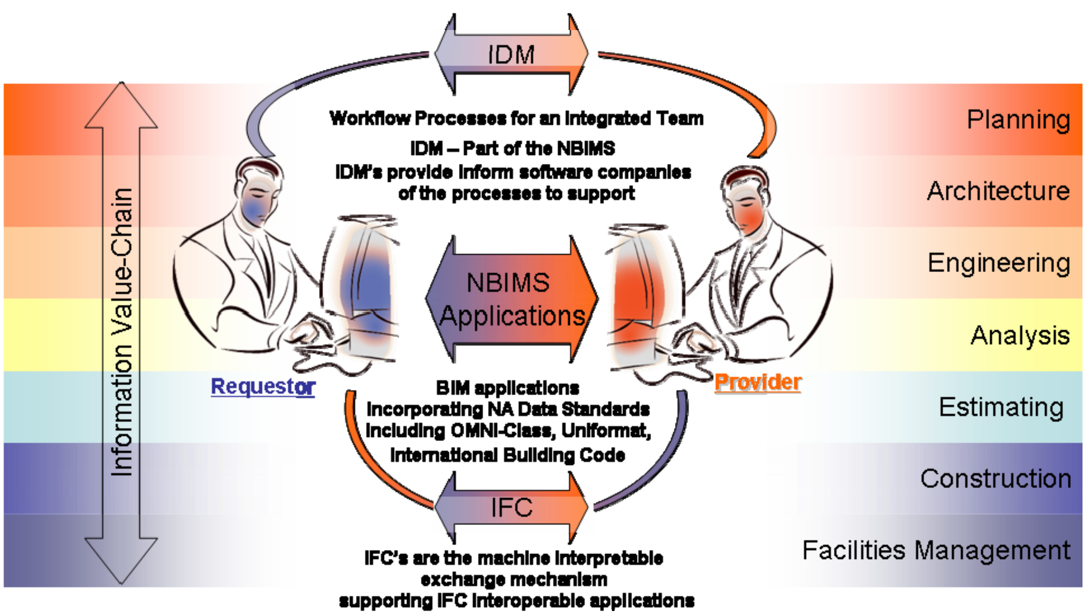

Figure 2.1-3 NBIM Standard Definition (Product, Process Supporting Collaboration)

[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.

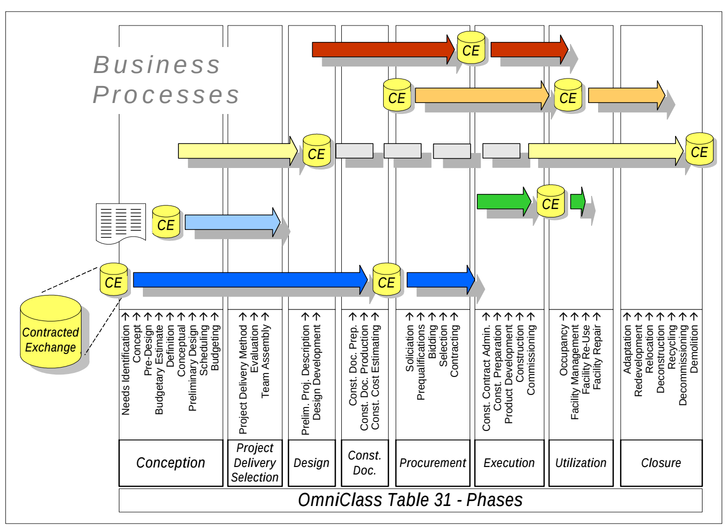

Figure 2.1-4 Business Processes

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.

<table>
<tr><th colspan="3">NBIMS Goals, Objectives, Strategies Version 1.0</th></tr>
<tr><td colspan="3">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.</td></tr>
<tr><th>2007- 2008 Goals</th><th>Objectives</th><th>Strategies</th></tr>
<tr><td colspan="3">1. Overview and Methodology</td></tr>
<tr><td rowspan="3">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.)</td><td rowspan="3">1.1 Identify the stakeholders needing and affected by the NBIMS Initiative and gain their support and participation for its activities.</td><td>1.1.1 Create and distribute the NBIMS Charter and Version 1 of the NBIMS Overview and Methodologies for industry review and participation.</td></tr>
<tr><td>1.1.2 Provide clear information on the opportunities for industry participation in NBIMS creation</td></tr>
<tr><td>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.</td></tr>
<tr><td rowspan="4">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.</td><td>1.2 Develop the broad coalition of stakeholders required to define this industry “standard of standards”.</td><td>1.2.1 Develop relationships with industry knowledge groups and bring this knowledge to the NBIMS effort.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td>1.4 Promote NBIMS vision and mission via a participatory communications plan and program of activities involving all stakeholders.</td><td>1.4.1 Utilize the NIBS website, WBDG industry journals, websites and industry forums to communicate and inform stakeholders of NBIMS and its progress.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td colspan="3">2. NBIMS Creation</td></tr>
<tr><td rowspan="3">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.</td><td rowspan="2">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.</td><td>2.1.1 As a business process enabler NBIMS shall identify open and efficient information workflows and the relevant data standards integrating stakeholders’ requirements.</td></tr>
<tr><td>2.1.2 Provide educational information on BIM implementation and the importance/use of open standards in any BIM based process.</td></tr>
<tr><td>2.2 Identify immediate societal and user business-case driven processes needed for NBIMS and act on these priorities.</td><td>2.2.1 Use the societal needs and industry identified challenges, and current work in progress as a departure point for NBIMS development.</td></tr>
</table>

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

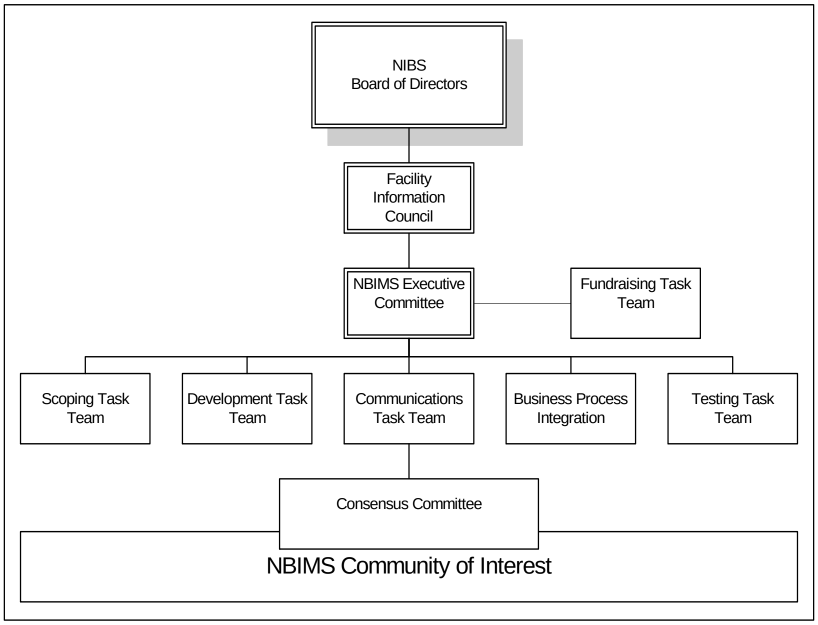

Figure 2.2-1 NBIMS Organization Chart

"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]

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.

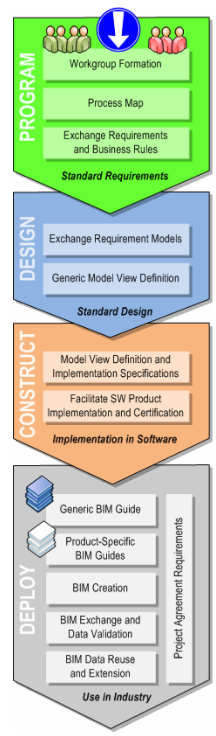

Figure 2.2-2 NBIM Standard Development and Use Process Overview

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.

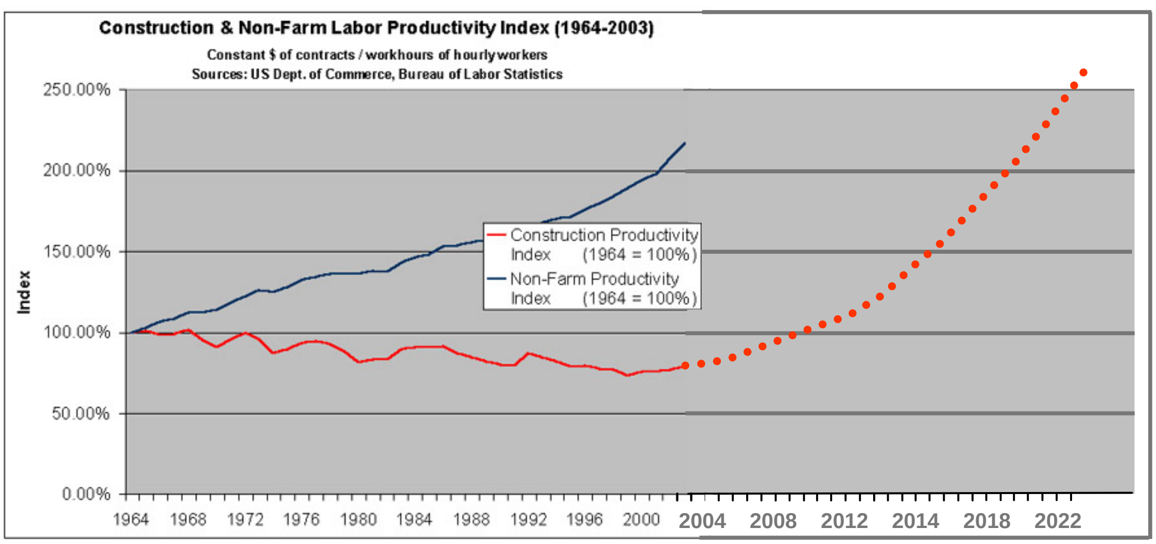

Figure 2.3-1 Construction Productivity (Historical information courtesy of Bureau of Labor Statistics; future projection courtesy of DKS Information Consulting, LLC.)

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.

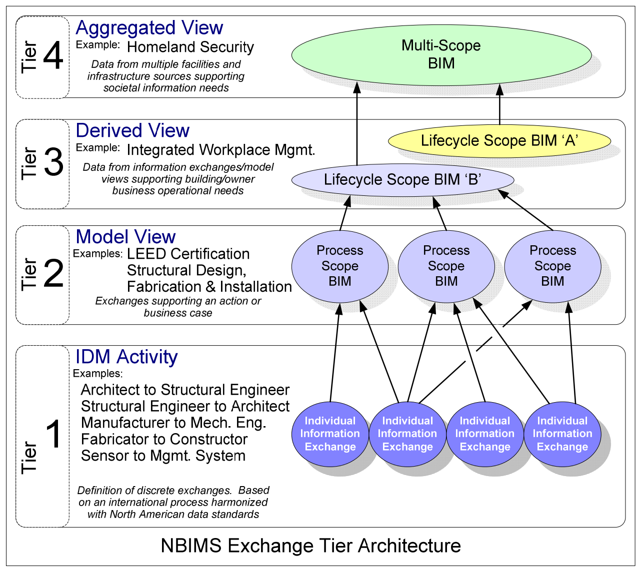

Figure 2.3-2 NBIMS Exchange Tier Architecture
(Courtesy D. Davis, AEC Infosystems)
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

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.
- 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)

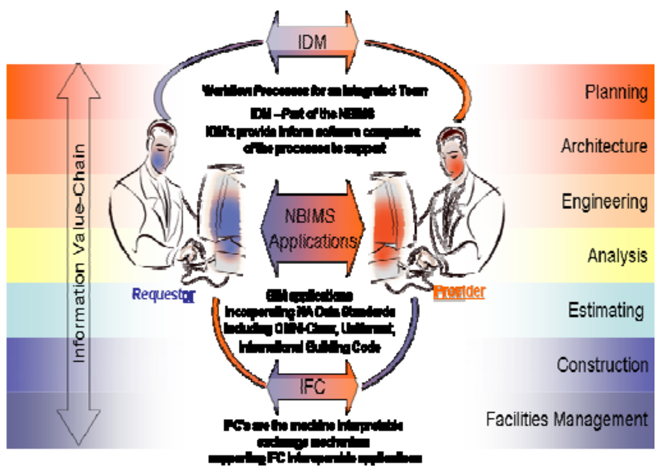

Figure 3.1-1 Relationships and Enablers of the Information Value Chain

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

[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.

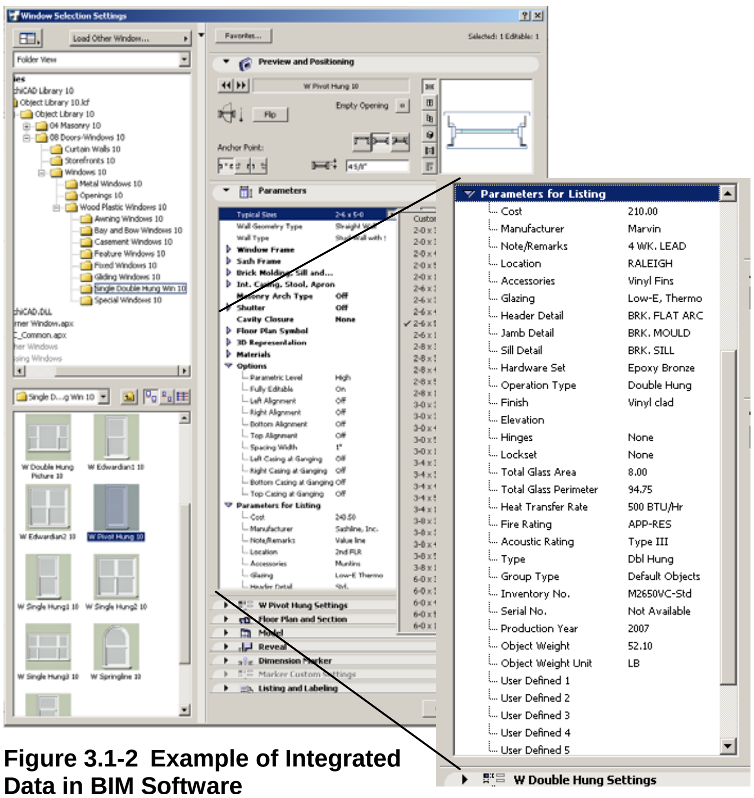

Figure 3.1-2 Example of Integrated Data in BIM Software

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,

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[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.
  - o **International Framework for Dictionaries (IFD)** allows IFC to be translated to other languages.
  - o **Industry Foundation Classes (IFC)** show the molecular level of a BIM.

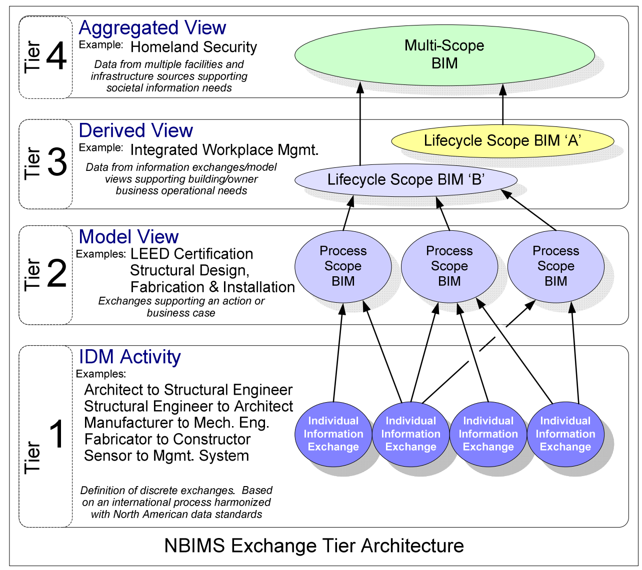

Figure 3.2-1 NBIMS Exchange Tier Architecture
(Courtesy D. Davis, AEC Infosystems)
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

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.

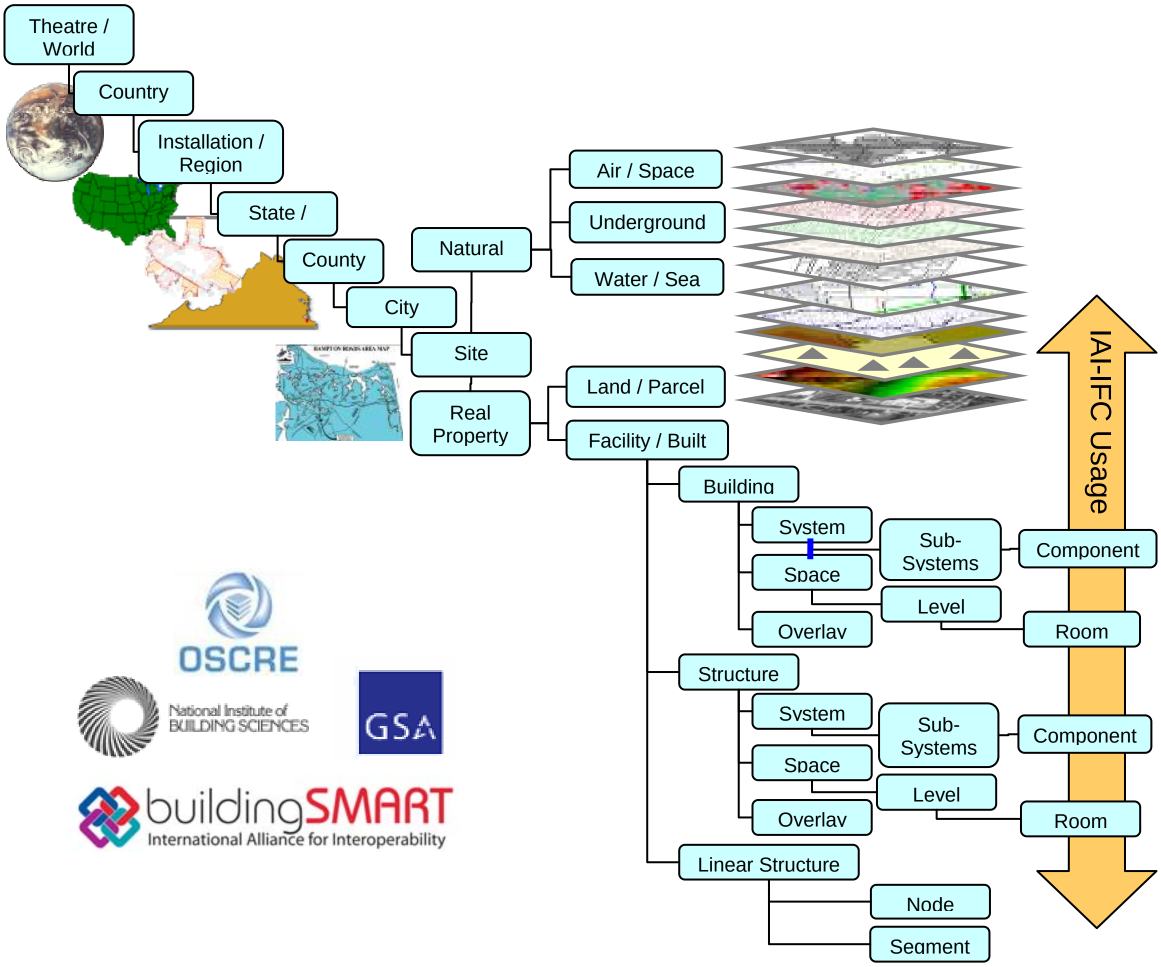

Figure 3.2-2 NBIMS Hierarchical Relationship
(Diagram courtesy DKS Information Consulting, LLC, OSCRE, GSA, and IAI International)

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.

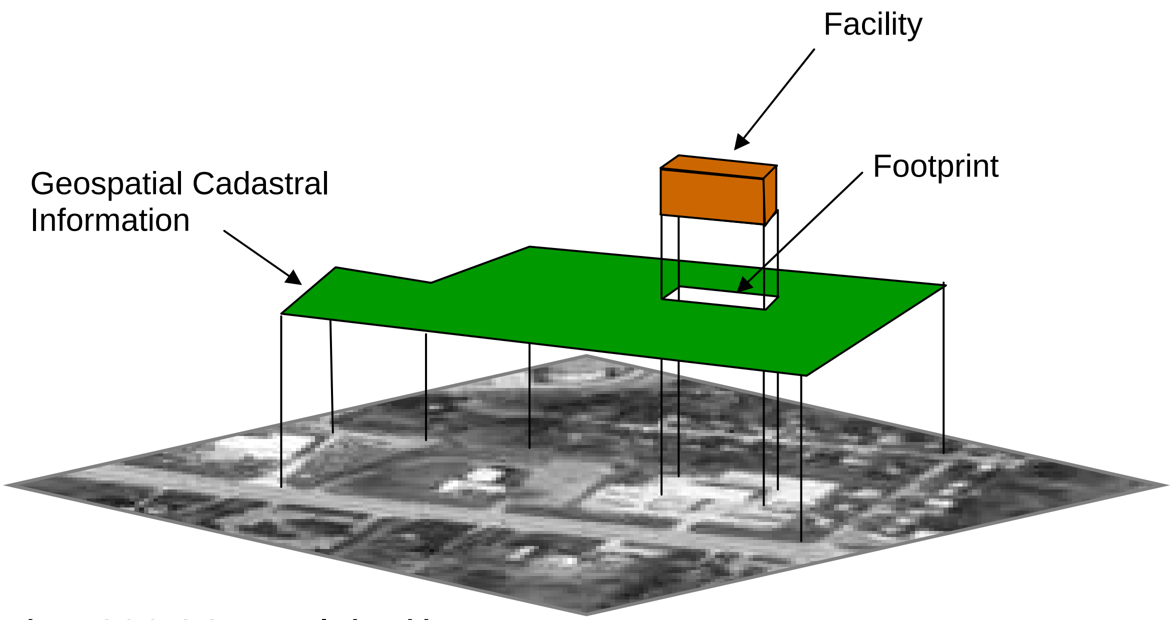

Figure 3.2-3 GIS-BIM Relationship (Diagram courtesy DKS Information Consulting, LLC)

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.

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[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.

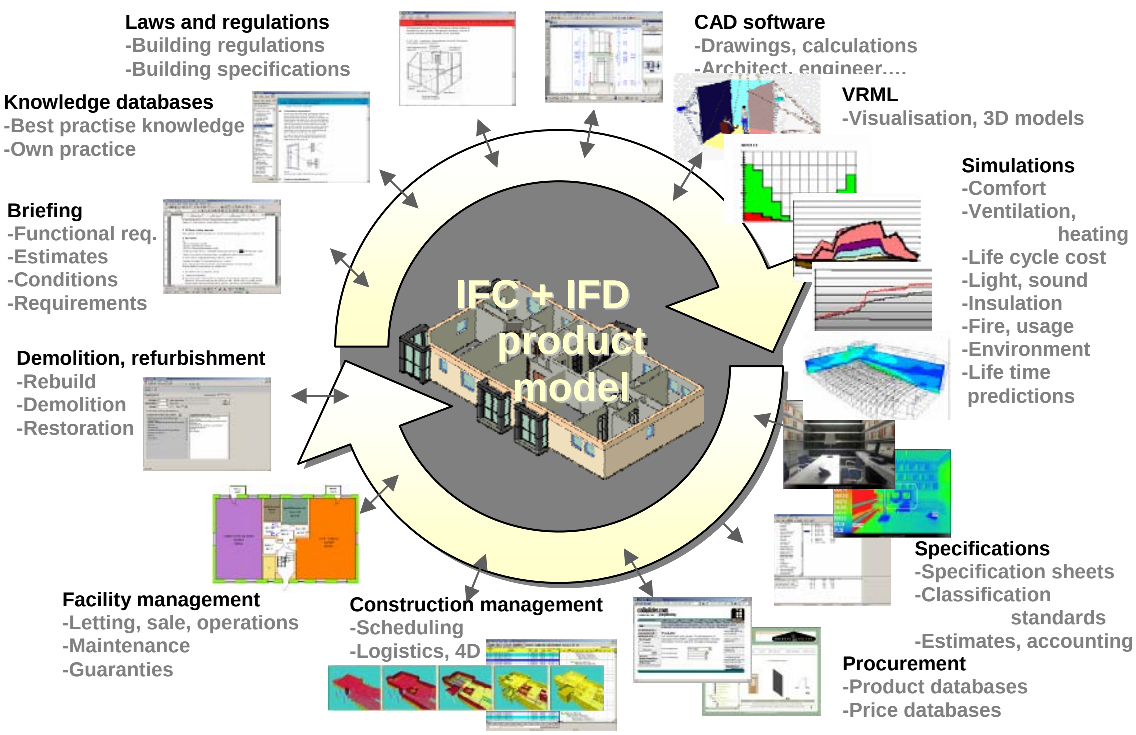


Figure 3.2-4 BIM Relationships (Drawing courtesy IAI International and AEC Infosystems, Inc)

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

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.

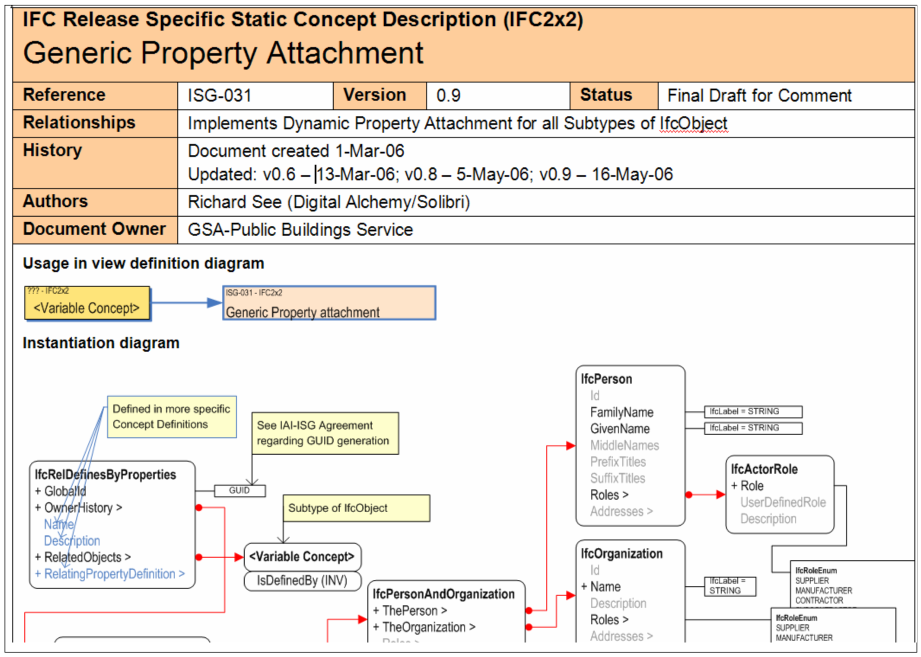


Figure 3.2-5 Model View (Diagram courtesy of Digital Alchemy and GSA)

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.)

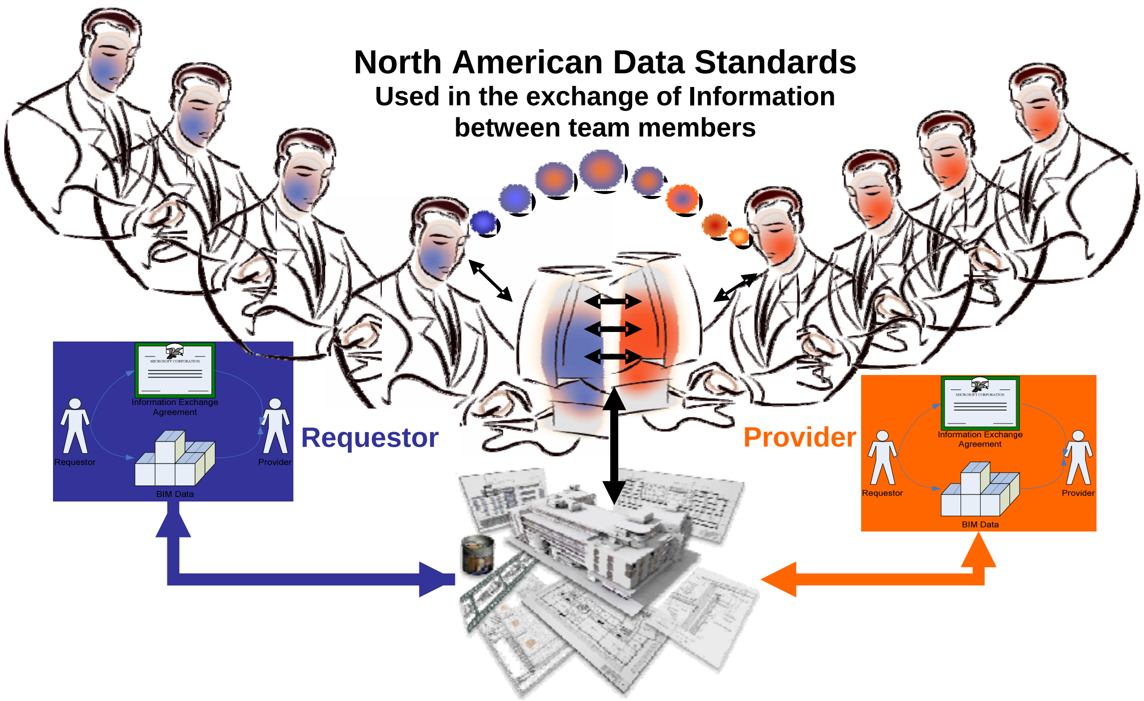


Figure 3.2-6 Figure Information Request and Delivery BIM Data Transferred by IFC (Figure courtesy AEC Infosystems)

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.

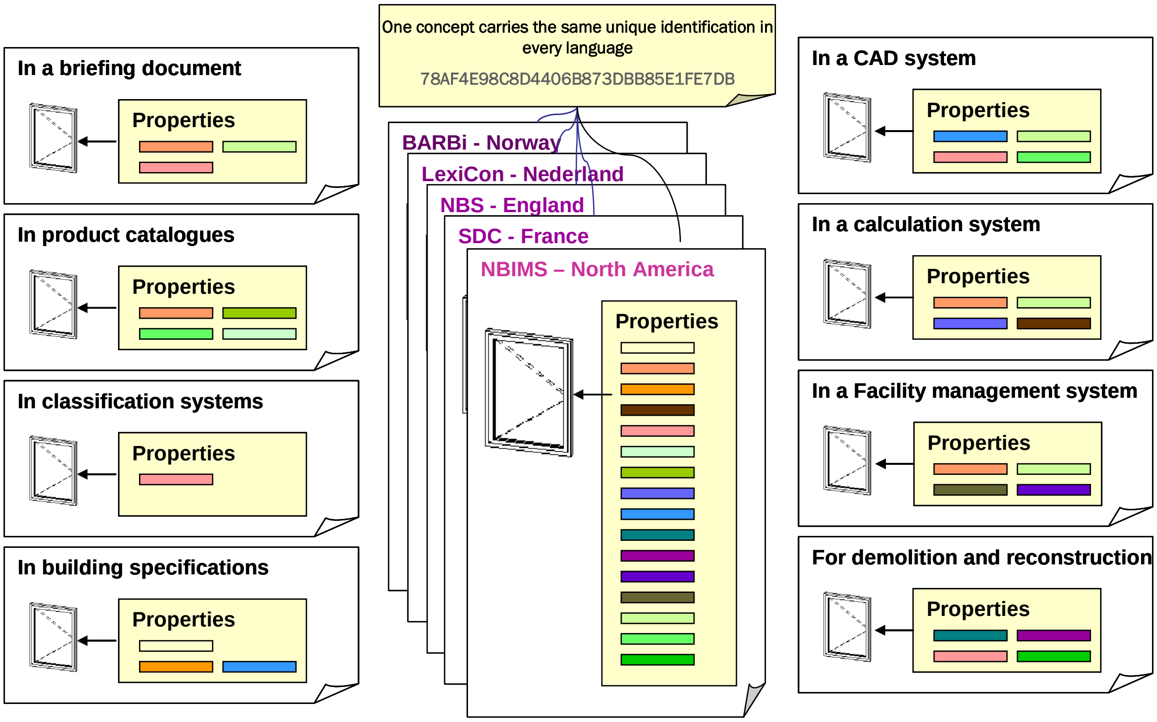


Figure 3.2-7 Relationship of IDMs to the International Dictionary (Courtesy Norwegian Building Research Institute)

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.

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

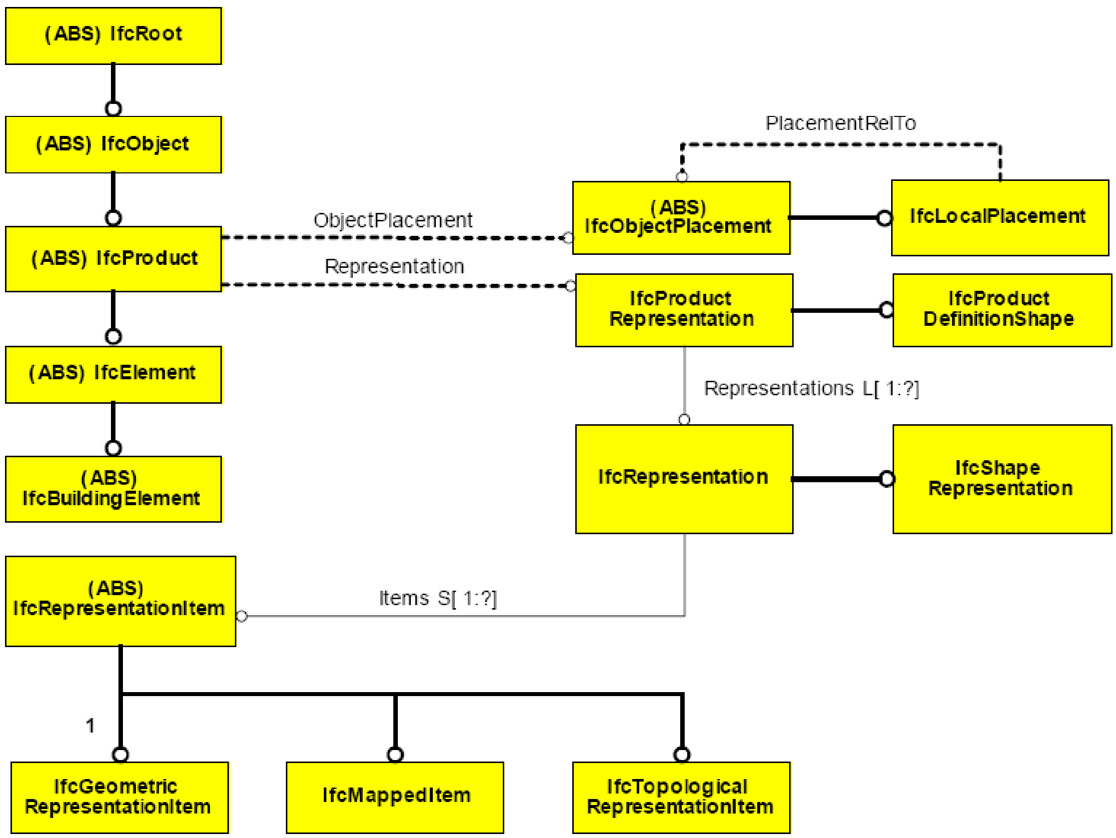


Figure 3.2-8 Representation of Data Structures in IFC 2x (Courtesy of IAI International)

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 a dialogue about BIM implementation in the context of their business lines, partners, and stakeholders.

Relevance to National BIM Standard

The requirements for NBIMS are driven by the business processes that define how BIM data will be exchanged. While there are alternate processes through which data may be captured, to date, those working on the technical side of NBIMS believe that as much as 85% of the content of the BIM data required is common regardless of the process. The process through which data exchange takes place will affect the implementation standards and specific software applications needed to support these new processes.

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 data base or by defining the rules through which specific components of BIM 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 expand the framework under which NBIMS operates.

Discussion

Building information models may be shared during a project in many settings. In full-service design and engineering organizations, information may be shared during the design phase across several engineering disciplines. Such sharing would require the identification of which group in the firm has access to add, edit, and delete specific types of building systems and/or components. Procedures for version control and check-in/check-out of individual parts of building models must be established within these firms. Information assurance to identify who made what changes and when is critical to future confidence in the information. Checks based on the contents of the BIM for completeness, consistency, and collisions are enabled when sufficient progress is made on the shared building model. While there are many different schemas that can create this environment, it clearly requires tightly coupled information. Openness of the data stored in a neutral file format such as IFC will allow many software packages to access the information giving users the most flexibility as to which software they use to perform various tasks. The use of multiple packages may in fact yield a better product.

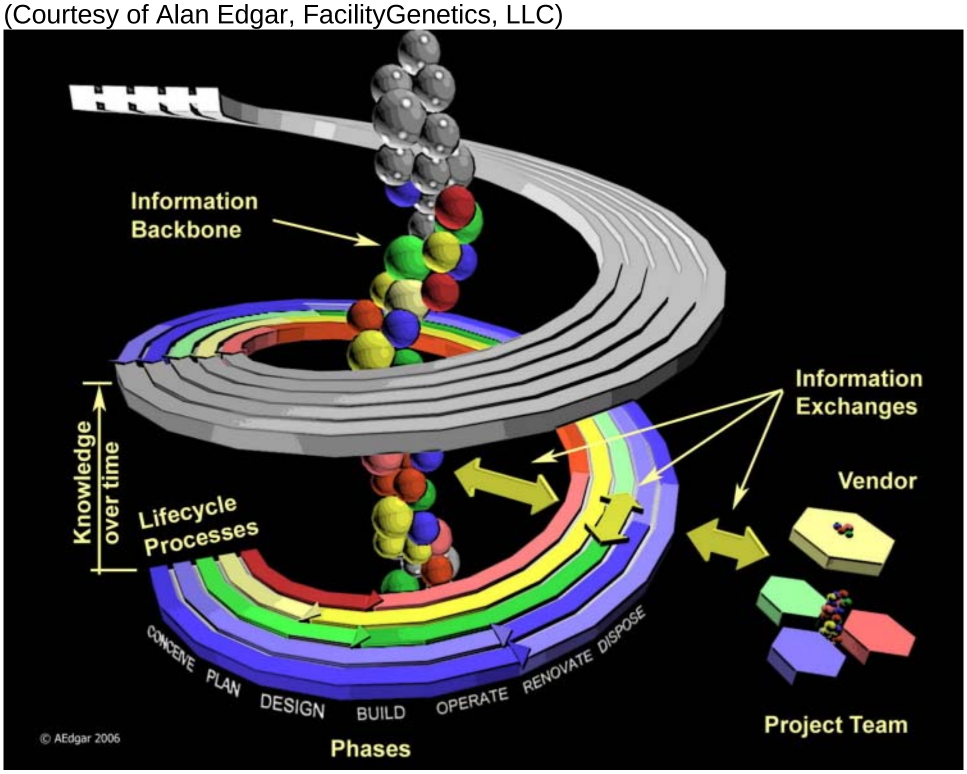
Since the greatest cost associated with capital facilities occurs during the operational phase, owners are expected to obtain the greatest value from having real-time, as-is BIM. To take advantage of the data provided by NBIMS, owners are likely to create internal as-built and as-maintained BIM repositories. Full sets of NBIMS data can be merged into a repository following the occupancy of new capital construction projects. With planning, owners will be able to create complete building models of existing facilities through the accretion of information from renovation and maintenance projects. Over time, the internally maintained building model repositories can provide a full digital representation of an owner’s infrastructure portfolio. This data, describing the project over multiple cycles of renovation and maintenance activities, can form the backbone for new value propositions in both the public and private sectors.

An owner’s repository portfolio is likely to begin with the inclusion of one or two new projects. The problem is all the existing facilities in the owner’s portfolio. Even with planning, it will take many years before facility turnover results in a fully populated repository. To back-fill repositories, some owners have seeded their repositories with just the general building location and square footage information. The business case for the expenditure required to complete site surveys to gather as-is BIM often is driven by asset management functions. As more information becomes available through BIM-based information exchanges, owners are able to drill down into the details of each added facility or infrastructure asset for more and more information.

Commercial developers and property managers will benefit from the shared repository of facility information since they will be able to maximize rents based on detailed knowledge of the attributes of each physical space. The tracking of maintenance activities that have been (and have not been) accomplished on a project will also provide a more transparent picture of asset condition. This is valuable to both the existing owner as well as potential future owners.

Figure 3.3-1 illustrates the framework through which a long-term vision of open standard-based BIM may be seen. For capital project owners, the construction of a given asset represents only the initial stage of many stages of work on a given piece of real estate. During a given project, a central repository is provided by the owner to capture the information needed to manage, operate, and maintain the facility. Such information should be captured during the creation process of the project, through the specification of open standard deliverables. The information of technical interest to engineers, architects, and lawyers may or may not be directly included in

Figure 3.3-1 Facility Lifecycle BIM Repository
(Courtesy of Alan Edgar, FacilityGenetics, LLC)



the model. In many cases, this information may be contained in separate files linked to the model. In cases where proprietary information is applied during the design, only the design-specific information is likely to be part of the model. Yet the information must be put into an open format for use by other software tools.

Over multiple construction, renovations, and upgrades, information about the building will be transformed from as-built to as-is data. There are some strategies emerging that create true as-built models of the facility that will mitigate this step. Should business processes change to support these approaches many problems will be resolved. Given concerns over the historical use of real estate and material composition of facilities, the information backbone will ultimately assist property owners to evaluate future risks and opportunities.

Work to develop lifecycle repositories of building model components and libraries that contain the intellectual property of owners, designers, manufacturers, and others is currently underway. We have faced this problem in the past, as we need to keep the information alive for much longer periods. In the reader's lifetime, he or she probably has data captured on media or software that can no longer be read. This is not an acceptable scenario moving forward. NBIMS provides an open standard upon which to build repositories of information that will provide value much longer than the current version of software or current hardware platform.

Next Steps

The owner's internally maintained repository will be even more valuable as new technologies that integrate sensor networks into BIM move into everyday commercial practice. Today, researchers at many institutions are looking at the impact of a future when sensor networks provide location-based computing inside buildings, similar to that provided outside buildings using Global Positioning System (GPS) networks.

References and Links

For those interested in IFC compliant BIM servers there are currently two products that we know of and certainly, others that will emerge.

- EDM, http://www.epmtech.jotne.com/products/index.html
- IFC Model Server, http://www.secom.co.jp/isl/e/theme/ps07/report01/index.html
- Oracle® has the capability although a specific site is not currently available.

Chapter 3.4 Information Assurance

Introduction

A Building Information Model (BIM) provides an opportunity to store all the information about a facility in essentially one place. It is a capability that we have never known, and a tool that anyone who requires information about a facility or a group of facilities can tap. While that is a good thing for designing, constructing, operating, and sustaining a facility, creating many opportunities for improved efficiency, data aggregation can also open the door to significant risk.

Managing the risks of data aggregation requires advanced planning to control the discovery, search, publication, and procurement of shared information about buildings and facilities. Such control will ensure that the quality of the information is protected from its creation through its sharing and use, that only properly authorized people have access, and only to that subset of the information to which they are authorized to 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 care that is commonplace in personnel and banking systems worldwide.

The handling of Information Assurance (IA) must start with the creation of data. Associated with the data should be such facts as who created the data, how, why, when, and how good the data are.

Background

While most information related to a facility is not sensitive, some of the information in the wrong hands could result in serious harm. Historically, we have made no particular effort to share or prohibit sharing of information about what goes on inside buildings. However, we now live in a 'Google Earth world' in which the existence of a facility can be known to anyone with internet access. The activities that occur inside the facility can, in some cases, be inferred fairly reliably from the structure, its location, and its surroundings. Whether the facility is a hospital, office building, laboratory, airport, or industrial building, some information, for example where hazardous materials are stored or where specific people are located, is likely to be sensitive. In other cases, the activities themselves might be sensitive. While sensitive information needs to be protected from general access, its availability to people with a need to know is critical and must be facilitated. People with a need to know may range from personnel or facility managers to first responders or incident commanders in an emergency.

Relevance to Users

Information Assurance is important any time you plan to share information outside your stovepipe or functional area. For example, if everyone inside your design office has authorization to see all the information about a project and you do not intend on sharing that information with anyone later in the lifecycle, then Information Assurance is not a critical concern or particularity important to you. But then the BIM you have created is not being implemented as it is intended. The whole point of BIM is to be able to collect data authoritatively and then make it available to others later in the lifecycle. Assuming that is the environment you plan to work in, then it is important to know who entered the data and in what sequence (time and date) so that people using the information later will have confidence in its authenticity and not have to go through extraordinary means to verify it. Many of the readers may remember when calculators first came out people used to check the results by hand, but that practice quickly passed when confidence in the new tool was established. Suffice it to say, if you intend to implement BIM for the facility lifecycle, Information Assurance is important to you.

Relevance to the National BIM Standard

In order for everyone who will touch the information in a BIM throughout its lifecycle to be able to do so in a way so as to protect the integrity of the data, strong standards are needed. Software vendors must use open standards so that various software programs can lock and unlock the BIM with correct authorization. In most cases, the BIM will be encrypted at rest and during transmission; hence, any package accessing the information will need to be able to handle the standardized security aspects. Authorization for access to the BIM will need to be controlled throughout its lifecycle and able to be passed from one control point to the next without danger of compromise. When done appropriately, this will not and cannot limit access to any one vendor in order to protect BIM sustainability over the facility's lifecycle.

Discussion

The most desirable solution would use open source, while an alternative would be to use proprietary software tools to help manage the publication, discovery, and procurement of shared information about buildings and facilities. The work of the Open Geospatial Consortium (OGC®) provides significant insight into the issue. The OGC Technical Committee Working Group on Digital Rights Management (DRM) has created a Reference Model for digital rights management functionality for geospatial resources (GeoDRM RM). This reference model covers capabilities that are not covered by earlier standards or by rights models for non-geographic resources (e.g. movies and music), capabilities of interest to our community because our facilities are inherently geographic.

The Scope of the GeoDRM standard is as follows (quoted from page 16 of the GeoDRM Reference Model[28]).

> *This standard defines:*
> - *A conceptual model for digital rights management of geospatial resources, providing a framework and reference for more detailed specification in this area.*
> - *A metadata model for the expression of rights that associate users to the acts that they can perform against a particular geospatial resource, and associated information used in the enforcement and granting of those rights, such as owner metadata, available rights and issuer of those rights.*
> - *Requirements that are placed on rights management systems for the enforcement of those rights. A rights management system must be necessary and sufficient: it must implement only those restrictions necessary to enforce the rights defined therein, and it must be sufficient to enforce those rights.*
> - *How this is to work conceptually in the larger DRM context to assure the ubiquity of geospatial resources in the general services market.*
>
> *A resource in this context is a data file, or service for geographic information or process.*

[28] http://www.opengeospatial.org/standards/as/geodrmrm

This abstract specification builds on and complements the existing OGC specifications, and defines at an abstract level a Rights Model to enable the digital rights management of standards-based geospatial resources. Future GeoDRM Implementation Specifications will be written to implement the concepts defined in this document.

The GeoDRM Working Group uses scenarios (families of use cases) to illustrate and understand the range of situations that systems may need to be able to accommodate. One way of organizing the scenarios is by general user categories: private, public, and emergency.

- **Private-access resources** are those resources that may be sensitive in nature or are classified for security reasons. In our BIMs, the locations of the offices of specific employees who would need assistance in case of evacuation (for example, due to infirmity) are sensitive information; facilities used by the military exemplify private-access resources that are classified for security reasons.
- **Public-access resources** can be made available to anyone, such as the directory of tenants in a public office building.
- **Emergency-access resources** are those to which first-responders must be able to easily gain access in emergency situations. Examples of information they may need include the exact types and quantities of hazardous materials and the locations of master switches for electricity and water.

Best Practice Steps

As we develop our building information models with Information Assurance (IA) in mind, we can also benefit from the experience of federal agencies after the passage of the Federal Information Security Management Act (FISMA) of 2002. All federal agencies are required to implement an IA plan to protect their information. The Department of Defense (DoD) has been applying IA to its information systems for over ten years. When IA is applied throughout the life of the system used to maintain the information, the information stands the best opportunity of being protected. This structured approach ensures that IA is built in from the beginning and is maintained throughout the life of the system.

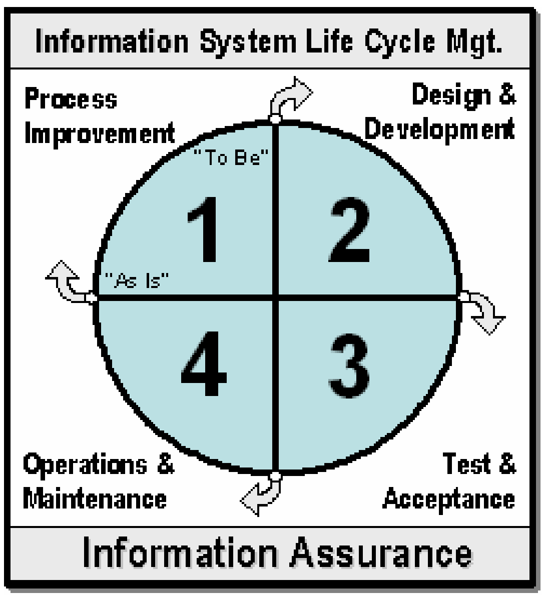


Figure 3.4-1 Information Assurance will be most successful when designed into management of the entire information system lifecycle from the beginning.

Best Practice Steps include:

- Process Improvement,
- Design and Development,
- Test and Acceptance,
- Operations and Maintenance.

Step 1: IA Process Improvement

Process Improvement is a methodology used to catalogue and document all of the processes used to conduct business. This includes the definition of each process that collects, maintains, and uses information during the course of conducting business. The product is a document that describes the participants, what steps make up a process, what data is involved, how the data is processed within each step, what business rules are applied and other information. The methodology is applied to how business is conducted today. This creates the 'As Is' business model. Through a structured approach to improve the process a 'To Be' model emerges. The documented 'To Be' model will describe all of the processes for the collection, maintenance, and use of data for the business process. This information can be used to start the IA process because it contains items such as (and limited to) data elements, processing steps, roles, and responsibilities. From this understanding, things like the security classification of the data, the clearance level of the system users, and the initial information protection level of the system can be determined. In most cases, the 'To Be' model/documentation is used to proceed into the next step of information system lifecycle management – design and development. This can be applied to the design and development of a new information system or the maintenance of an existing (operational) information system.

Step 2: IA Design and Development

During the Design and Development phase of the information system's life, the 'To Be' documents are analyzed to develop the system's data model, edits, and other information. These documents also identify who will initiate the process, who will review the results, what data will be used and with what values, when the data will be processed, and more. This information is translated into system user types that are associated with roles; user types and associated roles facilitate the creation of user profiles. Access rights may vary within user profiles. This information is translated into access controls for each user profile. Access controls are applied to users to ensure that only authorized users of the system access only the data they are authorized to access. Based on the collected data (from steps 1 and 2), the system engineers can begin to apply additional security definitions. For example, from this information they can determine if the information is private or public or a combination and which information is where. From this, they can begin to model an information technology infrastructure appropriate to the system requirements. The design documentation is presented to the process (and/or information system) owner. With the acceptance of the design by the process/system owner, the design is presented to the Chief Information Officer (CIO), who, with his or her staff, will review system design and authorized development. This ensures that the information technology division is aware of the pending impacts to the operational information technology infrastructure. This should ensure the active participation and support of the information technology operational group. The system developers have authority to begin development of the system, in accordance with the approved/accepted design. After unit testing is complete, the system will proceed to system testing with the goal of full user acceptance.

Step 3: IA Test and Acceptance

The Test and Acceptance step is where the system user and information technology communities test the system. The user community develops test data, test scenarios, and has test users exercises the system with vendors so that both may verify that the system was designed and performs functionally in accordance with the design documents. Should the system fail to meet design requirements, it will return to the development phase for rework. This ensures that both functional and operational (including IA) requirements are met prior to entering the next step in the system's lifecycle. Additionally, the informational technology operational group (i.e. database administrators, system/network administrators, and others) exercise their operational functions (i.e. build/delete user accounts, assign/delete access privileges, backup/restore data, and run scans on the system to check security vulnerabilities). During this time, the IA team is able to develop and complete the information system security certification and accreditation documents (which identify operational risks associated to this system in an operational environment). This documentation, along with the IA manager's certification and accreditation recommendations, are presented to the CIO, seeking authority to operate the system in a production environment.

Step 4: IA Operations and Maintenance

When a system reaches the Operations and Maintenance stage of its life, there is an assurance that the system meets the functional needs of its user community and that the information associated with the system is adequately protected. Once in this step, the system is in 'lock-down' mode. This means that neither the functional manager (owner) nor the operational manager can change the system without going back to step one. If the system needs functional modifications, the owner will need to define them, update the process, update the design document, and have the system re-evaluated from an IA perspective. The IA review will be looking for changes that may modify the security posture of the system by raising the operational risk. If, for example, a new interface were added to the system, the security risk would change. This would require changes in the information technology infrastructure and operations, and such changes would require the recertification and re-accreditation of the system. On the other hand, if the change included the addition of a new data element or a change in acceptable values associated with a data element, it may not cause an information technology configuration change. In either case, system testing and acceptance would be required prior to moving the change into an operational environment.

When a system is in the operational stage of its lifecycle a number of information assurance activities, designed to protect the information, are active. Below is a partial listing.

- **System Administrator Registration and Certification.** System/network administrators (privileged users) are registered, screened, and certified to perform their privileged user duties (some are listed below).
- **System Log Monitoring.** System administrators monitor the system logs to ensure that only authorized users are accessing the system and that there are no functional problems associated with the system.
- **Account Management.** System administrators add/change/delete accounts, as directed by the system owner, to ensure that only authorized users have access to the information they have a need to access.
- **Information Assurance Vulnerability Actions.** System/network administrators are installing patches to close documented vulnerabilities in the information technology infrastructure and reporting compliance.
- **Incident Reporting/Reaction.** Should an incident occur which is related to the system, the Information Assurance Manager (with support from the system/network administrators) documents and reports the incident to the appropriate response team. Should the incident originate outside the local information technology infrastructure, resulting in the system/network being the victim of the attack, local system/network administrators may be required to take action to protect the system/network.
- **System Risk Assessments.** System/network administrators, in conjunction with the Information Assurance Manager, work on system/network security certification/accreditation tasks. The results of these collaborative actions are risk assessments of our information and information systems and recommendations to overcome the operational risks.

- **Annual User IA Awareness Training.** All users of information technology must complete annual IA awareness training. Failure to comply with this requirement may cause the user to lose his/her access privileges.

Summary

Current methodologies do not typically apply commonly available tools for Information Assurance. The work of the Open Geospatial Consortium and the experience of U.S. federal agencies in IA will enable NBIMS to move forward effectively and quickly. IA is a critical foundational capability that must be provided for each BIM as it is developed and matures, so that the information will be simultaneously well protected and readily available to authorized users when needed.

Next Steps

The OGC process for reaching consensus and proving the technical feasibility of specifications is an appropriate model for ensuring the standards we develop are appropriate for all parties to the capital facilities industry process throughout the entire lifecycle of a facility.

> *OGC's Interoperability Program is a global, hands-on and collaborative prototyping program designed to rapidly develop, test and deliver proven candidate specifications into OGC's Specification Program, where they are formalized for public release. In OGC's Interoperability Initiatives, an international team of technology providers work together to solve specific geo-processing interoperability problems posed by the initiative's sponsoring organizations. OGC Interoperability Initiatives include test beds, pilot projects, interoperability experiments, and interoperability support services - all designed to encourage rapid development, testing, validation and adoption of open, consensus based standards specifications.*[29]

Next steps in IA for BIM:

- 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.

Items Needing Standardization

The question to ask is: What needs to be established as a part of the National BIM Standard? Primarily, it is authentication of the user who is providing or accessing information. Each person desiring to add, modify, or extract information from a BIM should be known to the BIM. An Information Assurance manager shall be assigned for every BIM. This IA manager will be in charge of registering the BIM users. The criticality and credentials of this IA manger should be relative to the level of protection deemed necessary for the function of the facility.

Many BIMs in service today in design or contractor's offices provide relatively limited access, so that access can be managed by a single IT manager establishing relationships between specific users and files within the organization. However, the larger vision of BIM that the NBIMS Committee is proposing to facilitate improved efficiencies at all stages of a facility lifecycle will require transfers of data between independent organizations. The following events are deemed to be important, based on this discussion of information assurance:

[29] http://www.opengeospatial.org/projects/initiatives/ows-4

- Establish IA procedures in new BIMs.
- Initiate encryption-at-rest measures.
- Implement encryption-during-transmission.
- Build IA procedures into the management of the entire lifecycle of the BIM.

Successful Information Assurance will depend on the system architecture and, thus, will have different characteristics for a file-based system than for a system based on web services architecture.

Both the provider and the receiver sides of information access are important. Specific access information is tracked by open source software in each information exchange and managed at the overall BIM level. We must form a basic information management strategy to have assurance that the person adding information has the most accurate information. This does not mean that only someone in the ultimate authoritative position can add information, since the information may be the best available information at that point in time; however, the user of that information needs to know the quality of the information. An example may be as simple as an architect estimating that a column is 24" x 36" for layout purposes, and the structural engineer, after analysis, identifying the column to be 22" x 34". The information about who entered the information is in fact metadata about the information. Hence, the following information should be recorded about each data entry.

Name	Who entered the data? This person needs to be recorded and known to the BIM.
Role	What role does this person play? This information may be stored with the registration information; however, the person may have different roles and the role he or she is in when this particular information is entered may be important.
Contact information	This information is stored with the registration information but may be added here as an aid in operations.
Date/time entered	Knowing when the information was acquired is important in order for users to assess the value and quality of the information. Old information may not be as valuable.
Quality indicator	The person entering the data should have an idea of just how good the information is, whether it is a guess or comes from an authoritative source. At an early phase, a guess may be very helpful; however, one may also want to know what information needs to be updated as the project progresses. Analysis accuracy may also be derived from this indicator.

The standard must address how the system will authenticate the identity of each user, verify the access privileges of each user, and certify the integrity of the data and the processes. Just as you and appropriate banking officials can access your bank account while other people cannot, or a supervisor can access personnel records of direct reports but not of other employees, we must undertake Information Assurance throughout the real property lifecycle of facilities for which we create BIMs.

References and Links

To learn about the mission, background, and objectives of the GeoDigital Right Management Working Group of the OGC:

“Geo Digital Rights Management (GeoDRM) WG”
Open Geospatial Consortium, Inc. (OCG®)
http://www.opengeospatial.org/projects/groups/geodrmwg

Three categories of user scenarios illustrating management of rights to access geospatial data are described:

“Geospatial Digital Rights Management: More than Making Money”
Tina Cary, GeoWorld, vol. 20, No. 1, January 2007, pages 32-35.

An introduction to geospatial digital rights management, how it benefits users of digital spatial content, and how it differs from digital rights management in other industries:

“Geospatial Digital Rights Management”
Tina Cary
http://www.geospatial-solutions.com/geospatialsolutions/article/articleDetail.jsp?id=312232

Ten principles of Information Assurance for owners of home computer systems as well as system administrators:

“Principles of Survivability and Information Assurance”
CERT Coordination Center at Carnegie Mellon University
http://www.cert.org/info_assurance/principles.html

Links to such topics as “Common Sense Guide for Senior Managers: Top Ten Recommended Information Security Practices,” “Which Best Practices are Best for Me?” and “Focus on Resiliency: A Process-Oriented Approach to Security Management”:

“Articles & Reports”
CERT Coordination Center at Carnegie Mellon University
http://www.cert.org/nav/articles_reports.html

Chapter 4.1 Minimum BIM

Introduction

The National Building Information Model Standard (NBIMS) is, by design, a standard of standards. Those who require specific information associated with the exchange of information at any time during a project's lifecycle may select those NIBMS standards that contain the information of interest. Formal or informal agreements between parties to provide standard information exchanges are used to implement these exchanges.

From the point of view of traditional vertical construction (e.g. office buildings), *NBIMS Version 1 - Part 1* defines a minimum standard providing a baseline against which additional, developing information exchange requirements may be layered. The minimum Building Information Model requirements identified below, as well as other references from visionary industry stakeholders, are referenced below. These include works from sources abroad, such as the internationally recommended practices as discussed in Hietanen and Lehtinen's "The Useful Minimum."[30] Here, a useful minimum for IFC implementations is discussed and the authors prescribe technical level approaches for practitioners to maximize collaboration using currently existing BIM software and cultural BIM functionality. Domestically, the General Services Administration (GSA) and Army Corps of Engineers (USACE) clearly and pragmatically define their desired minimum BIM, and these models have been taken into account in the NBIMS Minimum BIM. However, these proven formulas could easily serve as the basis for any AECO firm upon which to base their BIM approach. These documents are highlighted for their content, but they are only a few of the top resources among many advisable current best practices for the use of open standard Building Information Models.

The specific implementation of this guidance in contract language or agreements is beyond the scope of NBIMS. There are contract documents available from the American Institute of Architects (AIA) and a new group called ConsensusDocs.

The minimum requirements for a NBIMS Version 1 building information model include standards for the selection and configuration of software tools, minimum sets of data required for deliverables, requirements for use during construction, and project handover requirements. The specific requirements in each of these areas are described in the following two sections. Either method can be used to determine a minimum BIM.

Using the Capability Maturity Model to Define a Minimum BIM

It is important to note that the NBIMS Capability Maturity Model (CMM) described in Chapter 4.2 provides a complete range of opportunity for BIMs; however, in this section we are simply looking at what constitutes the minimum BIM. By virtue of the information in this section, we are saying that if you are not taking into account this minimum BIM level, then you shall not call what you are doing a building information model. Conversely, you may only be accomplishing visualization or some level of improved document production. We, therefore, define the minimum BIM as having

[30] See Hietanen, J. and Lehtinen, S. "The Useful Minimum," Tampere University of Technology, Virtual Building Laboratory (2006) http://www.facilityinformationcouncil.org/bim/pdfs/usefulminimum.pdf

the following characteristics through the associated areas of maturity in the complete CMM, which can be seen in its entirety in Chapter 4.2.

- **Data Richness.** Having some level of expanded data collected so that the model is a valuable source of information about a facility to a group other than the one developing the information.
- **Lifecycle Views***.* A complete lifecycle project phasing does not need to be implemented at this point.
- **Change Management or ITIL Maturity Assessment.** Note: Business process change management does not yet need to be considered for a minimum BIM. However, it is the hope of the NBIMS Committee that a change management process such as the Information Technology Infrastructure Library (ITIL) program that provides a set of best practice approaches to information management would be used. Using these business processes as your basis will help ensure that everyone is working to converge their efforts. This will help information flow. If it does not, there are procedures to rectify the problems.
- **Roles or Disciplines.** The basis for a BIM includes the sharing of information between disciplines. A minimum level of information sharing is required between designers such as architect and structural engineer.
- **Business Process.** While business process and information interoperability is the cornerstone of BIM, only a minimum level of business processes must integrate their data collection at the minimum BIM level.
- **Timeliness/ Response.** At the minimum level, most information is still being recollected during the lifecycle of the facility and the BIM is not yet expected as the trusted authoritative source for information about the facility.
- **Delivery Method.** In order for a data set to be called a BIM, it must be implemented on a network so discipline information can be shared; however, robust information assurance need not yet be implemented and may be limited to simple password access control to the workstations.
- **Graphical Information.** Since all drawing output should at this point be National CAD Standard compliant, we are making this a requirement for a minimum BIM. This demonstrates that standards are being considered, when possible.
- **Spatial Capability.** The facility need not yet be spatially located as this is a higher-level goal to be considered a minimum BIM.
- **Information Accuracy.** It is a critical element to ensure that ground truth has been implemented, meaning that polygons are located and used to compute space and volume and to identify what areas have been quantified. Hence, we include this item as part of the minimum BIM.
- **Interoperability/IFC Support.** Things may not flow as smoothly as desired today; hence, we are only requiring that ‘forced interoperability’ occur in the minimum BIM, but some level of interoperability must occur.

The following table describes the minimum BIM. By using the Interactive CMM accompanying NBIMS, one should obtain a minimum score of 20.1 in order to consider true BIM maturity. If you are working below this level, then you should consider action to implement additional capabilities in order to mature your building information model. The provision of this report shall constitute certification by the designer that a minimum BIM was attained.

Over time, this minimum level will increase as the rhetorical bar is raised and owners demand more from the models being delivered. This requires cultural change on many levels; not only from designers and contractors, but also from real property operators and sustainers who may have to account for this information in the future. A few early adopters of BIM have implemented far more robust levels of these capabilities.

These metrics are critical to ensure that the BIM produced will be of true value to the facility lifecycle and the capital facilities industry in general. As we progress, perhaps other categories of metrics will be included in the model.

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The Interactive BIM Capability Maturity Model

Area of Interest	Weighted Importance	Choose your perceived maturity level	Credit
Data Richness	84%	Expanded Data Set	1.7
Life-cycle Views	84%	No Complete Project Phase	0.8
Change Management	90%	No ITIL Implementation	0.9
Roles or Disciplines	90%	Two Roles Partially Supported	2.7
Business Process	91%	Few Bus Processes Collect Info	1.8
Timeliness/Response	91%	Most Response Info manually re-collected	1.8
Delivery Method	92%	Network Access w/ Basic IA	2.8
Graphical Information	93%	NCS 2D Non-Intelligent As Designed	2.8
Spatial Capability	94%	Not Spatially Located	0.9
Information Accuracy	95%	Initial Ground Truth	1.9
Interoperability/IFC Support	96%	Forced Interoperability	1.9
		Credit Sum	20.1
		Maturity Level	Minimum BIM

National Institute of Building Sciences
Facilities Information Council
National BIM Standard

Figure 4.1-1 Example of a BIM Achieving a 'Minimum BIM' Maturity Level as seen in the Interactive CMM (Courtesy of NIBS)

Using Data Quality to Determine a Minimum BIM

The USACE BIM Roadmap[31] can be helpful when looking for specific data to include in a BIM from a design or construction perspective. While the Army Corps of Engineers is a large federal owner, it makes sense that the information included in the USACE BIM Roadmap in Chapter 4.2 could be beneficial for any AECO practitioner when creating, using, or editing a BIM. Therefore, the information is referenced here for industry practitioner ease of use and widespread consumption; however, it is important to note that the NBIM Standard is not a compendium of other federal standards rolled into one document. Rather, it is the embodiment of an initiative to improve the performance of facilities over their full lifecycle by fostering a common, standard, and integrated lifecycle information model for the capital facilities industry.

Next Steps

We are only at the earliest stages of BIM implementation in our industry. We are certainly seeking more than minimums in order to realize the true potential of BIM. We see the following as the next steps in achieving improved capabilities.

- Identify the baseline in the industry as it stands today. What is the typical level of BIM in use?
- Continue developing a vision for more mature BIMs and develop a roadmap for raising the level of BIM robustness. Identify deadlines for achieving higher level and more mature implementation over the next 20 or more years.

[31] See https://cadbim.usace.army.mil/default.aspx?p=s&t=19&i=1 for the complete USACE BIM Roadmap or http://www.facilityinformationcouncil.org/bim/pdfs/ERDC-TR-06-10.pdf

References

http://www.nationalcadstandard.org/

Chapter 4.2 Capability Maturity Model

Introduction

The electronic version of the Capability Maturity Model workbook may be downloaded at: http://www.facilityinformationcouncil.org/bim/I-CMM. This will also provide a more readable copy than what is able to be displayed in this document.

The objective of NBIMS and embedded IFC Initiative is to take the next step in technology infusion to transform the building supply chain through open and interoperable information exchange. In this standard, the group of stakeholders in the BIM discussion is referred to as the Architect/Engineer/Constructor/Operator or Owner (AECO) community. To meet the future needs of a more streamlined AECO community and build on existing best business practices, a Capability Maturity Model (CMM) has been developed for users to evaluate their business practices along a continuum or spectrum of desired technical level functionality. The concept of a CMM may be familiar to software developers who create, test, field, and update their software,[32] but the CMM included here is not targeted at software designers. On the contrary, most of NBIMS consists of high-level doctrine or lessons learned regarding BIM, but the CMM is one of the items targeted at the AECO industry for immediate use and application on current processes or BIM projects. The vision is that stakeholders will use the CMM as a tool to plot their current location, while looking to more robust parts of the spectrum as goals for their future operations.

WARNING: While we recognize the temptation, it is not intended for the Capability Maturity Model to be a measure of a company's BIM capability for marketing purposes and use for that purpose is highly discouraged. However, when implemented, stating that a company uses the National BIM Standard will be encouraged.

Tabular CMM

Tabular BIM Capability Maturity Model 5/30/2006

Maturity Level	A Data Richness	B Life-cycle Views	C Roles Or Disciplines	ITIL Maturity Assessment	D Business process	F Timeliness/ Response	E Delivery Method	H Graphical Information	I Spatial Capability	J Information Accuracy	K Interoperability / IFC Support
1	Basic Core Data	No Complete Project Phase	No Single Role Fully Supported	No ITIL Implementation	Separate Processes Not	Most Response Info manually re-	Single Point Access No IA	Primarily Text - No Technical Graphics	Not Spatially Located	No Ground Truth	No Interoperability
2	Expanded Data Set	Planning & Design	Only One Role Supported	Initiation	Few Bus Processes Collect Info	Most Response Info manually re-	Single Point Access w/ Limited IA	2D Non-Intelligent As Designed	Basic Spatial Location	Initial Ground Truth	Forced Interoperability
3	Enhanced Data Set	Add Construction/ Supply	Two Roles Partially Supported	Limited Awareness	Some Bus Process Collect Info	Data Calls Not In BIM But Most Other Data Is	Network Access w/ Basic IA	NCS 2D Non-Intelligent As Designed	Spatially Located	Limited Ground Truth - Int Spaces	Limited Interoperability
4	Data Plus Some Information	Includes Construction/ Supply	Two Roles Fully Supported	Full Awareness	Most Bus Processes Collect Info	Limited Response Info Available In	Network Access w/ Full IA	NCS 2D Intelligent As Designed	Located w/ Limited Info Sharing	Full Ground Truth - Int Spaces	Limited Info Transfers Between COTS
5	Data Plus Expanded Information	Includes Constr/Supply & Fabrication	Partial Plan, Design&Constr Supported	Limited Control	All Business Process(BP) Collect Info	Most Response Info Available In	Limited Web Enabled Services	NCS 2D Intelligent As-Builts	Spatially located w/Metadata	Limited Ground Truth - Int & Ext	Most Info Transfers Between COTS
6	Data w/Limited Authoritative Information	Add Limited Operations & Warranty	Plan, Design & Construction Supported	Full Control	Few BP Collect & Maintain Info	All Response Info Available In BIM	Full Web Enabled Services	NCS 2D Intelligent And Current	Spatially located w/Full Info Share	Full Ground Truth - Int And Ext	Full Info Transfers Between COTS
7	Data w/ Mostly Authoritative Information	Includes Operations & Warranty	Partial Ops & Sustainment Supported	Limited Integration	Some BP Collect & Maintain Info	All Response Info From BIM & Timely	Full Web Enabled Services	3D - Intelligent Graphics	Part of a limited GIS	Limited Comp Areas & Ground	Limited Info Uses IFC's For Interoperability
8	Completely Authoritative Information	Add Financial	Operations & Sustainment Supported	Full Integration	All BP Collect & Maintain Info	Limited Real Time Access From BIM	Web Enabled Services - Secure	3D - Current And Intelligent	Part of a more complete GIS	Full Computed Areas &	Expanded Info Uses IFC's For Interoperability
9	Limited Knowledge Management	Full Facility Life-cycle Collection	All Facility Life-Cycle Roles Supported	Limited Optimization	Some BP Collect&Maint In Real Time	Full Real Time Access From BIM	Netcentric SOA Based CAC	4D - Add Time	Integrated into a complete GIS	Comp GT w/Limited Metrics	Most Info Uses IFC's For Interoperability
10	Full Knowledge Management	Supports External Efforts	Internal and External Roles Supported	Full Optimization	All BP Collect&Maint In Real Time	Real Time Access w/ Live Feeds	Netcentric SOA Role Based CAC	nD - Time & Cost	Integrated into GIS w/ Full Info Flow	Computed Ground Truth w/Full	All Info Uses IFC's For Interoperability

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Figure 4.2-1 CMM Chart (Courtesy NIBS)

[32] For specific information, see http://www.sei.cmu.edu/cmm/ or read *Capability Maturity Model: Guidelines for Improving the Software Process*, Software Engineering Institute, Carnegie Mellon University, ISBN: 0-201-54664-7, 1995. Hardcover, 464 pages, 2006.

There are two versions of the BIM CMM included in NBIMS. The first is called the tabular CMM because it is a static Microsoft Excel® workbook consisting of three worksheets with information that lists the information in a true spectrum. The second is the interactive CMM which consists of a multi-tab Excel workbook that is based on the tabular version, but is different because it interacts with the user as information is entered into the user interface. It is envisioned that the CMM will be web-enabled and served off the NIBS-FIC website, but the Excel file is a low-tech, user friendly way to deliver the same functionality. Both of these two versions of the CMM will be explained here in order of their worksheet tabs in their respective workbooks in Microsoft Excel.

1. **CMM Chart**
As seen in the screen capture, Figure 4.2-1, the CMM is a matrix with an x-axis and a y-axis. On the x-axis, you see 11 areas of interest, in no particular order. On the y-axis, you see maturity levels from 1 to 10 with 1 being the least mature and 10 being the most mature. The body of the matrix puts into words varying levels of maturity describing the areas of interest in an organization or on an individual project. Since the words are subjective and open to interpretation, it is likely that no two people will always agree on all the possible divisions or descriptions of the varying levels of maturity, but they represent a simplified consensus-based approach. In this way, a large number of items are structured in a way that people can use as a launching point for classifying themselves on a somewhat standardized continuum. Finally, it is understood that these descriptions will be updated as the community progresses and greater levels of BIM adoption dictate.

2. **Descriptions**

Capability Maturity Model Category Descriptions

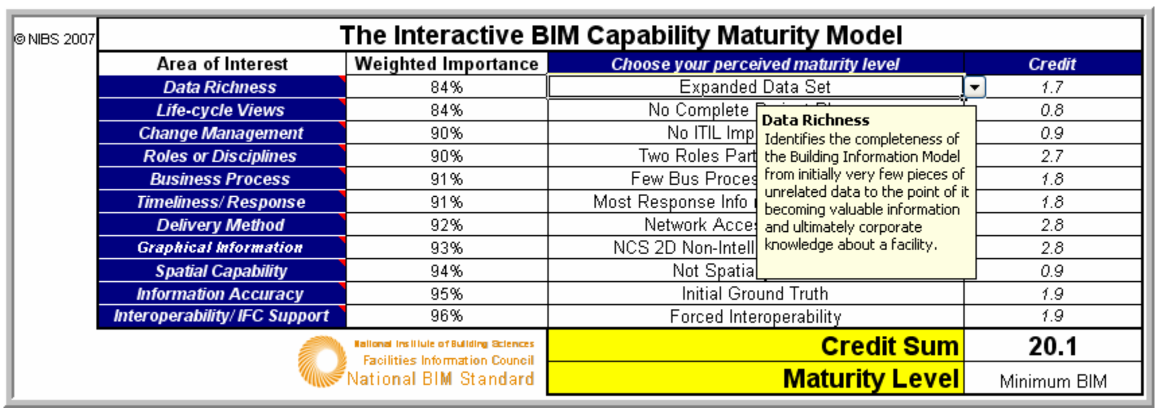
Weight	Title	Description
1.1	Data Richness	Identifies the completeness of the building Information Model from initially very few pieces of unrelated data to the point of it becoming valuable information and ultimately corporate knowledge about a facility
1.1	Life-cycle Views	Views refer to the phases of the project and identifying how many phases are to be covered by the BIM. One would start as individual stove pipes of information and then begin linking those together and taking advantage of information gathered by the authoritative source of the information. This category has high cost reduction, high value implications based on the elimination of duplicative data gathering. The goal would be to support functions outside the traditional facility management roles, such as first responders.
1.2	Roles Or Disciplines	Roles refer to the players involved in the business process and how the information flows. This is also critical to reducing the cost of data re-collection. Disciplines are often involved in more than one view as either a provider or consumer of information. Our goal is to involve both internal and external roles as both providers and consumers of the same information so that data does not have to be re-created and that the authoritative source is the true provider of the information.
1.2	ITIL Maturity Assessment	Information Technology Infrastructure Library provides a set of best practice approaches to information management. Using these business processes as your basis will help ensure that everyone is working to converge their efforts and information will flow. If it does not then there are procedures to rectify the problems.
1.3	Business process	The business process defines how business is accomplished. If the data and information is gathered as part of the business process then data gathering is a no cost requirement. If data is gathered as a separate process then the data will likely not be accurate. The goal is to have data both collected and maintained in a real time environment, so as physical changes are made they are reflected for others to access in their portion of the business process.
1.3	Timeliness/ Response	While some information is more static than other information it all changes and up to the minute accuracy may be critical in emergency situations. The closer to accurate real time information you can be the better quality the decisions that are made. Some of those decisions may be life saving in nature.
1.4	Delivery Method	Data delivery is also critical to success. If data is only available on one machine then sharing can not occur other than by email or hard copy. In a structured networked environment if information is centrally stored or accessible then some sharing will occur. If the model is a systems oriented architecture (SOA) in a web enabled environment the nentcentricity will occur and information will be available in a controlled environment to the appropriate players. Information assurance must be engineered into all phases.
1.5	Graphical Information	Often the starting point is a non-graphical environment. The advent of graphics helps paint a clearer picture for all involved. As standards are applied then information can begin to flow as the provider and receiver must have the same standards in place. As 3D images come into play more consumers of the information will have a common view and a higher level of understanding will occur. As time and cost are added then the interfaces can be expanded significantly.
1.6	Spatial Capability	Understanding where something is in space is significant to many information interfaces and the richness of the information. Energy calculations must know where the heat gains will come from, first responders need to know where water supplies and utility cutoffs are located in relation to the facility.
1.7	Information Accuracy	Having a way to ensure that information remains accurate Is only possible through some mathematical ground truth capability. Having a mathematical product will also allow for better management by supporting difficult to game metrics. These numbers can be used for occupancy, information collection completeness and overall inventory calculations.
1.8	Interoperability/ IFC Support	Our ultimate goal is to ensure interoperability of information. Getting accurate information to the party requiring the information. There are many ways to achieve this, however the most effective is to use a standards based approach to ensure that information is a form that it can be shared and products are available that can read that standard for of information.

Figure 4.2-2 Descriptions (Courtesy of NIBS)

As the screen capture, Figure 4.2-2, shows, the descriptions tab lists and describes all the areas of interest in weighted order in a tabular format. In the Description column, the text is primarily focused on the philosophy of the area of interest as well as setting the stage for what conditions are usually more preferable. For example, under the Information Technology Infrastructure Library (ITIL)[33] Maturity Assessment, it alludes to best business practices or processes for storing and finding information. Complying with this area of interest will first require ITIL awareness, followed by varying levels of excellence along the continuum of control, integration, or optimization. As was said earlier, this will need to be updated as times and terms dictate.

Interactive CMM (I-CMM)

As described above, the interactive CMM is based off the tabular CMM and, as such, it contains all the same information as the tabular CMM, but it centers on a graphical user interface that makes the static information come to life, in a way that may be more easy to digest and understand for some users. Just as the descriptions of the tabular CMM were listed according to their tab number and title in their workbook, so will the tabs of the interactive CMM be described here.



The Interactive BIM Capability Maturity Model			
Area of Interest	Weighted Importance	Choose your perceived maturity level	Credit
Data Richness	84%	Expanded Data Set	1.7
Life-cycle Views	84%	No Complete	0.8
Change Management	90%	No ITIL Imp	0.9
Roles or Disciplines	90%	Two Roles Part	2.7
Business Process	91%	Few Bus Proces	1.8
Timeliness/Response	91%	Most Response Info	1.8
Delivery Method	92%	Network Acce	2.8
Graphical Information	93%	NCS 2D Non-Intell	2.8
Spatial Capability	94%	Not Spatia	0.9
Information Accuracy	95%	Initial Ground Truth	1.9
Interoperability/IFC Support	96%	Forced Interoperability	1.9
		Credit Sum	20.1
		Maturity Level	Minimum BIM

Figure 4.2-3 Interactive Maturity Model (Courtesy of NIBS)

Hovering over each area of interest will elicit a comment with the full description of that area of interest.

1. Interactive Maturity Model

The first, and primary, tab of interest, see Figure 4.2-3, in the interactive maturity model workbook is the tab, Interactive Maturity Model. This interface's mission is to turn the tabular chart, which is successful in showing all the information at once in a matrix format, into an interface that users can interact with to self-evaluate their own processes or BIMs. The areas of interest are listed in the first column, in increasing order of perceived importance.

[33] In the 1980s, the UK asked what is now the Office of Government Commerce (OGC) to develop an approach for efficient and cost-effective use of IT resources by British public sector organizations. The aim was to develop an approach independent of any supplier. This resulted in the ITIL. For more information on ITIL, read: *Introduction to ITIL*, ISBN 0113308663, Published by the Stationery Office, 2002.

Points Required for Certification Levels		
Low	High	
20	29.9	Minimum BIM
30	39.9	Minimum BIM
40	49.9	Minimum BIM
50	69.9	Certified
70	79.9	Silver
80	89.9	Gold
90	100	Platinum

In 2008, the Minimum BIM requires 30 points

Figure 4.2-4 Highlighted, Date-Sensitive Minimum BIM levels (Courtesy of NIBS)

The next column shows the relative percentage out of 100% that each area of interest garners, see Figure 4.2-4. After that, users will choose their own perceived maturity levels by employing the drop-down menus aligned with each area of interest. When clicking on this cell, the dropdown text reminds you of the definition of the area of interest, so that you may make an informed choice among ten levels of maturity. After choosing the correct level of maturity in the desired area of interest, the amount of credits automatically appears in the next column. Together, these credits are summed in the TOTAL box, which in turn determines the level of certification achieved. The varying levels of certification from simply 'Minimum BIM' to 'Platinum,' and they are listed below in the ADMINISTRATION section. It is important to note that the Minimum score required for a Minimum BIM is dependent on the date that the interface is used, which automatically is known as soon as the user opens the interface. If the date is 2008, the minimum score required for the distinction of 'Minimum BIM' is 30 points. If the date were 2009, it is 40 points, and so on to allow for future education and BIM improvements industry-wide.

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The Interactive BIM Capability Maturity Model

Area of Interest	Weighted Importance	Choose your perceived maturity level	Credit
Data Richness	84%	Expanded Data Set	1.7
Life-cycle Views	84%	No Complete Project Phase	0.8
Change Management	90%	No ITIL Implementation	0.9
Roles or Disciplines	90%	Two Roles Partially Supported	2.7
Business Process	91%	Few Bus Processes Collect Info	1.8
Timeliness/Response	91%	Most Response Info manually re-collected	1.8
Delivery Method	92%	Network Access w/ Basic IA	2.8
Graphical Information	93%	NCS 2D Non-Intelligent As Designed	2.8
Spatial Capability	94%	Not Spatially Located	0.9
Information Accuracy	95%	Initial Ground Truth	1.9
Interoperability/IFC Support	96%	Forced Interoperability	1.9
		Credit Sum	20.1
		Maturity Level	Minimum BIM

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National BIM Standard

ADMINISTRATION

Points Required for Certification Levels		
Low	High	
20	29.9	Minimum BIM
30	39.9	Minimum BIM
40	49.9	Minimum BIM
50	69.9	Certified
70	79.9	Silver
80	89.9	Gold
90	100	Platinum

Remaining Points Required For:	Certified	29.9

Hyperlinks:
Interactive Maturity Model
Area of Interest Weighting Flowchart
Tabular Maturity Model
Category Descriptions
Matrix Definitions

Figure 4.2-5 Completed View (Certification Level = Minimum BIM)(Courtesy of NIBS)

All Certified scores, see Figure 4.2-5, currently stay the same regardless of date. The certification scores are similar to most academic grades, with a maximum possible, weighted score of 100 points. Some added user-friendly features include the area that shows the *remaining points required* to reach the next level of certification, as well as hyperlinks to other tabs of functionality within the workbook.

2. Area of Interest Chart

The Area of Interest Chart, see Figure 4.2-6, is tied to the credits column on the first tab of the application. Therefore, every time a perceived maturity level is selected, its credits are listed on the first tab but graphed on this tab. In this way, users can easily see where their operations are the most mature.

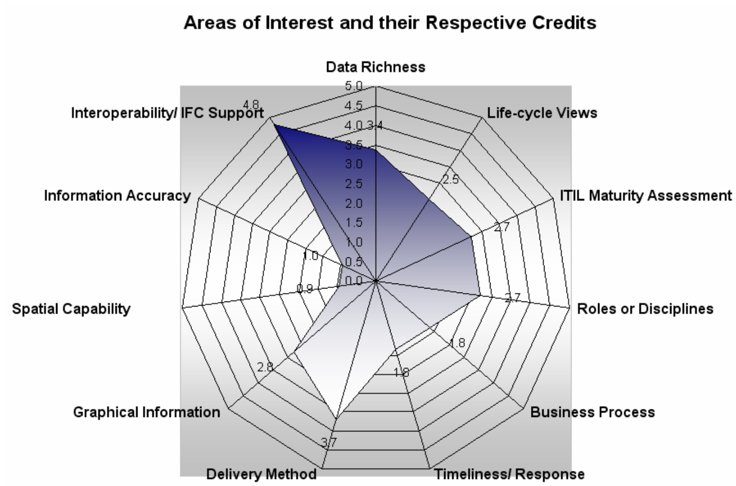

Figure 4.2-6 Areas of Interest and their Respective Credit Chart (Courtesy of NIBS)

3. Area of Interest Weighting

The next tab, see Figure 4.2-7, the Area of Interest Weighting tab shows a hierarchical decision tree of the weighting of the different areas of interest. Were your organization to disagree with the existing weighting scheme, you could use this as a launching point for creating your own weighting scheme and edit the application to reflect your own preferences. However, as the community grows and best business practices are achieved, the hope is for a national consensus on the appropriate level of weighting for the 11 areas of interest.

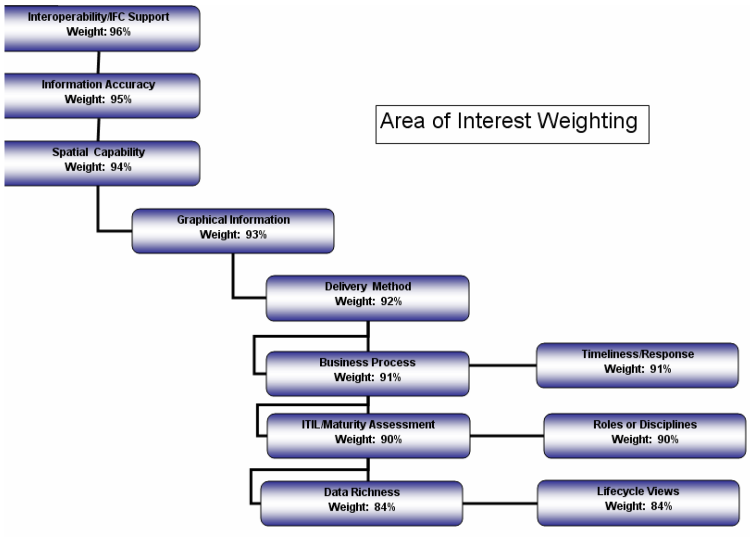

Figure 4.2-7 – Area of Interest Weighting Hierarchy (Courtesy of NIBS)

4. **Tabular Maturity Model/Category Descriptions**
The Tabular Maturity Model and Category Descriptions tabs are the same information as described above in the Tabular CMM portion of this section. The same information is also included in this application so that users may see their information in as many ways as necessary to help them establish a metric for establishing and evaluating their own maturity level.

I-CMM Testing and Evaluation

In order to ensure that the I-CMM could be used to successfully convert subjective case-by-case ratings into an objective quantitative score, the NBIMS Testing Team undertook a test bed validation of the NBIMS I-CMM in the summer of 2007. With the approval of the American Institute of Architects, Technology in Architectural Practice (AIA-TAP) Community of Practice, the winning 2007 BIM Award submissions were evaluated using the I-CMM. Six NBIMS Testing Team Members evaluated the nine winning submissions. Because the test was focused on validating the I-CMM and not on the already proven superior quality of the BIM models themselves, special attention was focused on the ability of the individual evaluators to replicate similar scores without any influences from the other evaluators.

The results yielded no more than a 5% difference in the various scores of the evaluators on the same BIM, and normally resulted in a 1% (or only 1 point out of 100) difference when the evaluators used the I-CMM to analyze the different BIM submissions.

The team noted that the I-CMM is primarily focused on leveraging information management, rather than architectural, engineering, construction, or management metrics. Accordingly, the BIMs scored received a wide range of scores commensurate with their project requirements. Logically, the highest scoring BIM submission was a test bed BIM pushing the edge of current interoperability, while the lowest scoring BIM (which received a 'Minimum BIM' rating) was for a custom-designed residential home. Therefore, it is important to note that the I-CMM is very effective at measuring BIM information management, but it should not be used as a benchmark for any other metrics. In other words, just as owners' needs do not require that every building be built to LEED-Platinum standards, neither should any BIM be perceived as less successful if it does not achieve an I-CMM Platinum score.

Further testing work has been accomplished with similar successful results at locations such as the Army Corps of Engineers Seattle and Louisville Districts on their test bed BIM projects; however, like NBIMS itself, the I-CMM will need to be updated according to industry capabilities and needs.

Conclusion

The purpose of the National BIM Standard Committee is to knit together the broadest and deepest constituency ever assembled to address the losses and limitations associated with errors and inefficiencies in the building supply chain. A BIM should access all pertinent graphic and non-graphic information about a facility as an integrated resource, but there are varying levels of maturity when pursuing this goal. The goals of the two Capability Maturity Models, both tabular and interactive, are to help users gauge their current maturity level, as well as plan for future maturity attainment goals through a commonly accepted, standardized approach. As industry evolves and more rapidly adopts greater levels of maturity, this model will change to accurately reflect best industry practices.

Next Steps

The NIBS-FIC Business Process Integration Task Team (BPITT) hopes to provide web-enabled publication support of the interactive maturity model. This currently notional web-based interface should provide a means for both certifying BIM products (such as specific models) and accrediting individual professionals for demonstrating knowledge in the information and processes outlined in NBIMS. A diagram of the proposed, added functionality of this notional web interface looks like Figure 4-2.8.

In this way, people would be motivated to learn the information in NBIMS because they could enjoy the recognition that accreditation would provide. The NBIMS Committee would benefit from having followers who could accurately relay correct information about proper BIM/IDM methodology. Furthermore, projects receiving certification would provide discriminators for forward-looking companies to demonstrate their ability to comply with proper NBIMS operations for the AECO community, which could help them win jobs or build respect in their fields. The corollary benefit would be that every certified BIM would go to a repository of information that the NIBS-FIC could mine for data regarding maturity or best business practices. This empirical data would provide trends that could easily be converted to lessons learned the BPITT could leverage in recommending or shaping future business practices.

While the information above is merely proposed, one thing is certain: This is the inaugural version of the BIM Capability Maturity Model and much work remains to be done in order to mature it to be a fully integrated product.

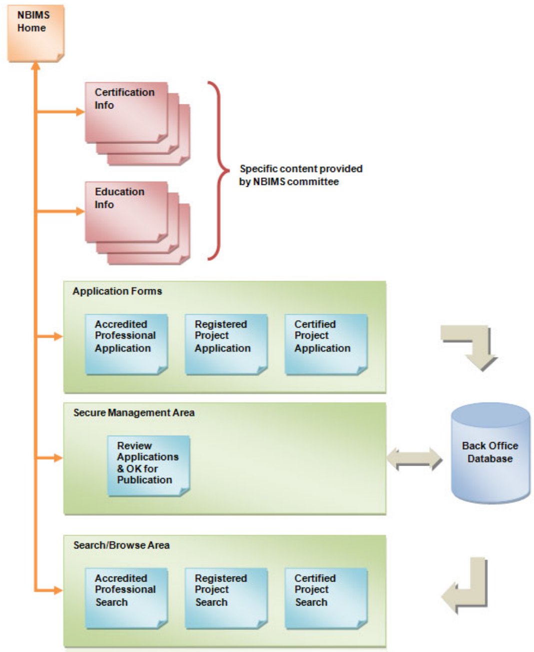

Figure 4.2-8 Proposed Web-Based Application for Certifying BIMs and Accrediting BIM Professionals (Graphic created and provided by Donald F. Sanborn, Unique Solutions, Inc)

The following steps are required to take the CMM to the next level.

- Research is required to evaluate the current level of capability of BIMs in use in the industry today and to ensure that the rankings proposed herein are valid. There is concern that we may have set the bar too high and that most current BIMs will not be certified.
- This section has been initially coordinated with the minimum BIM section[34] to ensure that the certified level is in fact what is being described in that section. The concern here is that there are many so-called BIMs in existence that are not truly BIMs, since they are actually only intelligent drawings, visualization tools, or production aides. In a more positive light, the current Capability Maturity Model gives the AECO community a spectrum of tangible capabilities where they can determine their current maturity and use higher levels on the spectrum as developmental goals. Future work will be done to improve the Maturity Model as it needs to be bettered to mirror the burgeoning BIM community.
- The governing body of the NBIMS team will need to certify BIMs and testing processes in order to build a database of best practices and isolate areas of opportunity for improvements in the BIM community. It also needs to provide a means and motivation for users to create reliable information that is stored in open and interoperable formats.

NOTE: The Capability Maturity Model workbook may be downloaded at http://www.facilityinformationcouncil.org/bim/I-CMM.

[34] See NBIMS Section 4.2.

Chapter 5.1 Overview of Exchange Standard Development and Use Process

Introduction

Section 5 is dedicated to describing processes the NBIMS Committee will employ to produce the NBIM Standard Exchange Definitions and facilitate Standard deployment and use. An overview diagram is provided in Figure 5.1-1. Components of this diagram correspond to chapters that follow in Section 5. A smaller orientation diagram is also provided within each chapter.

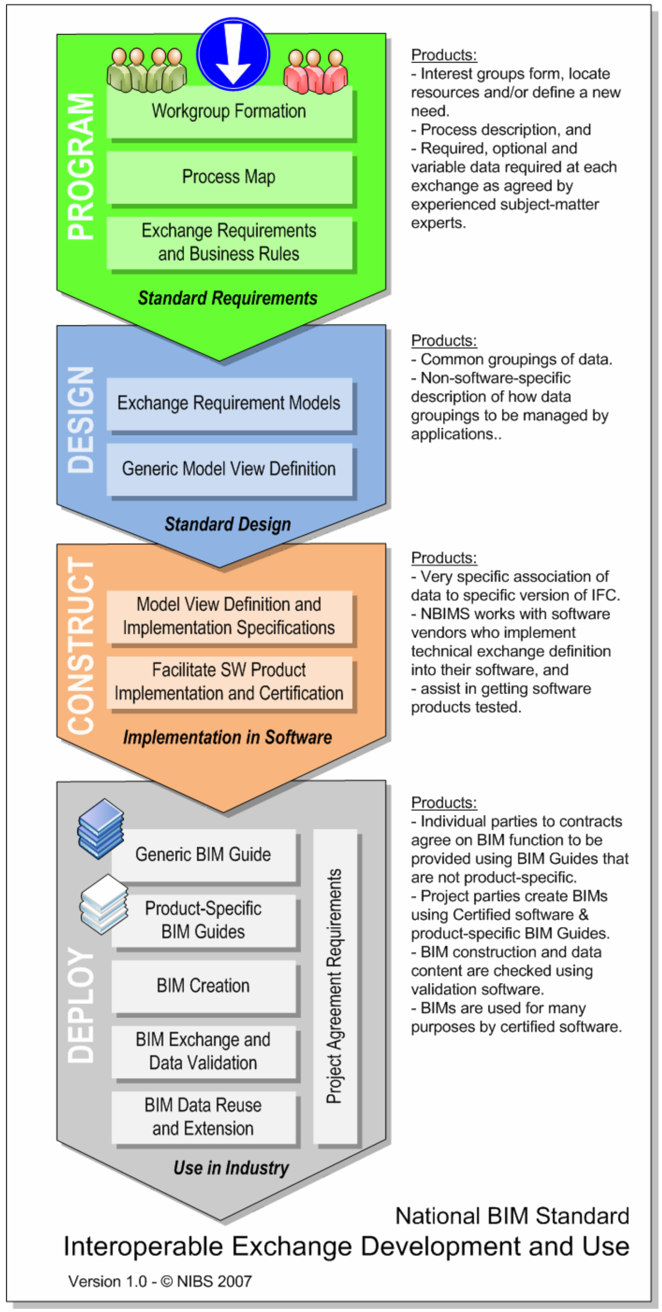

Figure 5.1-1 Development and Use Diagram

NBIM Standard Phases of Development and Implementation

Programming

'Programming' suggests that the purpose of this phase is support research and discovery of needed exchanges and to set the requirements for a useful exchange standard. Research and logistics activities are included in this phase as well in order to assure an efficient activity and set the stage for a successful deployment when the Standard is released. Chapter 5.2 describes this phase in detail.

Design

'Design' refers to organizing information concepts in the exchange in much the same way as architects organize physical and spatial elements needed in a facility. Exchange designers take into account existing concepts as well as those new to this particular exchange requirement. Similar to architectural solutions, exchange designers seek elegant and rich methods of organizing information into useful assemblies. Chapter 5.3 describes in greater detail the modeling of exchange requirements and generic model view definitions.

Construction

'Construction' describes the work in this phase linking generic information concepts with specific elements that are available in standard schema. A standard schema is a widely agreed 'family' of related information. If a concept is related to a known family structure then it is easy for everyone to use the information in a consistent way to achieve predictable results. A primary purpose of this phase is to prepare and express the data so that it is familiar and easy for software developers to implement the Standard in their applications. Once the Standard is implemented in software, developers will want to have their software tested and certified for this capability. The NBIMS Committee will not implement Standards in software but will work with application developers to implement the Standard as well as help to facilitate compliance testing and certification. Chapter 5.4 discusses technical specifications and facilitation of software product implementation and certification in more detail.

Deployment

Deployment refers to a wide range of products and activities, all focused on facilitating the successful implementation and use of NBIM Standard exchanges. Deployment is where the value of the NBIM Standard is realized. Whether it be during project planning and contracting, BIM creation with the confidence of a predictable result, easy and reliable BIM model exchanges, or models that can be readily reused and/or repurposed. Deployment concepts are discussed in Chapter 5.5.

Detailed Production Process Tasks

The National BIM Standard production process brings together concepts which have been in separate development until now. The purpose in bringing these concepts together is to provide a methodology for Standard development that works well both in its individual components and as a complete end-to-end solution. In short, this process is designed to identify a needed exchange, prepare and publish a specification that can be used by software developers, assist developers to implement the specification in applications, and assist end-users to apply the software and resulting BIM models beneficially. Figure 5.1.2 is a list of the tasks, ordered in sequence, of the planned production and use process. This figure also provides information on work products, required resources, how products will be reviewed and approved, and use of existing standards to accomplish the work. Detailed tasks are discussed and relevance of each is explored in more detail in other Section 5 chapters.

Figure 5.1-2 - Development Process Task Detail

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
1.0	Workgroup Formation						
1.1	Interest Group	Discussion group/s on website to establish need, build interest/committement and begin scoping activity.	NBIMS	none, NBIMS monitors discussions	NBIMS User Exchange Requirements Site	Scoping WorkGroup (WG), Interested domain experts	Discussion threads
1.2	Project Definition	Formal definition of workgroup, including: document business case, commit participants, commit resources, etc. Establish Development Approach including whether approach is to be a new development, an adaptation of a current development or support to an existing application. This will determine the order of work (whether process mapping occurs first or later)	NBIMS	No formal NBIMS approval at this point. NBIMS facilitates formation of groups.	NBIMS User Exchange Requirements Site	Facilitated WorkGroup populated by Interested domain experts	WG Charter
1.3	Propose NBIMS Project Team	Based on consensus in the tasks above, participants propose formation of a Project Working Group (WG) that will develop formal requirements specifications.	NBIMS	Completion of WG Charter and review of NBIMS Workgroup Program Manager	NBIMS Project Proposal Template	WG leadership, NBIMS Workgroup Program Mgr.	Qualified WG Charter
1.4	Acceptance of Project Status	Review and action by Executive Board of Acceptance	NBIMS	Executive Board of Acceptance	NBIMS Project Proposal Template	NBIMS Project Review Board	Announcement and Coordination with MOU members

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
	Project Reporting						
	Project updates	All project WGs will continuously post work to the NBIMS portal, and generate a project status report quarterly --- through all project phases.	NBIMS	WG Mgr, NBIMS Workgroup Program Manager	NBIMS Portal & Website	Project WG	Project Status Report, WG HealthCheck
	Requirements Specifications						
2	PM-Process Map	A Process Map gives an overview of the end user process, describing its objective and the project stage(s) at which the process will be used. This includes: process identification, process purpose,sub-processes, project stages, and project actors.	IAI-IDM	WG Consensus Vote	BPMN diagramming template, process task descriptions template	Project WG, Faciliitator, NBIMS PM	PM Document
2.1	PM Release for Comment	WG vote to release PM for selected review and comment.	NBIMS-IDM	WG Consensus Vote	NBIMS Portal	Project WG, Faciliitator, NBIMS PM	IDM Doc Set
2.2	PM Comment Period	Comment period with selected reviewers	NBIMS-IDM	calendar	? TBD	NBIMS PM	Comments
2.3	PM Revisions	Revisions based on comments	NBIMS-IDM	WG Consensus Vote	BPMN diagramming template, process task descriptions template	Project WG, Faciliitator, NBIMS PM	IDM Doc Set
3.0	ER-Exchange Requirement	Exchange Requirements document the information that must be passed from one business process to enable another. This includes: actors from/to, input, information requirements (req./opt.), and output	IAI-IDM	WG Consensus Vote	IDM Wiki, IFD Website	Project WG, Faciliitator, NBIMS PM	ER Document

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
3.1	ER - Functional Part (FP)	Identify and document reusable information groups, independent of any technical solution. FPs are part of the ER that may be reused in other Ers (not shown in diagram)	IAI-IDM	WG Consensus Vote	IDM Wiki	Project WG, Faciliitator, NBIMS PM	FP Document (w/o IFC mapping)
4.0	ER - Business Rules (BR)	Business rules define constraints or limitations on specific data in specific contexts. Generally these are defined as user level constraints or instructions. They may also require the use of a reference industry standard to guide or limit the relevant BIM data. For example: mandating use of the Uniformat classification system. BRs should be documented specifically for each ER as there is a 1:1 correspondence and the ER/BR combination will be used together for data validation in projects. Different organizations/regions/coutries may define different BRs for a given ER. Example: for an ER on classification, the US may choose to use Uniformat 'rules', whereas the UK will likely choose to use 'Rules' from the corresponding UK systems oriented classification standard.	IAI-IDM	WG Consensus Vote	IDM Wiki	Project WG, Faciliitator, NBIMS PM	Updated FP Document (w/o IFC mapping)
4.1	ER Release for Comment	WG vote to release ER for selected review and comment.	NBIMS - IDM	WG Consensus Vote	NBIMS Portal	Project WG, Faciliitator, NBIMS PM	IDM Doc Set
4.2	ER Comment Period	Comment period with selected reviewers	NBIMS - IDM	calendar	? TBD	NBIMS PM	Comments
4.3	ER Revisions	Revisions based on comments	NBIMS - IDM	WG Consensus Vote	IDM Wiki	Project WG, Faciliitator, NBIMS PM	IDM Doc Set
4.4	ER Consensus Ballot to Release for Public Use	NBIMS consensus voting process	NIBS-NBIMS	NBIMS Consensus Ballot	NBIMS consensus ballot	NBIMS committees	Ballot results

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
4.5	ER Release for Public Use	Document describing the information that must be passed from one business process to enable another is released for public use. This document is intended to be used by business people in general. Software developers may use this document, but other products are intended more specifically for use in software development.	NIBS-NBIMS	Milestone	NBIMS Portal & Website	Project WG	Published IDM
	NBIMS Solution Specification						
5.1	ERM - Exchange Requirements Model(s) - Generic SW Concepts -	Define the software concepts that will be used to represent the data in the ER. These will often correlate with the FPs identified in the ER. Reuse of SW concepts used to representat the same or similar FPs in past model views will be strongly encouraged and will be facilitated through the international MVD web site.	IAI-MVD	MVD Specialis submits recommendation, WG Approves	MVD Web site	Project WG, MVD Specialist	MVD Overview
5.2	ERM Release for Comment	Comment period with selected reviewers, after WG vote to release for comment	NBIMS-MVD	WG Consensus Vote	NBIMS Portal	Project WG, MVD Specialist NBIMS PM	MVD Overview
5.3	ERM Comment Period	Comment period with selected reviewers	NBIMS-MVD	calendar	? TBD	NBIMS PM	Comments
5.4	ERM Revisions	Revisions based on comments	NBIMS-MVD	WG Consensus Vote		Project WG, MVD Specialist NBIMS PM	MVD Overview
7.0	MVD - Model View Definition - Generic SW Concepts -	Integrate and harmonize the SW concepts from two or more ERMs to formulate a single model view that can be used to satisfy all requirements from all included ERs. While ERMs are specific to a process, MVDs will tend to align with standard or milestone exchanges between industry disciplines (e.g. from architec to structural engineer in the concept design phase). This version of the model view is still IFC release independent -- so it can be mapped/bound to any IFC release in the next development step.	IAI-MVD	MVD Specialist submits recommendation, WG Approves	MVD Web site, Visio toolset	Project WG, MVD Specialist NBIMS PM	MVD Generic Concept Documents

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
7.1	MVD Release for Comment	WG vote to release PM for selected review and comment.	NBIMS-MVD	WG Consensus Vote	NBIMS Portal	Project WG	MVD Generic Concept Documents
	MVD Comment Period	Comment period with selected reviewers	NBIMS-MVD	calendar	? TBD	NBIMS PM	Comments
7.2	MVD Revisions	Revisions based on comments	NBIMS-MVD	WG Consensus Vote	MVD Web site, Visio toolset	Project WG, Outsource	MVD Overview
8.0	MVD - Model View Definition - Concept Binding to IFC Release -	Map/bind each generic concept from the previous stage to objects, properties, and relationships in a specific release of IFC. This will be documented in 3 ways: IFC binding diagrams (using the MVD Visio based template) and implementation specifications (using the MVD MS Word template for descriptions, rules, labels, etc. and using the MVD Visio based template for data instantiation diagrams). The result is an unambiguous specification for implementing support for exchange of the concept data in this model view.IFC Release specific bindings for any of the contained ERMs can be extracted. In the near term these must be done maually, long term it should be possible to extract these using a tool.Business rules will be translated to a machine interpretable form to support automated data validation. There are multiple options for representing the rules, but the most appropriate to this IFC based technical solution is an IFC Constraints model -- which multiple data validation software products can support.	IAI-MVD	MVD specialist and Implementers	MVD Web site, Visio toolset	Project WG, MVD/IFC Specialist, Implementers	MVD Concept Binding Documents
8.1	Release for Comment	WG vote to release PM for selected review and comment.	NBIMS-MVD	WG Consensus Vote	NBIMS Portal	Project WG	MVD Document Set
8.2	Comment Period	Comment period with selected reviewers	NBIMS-MVD	calendar	? TBD	Project WG, MVD/IFC Specialist, Implementers	Comments

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
8.3	Revisions	Revisions based on comments	NBIMS-MVD	WG Consensus Vote	MVD Web site, Visio toolset	Project WG, Outsource	MVD Concept Binding Documents
8.4	Consensus Ballot to Release MVD for Public Use	NBIMS consensus voting process	NIBS/NBIMS	NBIMS Consensus Ballot	NBIMS consensus ballot	NBIMS committees	Ballot results
8.5	Release MVD for Public Use	MVD definition is released to public for general use.	NIBS/NBIMS	calendar	NBIMS Website	Project WG	Published MVD
8.6	Submit 'Draft' MVD to IAI	This submission will get the MVD on the international standardization track.	IAI - MVD	calendar		Project WG	Proposed MVD
	Information Model Changes (Optional and not shown in the diagram)						
	Submit IFC change requests to IAI	This request will address concepts seen as missing from IFC by the project team. It requests that IAI add the missing concepts in its next release if IFC.	IAI/IFC Dev Process	WG Consensus Vote	IAI Tools	Project WG	Request documents
	IAI Development of requested changes	Development of the requested extensions during the IAI's next IFC release development cycle.	IAI/IFC Dev Process	IAI Methods	IAI Tools	IAI Staff	IFC Development Reports
	New IFC version review and revision	Review, comment, and revision of new IFC release -- per IAI's review process.	IAI/IFC Dev Process	IAI Methods	IAI Tools	IAI Staff	IFC Release Specifications
	New IFC Release	IFC Release milestone	IAI/IFC Dev Process	IAI Methods	IAI Tools	IAI Staff	Press Release

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
	Information Model Changes (Optional and not shown in the diagram)						
11.0	Facilitated Implementation based on MVDs	NBIMS to organize and manage the program in which vendors teams will be implement and NBIMS will facilitate testing and update specifications based on feedback and questions through the program. Not shown in the diagram.	MVD	NBIMS/Vendor Team Consensus	MVD, Project schedule, test cases	Project WG, Outsource, Vendor staff	Candidate products (for certification)
12	Certification Testing and Revisions - relative to MVD implementation Specifications	Certification testing checks that software products have fully implementated requirements in the MVD Implementation Specifications.	MVD	NBIMS/IAI Methods	MVD, SW Testing tools	Project WG, Outsource, Vendor staff	Draft Project Implementations Report
12.1	Pilot Project Data Validation Testing and Revisions - relative to original ER/BR Requirements	Will need tools for automated checking against business rules and then Pilot Projects to test for usability by industry professionals. Pilot projects are not currently separated in the diagram, but these can be thought of as the first of the deployment (Project Data Exchange) cycles that are implicit in the diagram.	MVD	NBIMS/IAI Methods	IDM, data validation tools	Project WG, Outsource, Vendor staff	Project Implementations Report
14.0	Publish test results	Results of the pilot projects phase and the validated software products will be published on the NBIMS web site -- as a resource for industry professionals in planning for future projects.	MVD	NBIMS/IAI Methods	NBIMS Website	NBIMS Staff, Project WG	Press Release

Phase	Step	Activity Description	Normative Std.	Approval Method	Tools	Staffing	Product
	Industry Deployment (shown as Project Data Exchange in the diagram)						
15.0	Project agreements	Building project agreements will require use of specific ERs and associated BRs in routine project exchange.	IDM/MVD	Project Team Contract Agreements	NBIMS Website, IDM Website	Industry Projects	Project Agreement(s)
17.0	Project BIM Creation	Project team members will use BIM authoring applications that are certified for export support of the MVD(s) that include the ERs required by the project agreement(s). At the exchange milestone, they will export the appropriate Model View of the BIM.	IDM/MVD	Project Team Contract Agreements	Certified BIM Sofware	Industry Projects	Model View of the BIM
18.0	Project Data Validation	Project BIM model checking (data validation) will be done as part of the regular process using data validation tools. These tools will load the machine interpretible ERM rules and then check the BIM for conformance to those rules --- as mandated by the project agreement(s).	IDM/MVD	Project Team Contract Agreements	BIM Data Validation Software	Industry Projects	BIM Data Validation Report
19.0	Project BIM Use	Project team members will use BIM applications that are certified for import support of the MVD(s) that include the ERs required by the project agreement(s). At the exchange milestone, they will import the BIM validated in the previous step.	IDM/MVD	Project Team Contract Agreements	Certified BIM Sofware	Industry Projects	Analysis, report, or similar resulting from the app using the exchanged BIM
	END						

Glossary of Terms for Figure 5.1-2

Normative Standards Column:

IDM.. Information Delivery Manual. The exchange definition written in non-technical prose for use by end-users. Describes the business process, stakeholders, exchange points, information requirements and business rules.

MVD .... Model View Definition. The technical exchange definition for use by software developers.

Approval Method Column

Calendar.. Task or process proceeds for a set number of calendar days.

Executive Board of Acceptance .... NBIMS Executive Committee reviews and votes whether to approve.

IAI Methods .... NBIM Standards Committee anticipate adopting established IAI methods.

MVD Specialist and Implementers............. Model View Definition Specialists and/or trained implementers perform tasks and determine fitness of completed products. Guidance by NBIM Standard policies may control Specialist or Implementer actions.

NBIMS Consensus Ballot........................... Formal NBIM Standard Consensus Committee balloting and voting procedure. Planned to be similar to National Institute of Building Sciences National CAD Standard process.

NBIMS/IAI Methods................................... International Alliance for Interoperability (IAI) methods as adapted to NBIMS regional and organizational context.

NBIMS/Vendor Team Consensus.............. Vendor teams, with NBIMS oversight, will determine approval using a team-oriented majority voting process.

Project Team Contract Agreements........... Signed contract agreements made between members of a project team

WG Consensus Vote.................................. Workgroup Consensus Vote. Approval by majority vote of a workgroup.

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Chapter 5.2 Workgroup Formation and Requirements Definition

Introduction

Lessons learned from CAD implementation suggest that a systematic approach to documenting industry knowledge and processes and then mapping this knowledge to data standards is needed to facilitate better software for the industry. Without this process, knowledge capture and data mapping, implementation will take much longer, cost much more, and will propagate uncertain outcomes within the industry.

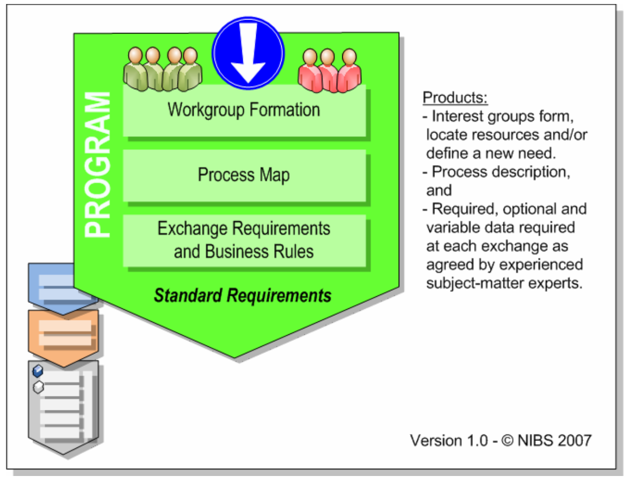


Figure 5.2-1 NBIMS Development and Use Diagram: Programming Phase

NBIMS supports a four step methodology to capture industry knowledge, data standards, and develop software schema supporting better BIM implementation. These stages of development align with the International Information Delivery Manual (IDM) (Figure 5.2-2) methodology of the International Alliance for Interoperability (IAI) and Business Process Modeling Notation (BPMN), a business process modeling standard used extensively by many industries for some activities.

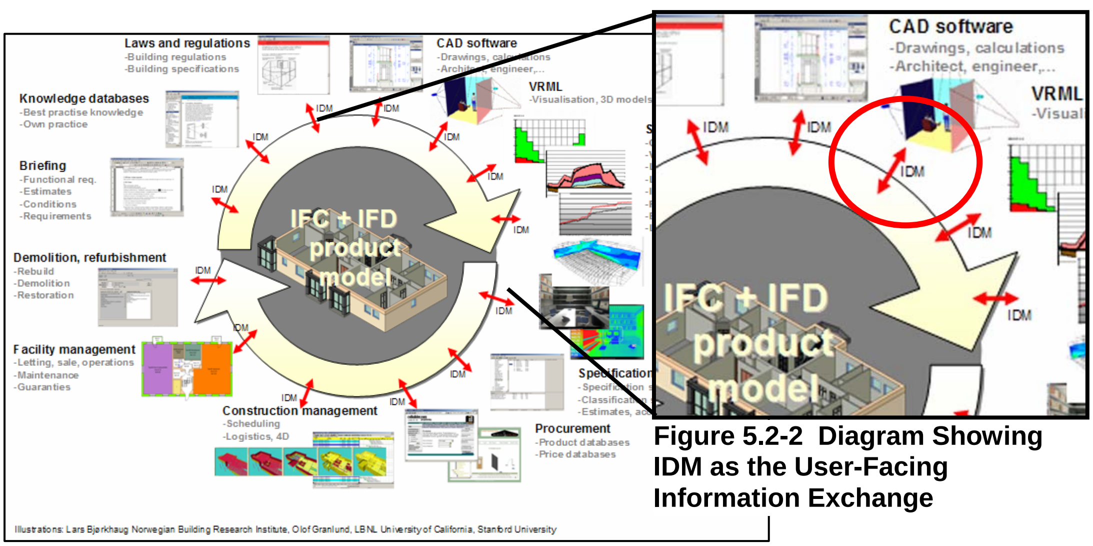


Figure 5.2-2 Diagram Showing IDM as the User-Facing Information Exchange

This chapter summarizes the Programming Phase of NBIMS and how industry organizations, groups, or individuals participate in this user-facing activity. It defines the procedures, tools, and templates being developed both globally and locally (North America and Canada) to support this phase.

The NBIMS Programming Phase

A goal of the Programming Phase is to capture user knowledge through use of the IDM process to create information exchange requirements (ER) for handover to the Design Phase of NBIMS development. The aim of IDM is to support the information exchange requirements for business processes within the building construction industry. Some examples of industry areas of interest for knowledge capture, process mapping, and information exchange creation include design, energy, structure, MEP (mechanical, electrical, and plumbing), and space. Many processes and information exchanges support these broad interests, and so programming focuses on the user requirements.

Activities in the Programming Phase are user-facing and centered on information requirements and workflow. The activities are not yet specific to particular software applications. Participants in the Programming Phase do not need to possess special technical capabilities. They are asked to function within a workgroup as subject-matter experts for the domain of the exchange definition under consideration. The activity relies upon common English, standard construction terminology, and classification standards.

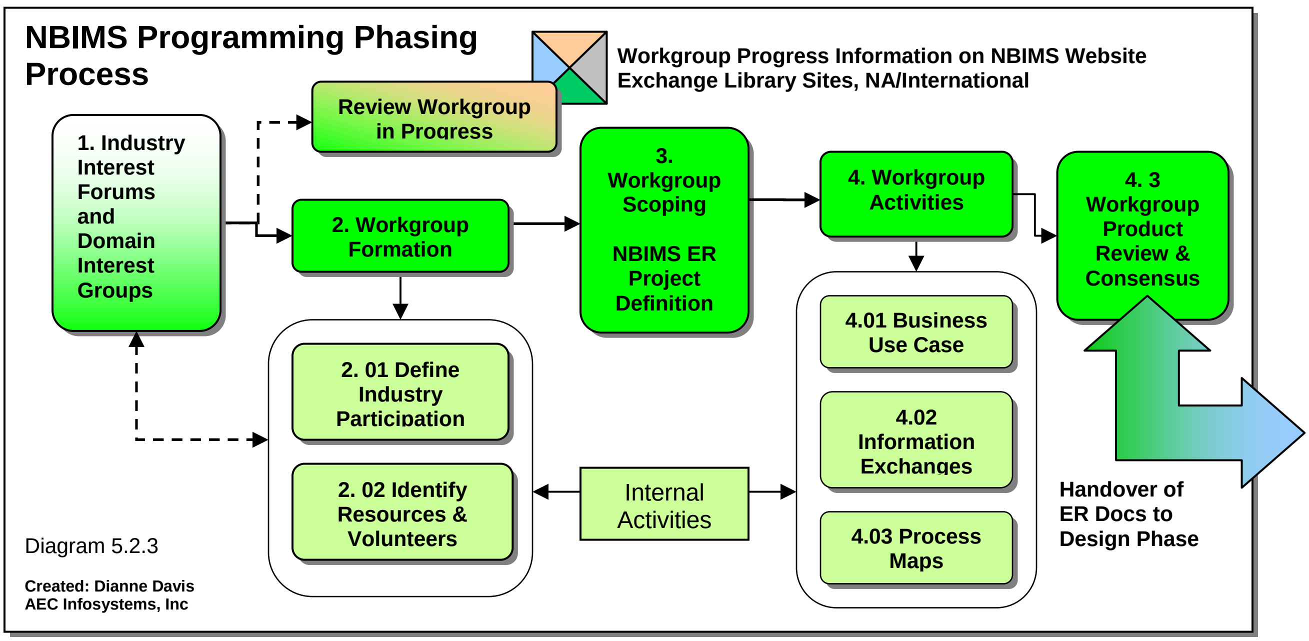


Figure 5.2-3 Numbers of the Following Headings Follow the Programming Phase Process Diagram

Exchange Requirements (ER) are the foundation of the more technically-oriented phases described in Chapters 5.3 and 5.4. Programming, design, and construction phases lead to commercially available software capable of supporting an industry-driven need.

Programming Phase Activity 1.0: Industry Involvement and Workgroup Formation

A listserv and a web-based team site are currently used to facilitate coordination of the NBIMS committees and task teams.

The listserv is hosted by the National Institute of Building Sciences (NIBS) and the team site is donated by and hosted by the Open Geospatial Consortium (OGC).

The listserv is a program that automatically sends messages to multiple e-mail addresses on a mailing list. When someone subscribes to a mailing list, the listserv will automatically distribute future e-mail messages to that address along with all the others on the list. The listserv currently serves as the community bulletin board. A bulletin board is adequate for notices or for brief, informal discussions around a topic. But as interests become more focused and discussions require a more persistent forum, a new type of resource is required.

Figure 5.2-4 NBIMS Knowledge Capture. (Image © 2007 Onuma/AEC Infosystems, Inc.)

The NBIMS Committee team site is a traditional web-based file management service for use by Committee task teams. Logon with a password is provided to active members of task teams. Individuals may sign up for task teams via the NBIMS website at http://www.facilityinformationcouncil.org/bim/committee_join.php.

The listserv and team site are useful for Committee management, but additional capabilities are needed to provide:

- Forums for interest groups where common interests may be explored and incubated,
- Workflow management, and
- Custom forms and capabilities needed to initiate and implement IDM development.

Areas of Interest for NBIMS
As a NIBS Committee, NBIMS will utilize the multi-disciplinary categories supported by NIBS as current designations for areas of interest.

Consumer and General Interest
Architects
Engineers
Federal Government
State and Local Government
Building Construction
Labor Organizations
Housing
Building Materials, Products or Software
Standards
Real Estate, Finance or Insurance
Research, Testing or Other Services

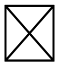
Figure 5.2-5 NIBS Areas of Interest

Programming Phase Activity 2.0: Workgroup Formation

IDM Research and Coordination. The NBIMS Workgroup Formation Phase is the formal starting point for NBIM Standard production activity. However, prior to starting any new activities it is important to know if previous or current work exists in the same or similar subject areas. Currently, researching IDM development activities, or even similar activities not following IDM methodology, requires searching several independent databases and/or contacting several individuals or institutions. Consolidating IDM research and relevant project status is an important component of the NBIM Standard Workgroup Formation phase.

An efficient, multi-disciplinary standard which re-uses information and technical encodings must be aware of existing results and of partnering opportunities. NBIMS will focus on developing exchange definitions appropriate for North American contexts, but NBIMS is also coordinating with international buildingSMART® alliances for methods and tools and for exchange definition work occurring outside North America. NBIMS anticipates that it will make use of the existing international buildingSMART IDM information website both to locate similar activities and to post North American IDM work in progress. The current link is: http://www.iai-tech.org/products/idm_specification/index_html/?searchterm=idm.

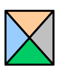
To facilitate a rapid understanding of existing exchange definitions and IDM activities in North America and to facilitate initial proposals for new IDM activities, an exchange library accessible through the NBIMS website is being developed. It will be searchable using areas of interest, current workgroups, and Construction Specifications Institute (CSI) *OmniClass*™ tables. The following key graphic, coordinated with the NBIMS Development and Use Process, is proposed to indicate the status of an activity.



White Box indicates an Area of Interest has been identified, but a workgroup is not formed. The activity may be incorporating some international activity.

When sufficient interest, appropriate professionals, and adequate resources are available to make knowledge capture successful, then the Programming activity and workgroup formation can begin. A member of a discussion group can act as Champion to work with NBIMS Task Team leadership to begin workgroup formation activities. During formation, a discussion group will define in general what process is to be modeled, identify existing information and/or capabilities, designate its leadership, develop a business case, prepare a project plan for completing the IDM activity, and show adequate sponsorship and industry need to sustain a workgroup activity at least through IDM completion. Members of the NBIMS Scoping Task Team will be available to work with discussion group to prepare these materials. NBIMS envisions that proposals for workgroup formation will be reviewed through a consensus process in order to approve and promote new workgroups.

Once a workgroup is formed the box will be colorized to show progress.



4-Colored Box where each color represents one of the four phases of the NBIMS Development and Use Process. The color denotes the progress of the activity.

Workgroup formation may result from activity occurring in several contexts.

Workgroup Formation: Organization Context. Within the context of international and North American (NA) organizations, IDM activities are already in progress. NBIMS is developing NA exchange requirements (ER) in partnership with other organizations through the buildingSMART alliance™ and Memoranda of Understanding (MOU). Some of these organizations include: American Institute of Architects (AIA), Construction Specification Institute (CSI), International Code Council (ICC), Open Geospatial Consortium (OGC), OSCRE America, and others.

Currently, individuals who work for organizations which have signed the NBIMS Committee Charter may participate in the Committee through their company affiliation. To see the current list of Participating Organizations go to: http://www.facilityinformationcouncil.org/bim/members.php.

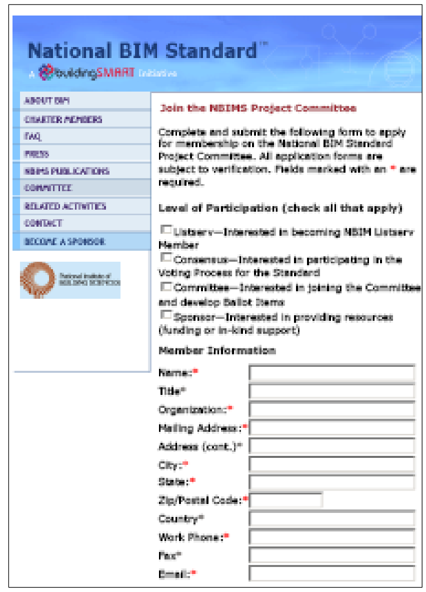
Industry organizations can partner with the NBIMS Committee and have access to IDM methodologies and expertise. These methodologies and partnerships will reduce coordination and harmonization costs between organizations.

For contact information see http://www.facilityinformationcouncil.org. Organizational level contact: Chair, NBIMS Executive Committee.

Workgroup Formation: Group Context. Many agencies, companies, and project teams are involved in the NBIMS Committee to help reduce the costs for BIM implementation. Groups will be able to use the development pages on the NBIMS website to review work in progress and suggest additional workgroup topics. The listserv will continue to support notices and discussions before and throughout the IDM activity.

Workgroup Formation: Individual Context. Individuals who have joined the Committee (see Figure 5.2-6) will be able to review and participate in current discussion groups and review IDM workgroups and/or post bulletins and comments to the listserv. Individuals are encouraged to sign up for a workgroup where they can add professional expertise or are seeking to gain knowledge.

Workgroup Formation: Implementers & Enablers. Implementers of NBIMS standards include software developers and standards organizations. Several are members of the buildingSMART alliance™ and supporters of NBIMS with MOUs in place. It is important that one or more implementers participate in an IDM activity but an implementers-only workgroup would probably not meet criteria for end-user representation. During the programming and design phases it is important that end-users determine requirements and business rules whereas during the construction and deployment phases Implementers and Enablers will be primary actors.


National BIM Standard™
A buildingSMART Initiative

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COMMITTEE
RELATED ACTIVITIES
CONTACT
BECOME A SPONSOR

Join the NBIMS Project Committee

Complete and submit the following form to apply for membership on the National BIM Standard Project Committee. All application forms are subject to verification. Fields marked with an * are required.

Level of Participation (check all that apply)

☐ Listserv—Interested in becoming NBIM Listserv Member
☐ Consensus—Interested in participating in the Voting Process for the Standard
☐ Committee—Interested in joining the Committee and develop Ballot Items
☐ Sponsor—Interested in providing resources (funding or in-kind support)

Member Information

Name:*
Title*
Organization:*
Mailing Address:*
Address (cont.)*
City:*
State:*
Zip/Postal Code:*
Country*
Work Phone:*
Fax*
Email:*

Figure 5.2-6 Join the NBIMS Committee
http://www.facilityinformationcouncil.org/bim/committee_join.php

Programming Phase 3.0: Workgroup Scoping

As a discussion group seeks to become a workgroup, project definition, scoping, and resource identification activities are validated, revised, as necessary, and completed. At this stage, all parameters for workgroup formation should be well defined and defensible. A business case and/or charter will be submitted for review and, when ready, voted on using the NBIMS consensus process. This process helps to ensure community acceptance, increase the likelihood of success, and avoid duplication of effort.

Sponsor-Driven Project Scoping. Sponsors with particular interests, subject expertise, or domain representation may initiate a Programming activity. These activities may proceed on their own using NBIMS methods or within NBIMS-formed workgroups. NBIMS needs for sponsors to support programming and the ongoing stages of an exchange definition with financial as well as in-kind resources. As an info-centric activity programming has bearing on many groups and applications depending on the topic. Workgroups which proceed on their own in coordination with NBIMS may submit work products to NBIMS for consideration through the NBIMS consensus process.

Programming Phase Activity 4.0: Methodology

In order for a free flow of information to occur, three factors need to be in place:

- The format for information exchange,
- A specification of which information to exchange and when to exchange the information, and,
- A standardized understanding of what constitutes the information to be exchanged.

Having these three items in place allows for a true computerized interoperability between two or more information parties.[35]

Information Delivery Manual (IDM) methodology defines the process and content for capturing user-defined requirements. IDM is intended for use in the Architect/Engineer/Constructor and Facility

[35] http://dev.ifd-library.org/index.php/Ifd:buildingSMART_and_IFD#The_three_pillars_of_buildingSMART

Management (AEC/FM) business process. IDM specifies the process definition including the context and purpose of the exchange, the originating and consuming actors, and the information created and consumed. An approved IDM standard can become the basis of a contract between two parties for data interchange, thereby, treating information as an asset, enabling BIM-based methods, and regulating the information sharing between project participants. To offer BIM end-users and software vendors selection from a more uniform and higher quality list of IDM, international and national standardization of IDM is recommended. NBIMS programming is the national focus for the internationally coordinated IDM process.

The Programming Phase of NBIMS supports the users' explanation and documentation of what is done in a specific workflow process and what information exchanges enable the process to be completed. An example would be quantity take-off by an estimator from an architect's BIM model. This is an information-centric workflow process and requires specific information contents.

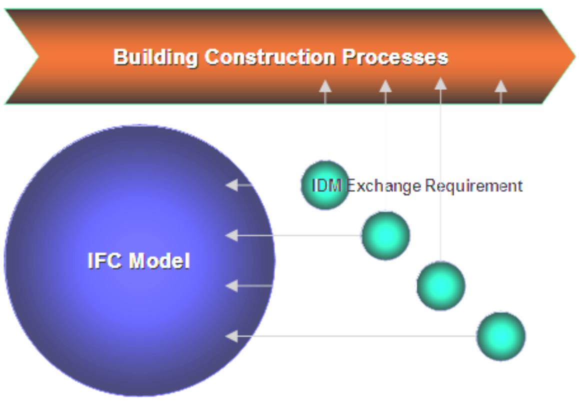


Figure 5.2-7 IDM Stages Context

NBIMS Programming includes the first two tasks of the total IDM activity.

1. Provide a process map for key processes within the scope of the exchange to be documented. This process map should be representative of a common methodology for the majority of the target domain. From this process map, sets of commonly-used processes are identified. These Reference Processes can then be reused in new arrangements to construct enterprise-specific process models with the knowledge that information exchanges supported in each arrangement are consistent.

2. IDM provides descriptions, oriented to end-users and written in common prose, of the information required by a building process. This allows industry practitioners working on projects to understand what and why information is needed without learning how to read complex data structures and encodings.

Programming Phase Activity 4.01: Business Case Development and Building Process Definition

As part of workgroup formation, project scoping develops a general case for the area of interest for the project. Once the workgroup is formed, business case reasoning is developed further.
Business cases will often require varying levels of complexity; for example, a simple single exchange of information will require less complexity than will an exchange that is part of an iterative process in which the exchange is used in varying ways throughout the life of a project or building. A single exchange may be located within a specific domain such as architecture or exist across multiple disciplines and/or applications. As model servers[36] emerge and web-services[37] become more commonly used, more complex levels of automation will be included in the model definitions. However, for now, transport mechanisms and service definitions are outside the immediate scope of the NBIM Standard, which will focus initially on the information exchange message content.

Programming Phase Activity 4.02: Information Exchanges Requirements

Currently, templates which use Microsoft Visio® software exist to assist in collecting information exchange requirements. These will be available for use by workgroups.

Figure 5.2-8 illustrates an overview of the information needed to support an exchange. This information is categorized into the following seven groups.

1. **WHO** is requesting the information? (The architect (actor) is requesting a cost of the current design.)
2. **WHY** is the activity happening? (In this case, a cost activity is needed.)
3. **WHEN** at what phase is project execution? (Design development is one *OmniClass* phase.)
4. **WHAT** define the entities, objects, and properties of the architectural model needed by the estimator to complete the task? (These items will be mapped to IFC and IFD, see Chapter 5.3.)
   WHAT(2) is the expectation of what is delivered between the parties and the applications? (The estimator may need only the quantity output of the architect's model, not the model geometry.)
5. **To WHOM** is the request being given? (For example, the cost estimator (actor) is asked to estimate the model.)
6. **HOW** generally are the resources used to develop the design and construction of a project that do not become part of the project? (For example, vehicles, computer systems, scaffolding, etc.)
7. **INPUTS & OUTCOME** data are referenced and utilized during the process of creating and sustaining the built environment.

---

[36] Model servers are software database applications used to receive, hold, and deliver building information modeling data. A model server may support an enterprise and, therefore, manage data describing many facilities in the enterprise portfolio, or a model server may be used by a project to coordinate the work of several parties to the project.
[37] Web services are software utilities made available in web-enabled software for sending and/or receiving messages using the Internet. Web services, using standardized transport protocols and information packages, can enable software products to engage in automated machine to machine commerce.

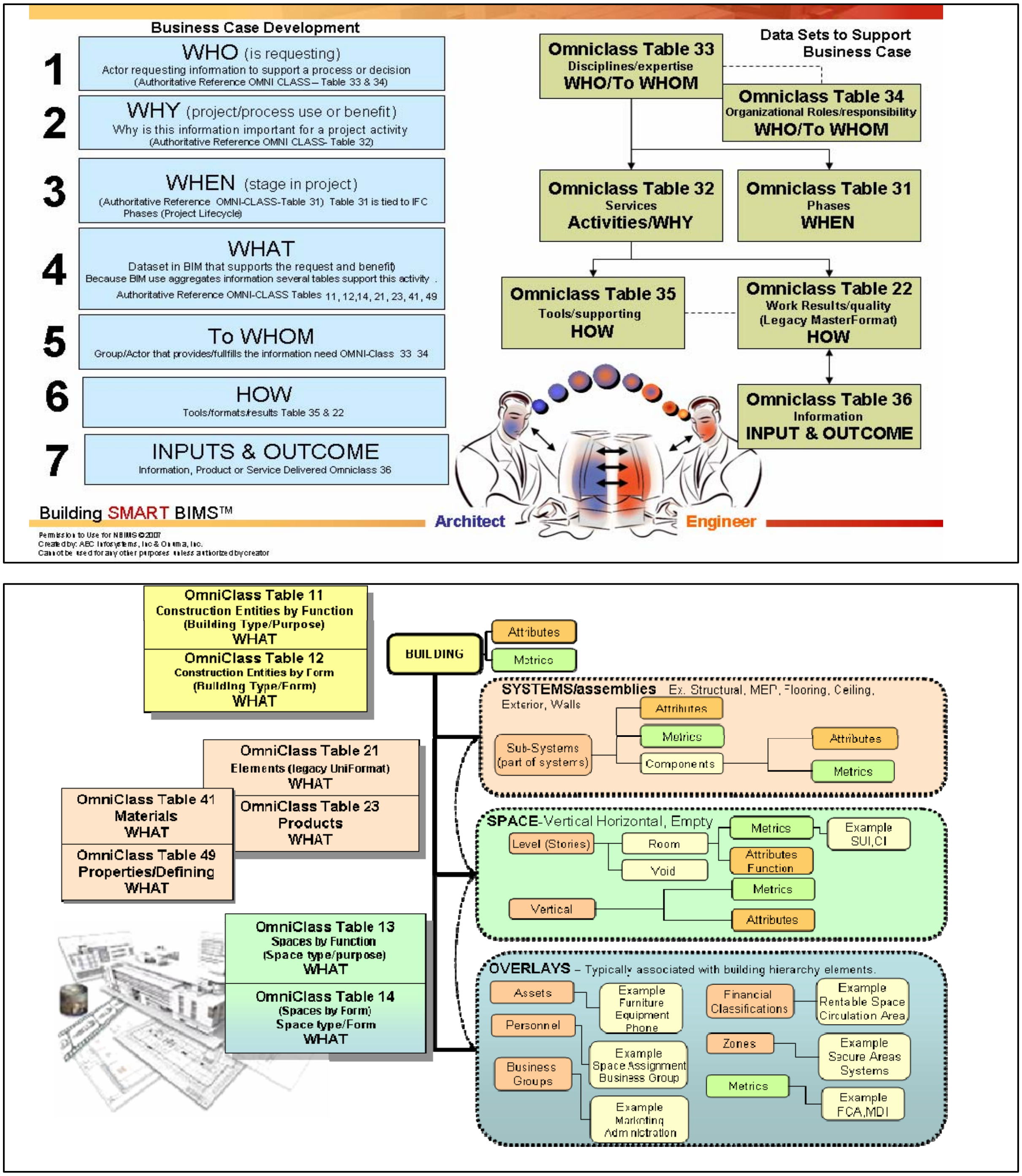


Figure 5.2-8 IDM Information Needed to Support an Exchange

Programming Phase Activity 4.03: Programming Process Models (IDM)

Through the development of a process map, the workgroup can further define exactly the use of the information type and level of detail needed for the information exchanged. Figure 5.2-9 is an example of a process flow for the precast concrete for design, bid, and build created as part of the Precast Concrete Workgroup.

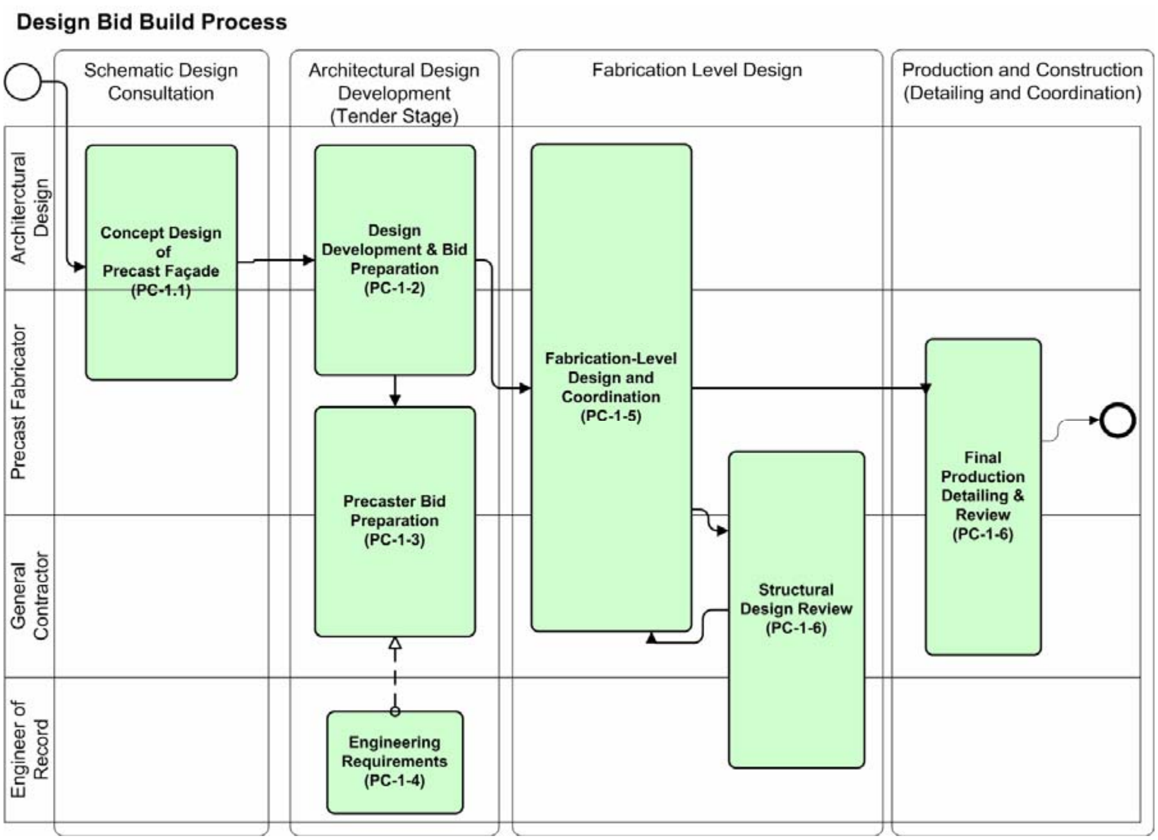


Figure 5.2-9 Design, Bid, Build Process for Precast Concrete. (Courtesy the Precast Concrete IDM Workgroup. Charles Eastman GA TECH)

Programming Phase Activity 4.3: Workgroup Product Review and Consensus

Prior to handover of Programming Phase products to NBIMS Design Phase, a review and consensus ballot of the IDM is envisioned. This measure is needed to assure the industry community that the process and information needed for a specific business case has been accurately captured. During and after this review, programming phase workgroup activities may continue on additional, related subjects or the workgroup may disband.

Chapter 5.3 User-Facing Exchange Models

Introduction

This chapter describes the part of the NBIMS development process in which generic data models will be developed to satisfy exchange requirements (see Chapter 5.2) and by which models from two or more related industry processes will be integrated. The data model addressing requirements for a single industry process is known as an Exchange Requirements Model (ERM). The integrated data model, addressing data requirements from two or more related processes, is called a Generic Model View. The process for translating these generic views into implementation specific Model View Definition (MVD) that can be implemented in software products is described in Chapter 5.4. All of this development will be done by an information modeling task team selected from or contracted by the project work group.

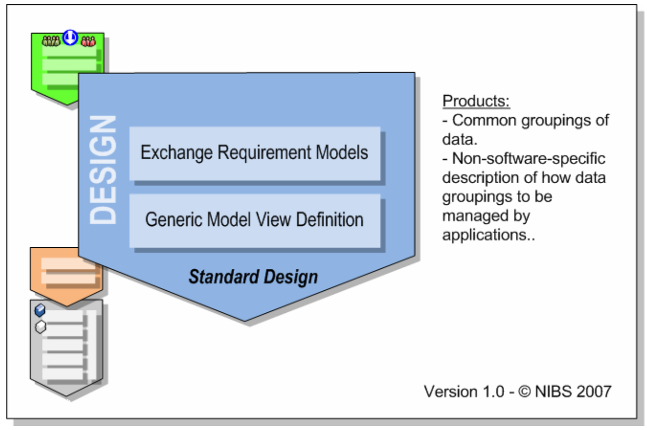


Figure 5.3-1 NBIMS Development and Use Diagram: Design Phase

Acknowledgements

This chapter summarizes the processes, tools, and templates being developed in a global project involving the International Alliance for Interoperability (IAI), several buildingSMART® alliances, the Virtual Building Lab at Tampere University of Technology, AEC3, and Digital Alchemy. Development of software tools and templates is being led by Jiri Hietanen at Tampere University of Technology in Finland. With his permission, this chapter borrows heavily from his early drafts of documentation for IDM Technology Layer and Generic Model Views.

NBIMS Design Phase Development Process

The design stage of NBIMS will use the following development process.

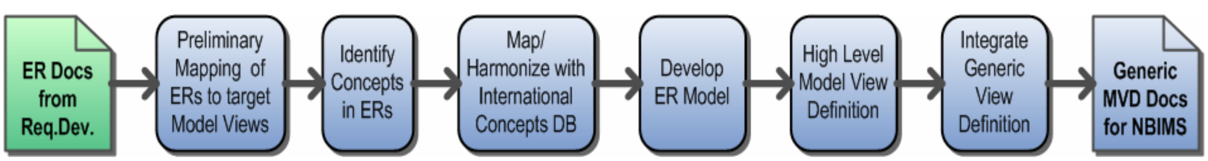


Figure 5.3-2 NBIM Standard Development Process

Preliminary Mapping of ER to Model Views

Model Views will be aligned with roles in building project teams (e.g. architect or structural engineer) and/or software applications (e.g. architectural BIM authoring or structural BIM authoring applications). These views will effectively aggregate information Exchange Requirements (ER) from multiple end user processes (defined in IDM projects, see Chapter 5.2). The first step after completing ER definition is to identify the most appropriate view through which the information should be exchanged. This may result in an update to an existing view or contribute to the definition of a new view.

Identify Concepts in ER

The fundamental building blocks in Model Views are called Concepts. In this process step, the fundamental concepts described in the information exchanges are identified. Whenever possible, these concepts will be harmonized with industry standard ontologies and taxonomies (see section 3).

Map/Harmonize with International Concepts Database

The next step is to harmonize the identified concepts with those supported by existing Model Views. Where like concepts exist, the mapping may be 1:1; where they are similar, the existing concept may be expanded, or a new concept added to the cross view database of concepts. An online database and Model View Coordination toolset is being developed. If a concept does not exist in the target Model View, its data representation pattern for another Model View may be re-used. This will help maximize reuse of software code in products supporting more than one Model View.

Develop ERM

Concepts are assembled in a set of data model diagrams that completely represent the Exchange Requirements in a data model (ERM).

High Level MVD

A high level Model View definition will be developed using the template introduced in the section above.

Integrate Generic View Definition

Generic concept definitions will then be integrated to form the generic MVD.

Exchange Requirements Model (ERM)

Chapter 5.2 described the use of process diagrams to document end user processes in which BIM exchange will be used and the process by which data exchange requirements will be documented for these exchanges. The design phase of the NBIM Standard development process begins by identifying generic software concepts that can be used to represent the data required in these exchanges. The aggregate of these software data concepts forms a generic model of the data structures that can be used in data exchange, independent of any particular model schema or format.

Any given Information Delivery Manual (IDM) project will generate one or more process maps and one or more exchange requirements for each process map. As a result, for a given release of NBIM Standard, we can expect there will be many Exchange Requirements and corresponding ERM.

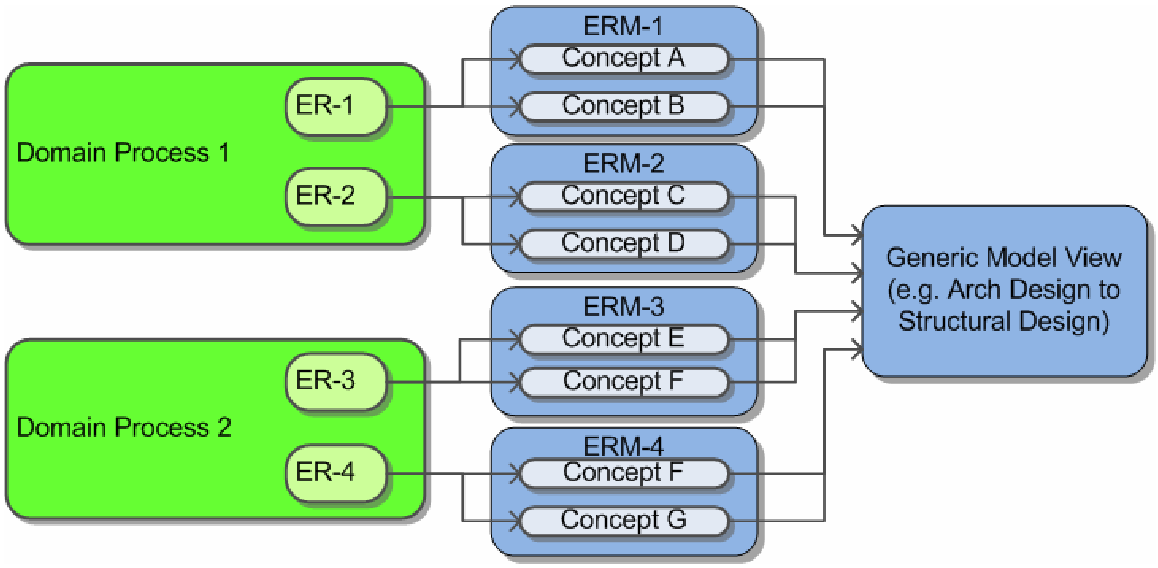


Figure 5.3-3 Generic Model View Development Process

Exchange Requirements Models will be diagrammed using software tools and a diagrammatic format agreed upon by the international project referenced above. The standard formats include several Microsoft Word and Visio® templates, add-on software, and .xml files that are generated out of the diagrams. There is also a website to facilitate collaboration across all Model View development globally.

Developing ERM

ERM Overview Document

Exchange Requirement Model Overview <Title field>					
Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
History					
Authors	<Author field>				
Document Owner	<Company field>				
Description					
<the description>					
This document uses the official ERM overview format as defined in the IDM Technology Layer					

Figure 5.3-4 Example of Template for the ERM Overview Document (ERM_Overview.doc)

The official format for the document is .pdf. An example of a template for the ERM is shown using Microsoft Word, but any other software or system may be used as well.

In documents based on the template, any field marked with <… field> should be edited through the software word processing properties of the document.

Field	Description
<Title field>	The name of the ER, which is also the name of the ERM
Reference	The reference number of the ERM. `<Author ID>-<ERM number>`
Version	The sequential version number of the ERM
Status	The status of the ERM; Sample, Draft, Final or Deprecated
History	The history of the ERM, e.g. a version history
Document Owner	The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address.
Description	The free form description of the ERM, preferably only one page long. If a copyright is asserted this can be done in the description field.

Figure 5.3-5 Template Example for ERM (ERM_Overview.doc)

Concepts

The purpose of Concepts is to allow a clear definition and reuse of ideas related to data exchange.

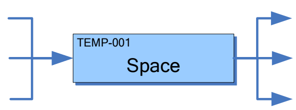
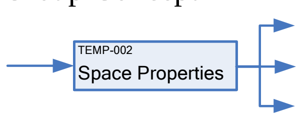
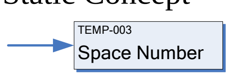
Variable Concept 	Variable Concepts have the same name in different views, but their content may not be the same. Hence, the variable concept must be configured separately for each case. This configuration is done by creating a diagram in which static concepts and business rules are connected to the variable concept. Examples: space in quantity take-off, wall in HVAC design
Group Concept 	Group Concepts provide structure for the diagrams by grouping together static concepts and/or other group concepts. In some cases the group concepts themselves do not require any other definition than a name. Examples: space properties, wall geometry
Static Concept 	Static Concepts remain the same in all scenarios in which they are used. They can be re-used without modification because they do not contain any options. Examples : space number, bounding box geometry

Figure 5.3-6 Concepts Diagram

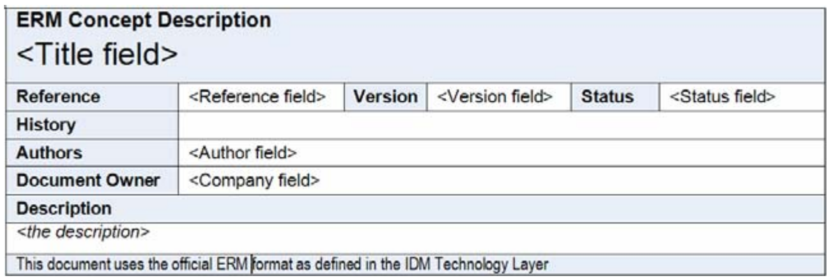
Each concept has an ID, which uniquely identifies the concept. The name is not used as the ID because concepts may be translated into different languages. The ID has the following format.

`<Author ID>-<Concept Number>`

For example: **`TEMP-001, ABC-123`**

When used in a diagram each concept automatically receives a fully qualified name, which identifies it in the context of the diagram. This name is created by iterating from the concept through all parent concepts to the variable concept and finally to the ERM. The fully qualified name is used when definitions and configurations are compared with each other.

If the example above were from ERM with the Reference TEST-01, the fully qualified name for Space Number would be: **`Test-01:TEMP-001:TEMP-002:TEMP-003`**



ERM Concept Description

<Title field>

Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
History					
Authors	<Author field>				
Document Owner	<Company field>				
Description					
<the description>					
This document uses the official ERM format as defined in the IDM Technology Layer					

Figure 5.3-7 Example of Template for the ERM Concept Description (ERM_Overview.doc)

The official format for the document is .pdf. An example of a template for the ERM is shown using Microsoft Word, but any other software or system may be used as well.

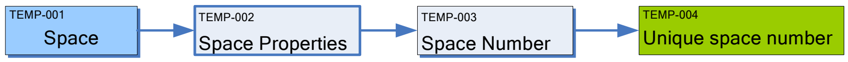
In documents based on the template, any field marked with <… field> should be edited through the software word processing properties of the document.

Field	Description
<Title field>	The name of the concept
Reference	The reference number of the concept `<Author ID>-<Concept number>` NOTE: Where the IDM Technology Layer is used together with the MVD methodology, the same Reference must be used on both sides. In this case it is also allowed, and sometimes necessary, to use the MVD document template for concepts.
Version	The sequential version number of the concept
Status	The status of the concept: Sample, Draft, Final, or Deprecated
History	The history of the concept, e.g. a version history
Document Owner	The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address.
Description	The free form description of the concept, preferably only one page. If a copyright is asserted, this can be done in the description field.

Figure 5.3-8 Template Example for Concepts (ERM_Overview.doc)

Business Rules

Business Rules are appended to static concepts to provide context specific rules for how the concept must be applied. Business rules also set requirements to the concepts, such as data type. For example, some business rules for the fire rating concept may require numeric values while other business rules require alphanumeric values. Each concept must be defined such that it can satisfy all business rules appended to it.



Each business rule has a uniquely identified ID. The name is not used as the ID because business rules may be translated into different languages. The ID has the following format.

`<Author ID>-<Business Rule Number>`

For example: **`TEMP-001, ABC-123`**

When used in a diagram each business rule automatically receives a fully qualified name, which identifies it in the context of the diagram. This name is created by iterating from the business rule through all parent concepts to the variable concept and finally to the ERM. The fully qualified name is used when definitions and configurations are compared with each other.

If the example above were from ERM with the Reference TEST-01, the fully qualified name for the Unique Space Number would be.

`Test-01:TEMP-001:TEMP-002:TEMP-003:TEMP-004`

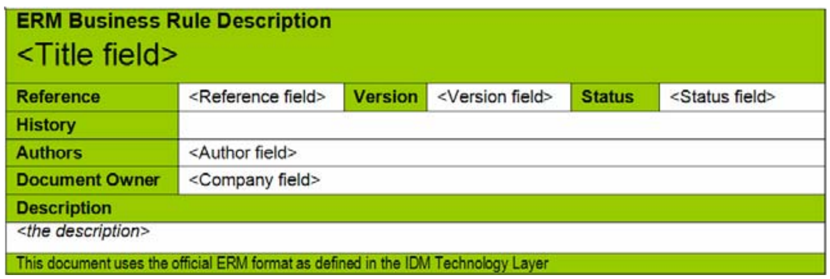


Figure 5.3-9 Example of Template for Business Rules (ERM_Overview.doc)

The official format for the document is .pdf. An example of a template for the ERM is shown using Microsoft Word, but any other software or system may be used as well.

In documents based on the template, any field marked with <… field> should be edited through the software word processing properties of the document.

Field	Description
<Title field>	The name of the business rule
Reference	The reference number of the business rule. `<Author ID>-<Business rule number>`
Version	The sequential version number of the business rule
Status	The status of the business rule; Sample, Draft, Final or Deprecated
History	The history of the business rule, e.g. a version history
Document Owner	The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address.
Description	The free form description of the business rule, preferably only one page long. If a copyright is asserted this can be done in the description field.

Figure 5.3-10 Template Example for Business Rules (ERM_Overview.doc)

Diagrams

The official format for diagrams and configurations is defined by an .xml schema (ERM.xsd). A Microsoft Visio® template (ERM.vss) is provided but diagrams and configurations may be created with any software or system. The Visio template can be used for reading and writing the official .xml format.

The .xml format for diagrams supports three different styles, which may be combined into the same .xml dataset.

- **Definition.** The concepts and business rules used in a diagram and their relationships in the context of that diagram.
- **Configuration.** The status of the concepts and business rules (ON/OFF) and diagram specific comments for concepts and business rules.
- **Layout.** The position, visibility, and other layout related settings of concepts and business rules in a diagram. The layout is typically specific to an application, such as, in the example used here, the Microsoft Visio® template uses a 'Visio layout.' Layouts are not part of the official format, only the ability to define layouts is.

This division makes it possible to create several configurations and layouts for the same definition.

A separate diagram is created for each variable concept in the ERM. Since the official format for diagrams is an .xml representation, there is no official page size or orientation. Large diagrams have to be kept on one page, since it is not allowed to split a diagram over several pages. The data structure of the diagrams is a tree, and an alternative way of presenting the diagrams would be a tree view.

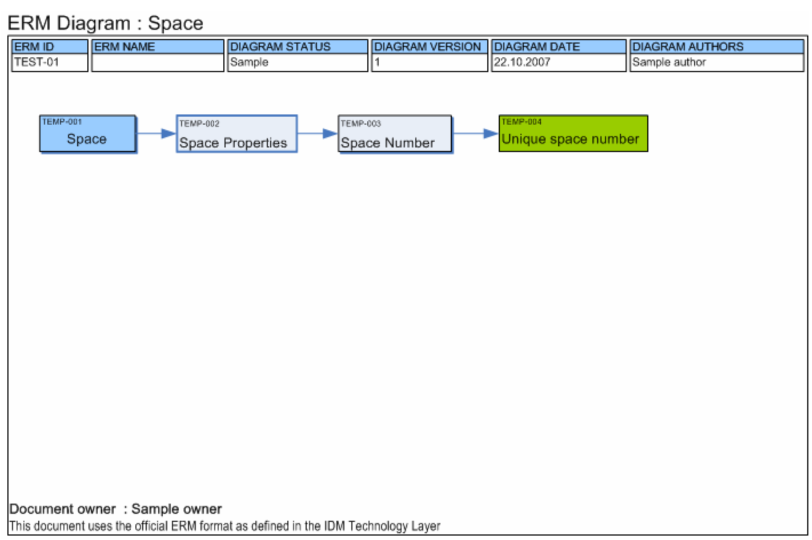


Figure 5.3-11 Example of Template for an ERM Diagram

The official format for the document is .xml. An example of a template for the ERM diagram is shown using Microsoft Visio®, but any other software or system may be used as well.

In documents based on the template, any field marked with <… field> should be edited through the software word processing properties of the document.

Field	Description
Diagram name	The name of the diagram is the name of the variable concept of the diagram. The name is shown in the title.
ERM ID	The ID of the ERM
ERM name	The name of the ERM
Diagram status	Sample, Draft, Proposal, Candidate, Official or Deprecated
Diagram version	The sequential version number of the diagram
Diagram date	The data the version of the diagram was completed
Diagram authors	The authors of the diagram
Document Owner	The person or organization responsible for maintaining the diagram. Should contain some contact information, e.g. email address.

Figure 5.3-12 Template Example for ERM Diagrams

A diagram defines which concepts and business rules are used in an ERM and the relationships between those concepts and business rules. Static, group and adapter concepts, and business rules may be placed on the right side of the variable concept. Connectors in the diagram always point from left to right. Circular connections are not allowed and each concept or business rule may only be connected to one parent.

A concept may be marked 'mandatory' if the whole ERM will not work or make sense if that concept is not supported. For example, thermal analysis is not possible if spaces do not have geometry suitable for this purpose. Mandatory should be used sparingly, only when absolutely necessary.

Diagrams may be configured using two mechanisms: turning concepts and business rules on/off and adding comments to the concepts and business rules. In a configuration it is not allowed to delete concepts or business rules from the diagram. Turning a concept or business rule off is used for reducing the scope. If a concept or business rule is turned off it means that the concept is irrelevant or not supported in the context of the diagram. Commenting is used to be more specific about the scope that remains. In addition, diagrams may contain any text or graphical element, but such elements are not part of the official definition and will not be captured in the official .xml format.

Project Workgroup Review/Comment on ERM

After an ERM is complete, it will be posted for a review and comment by members of the workgroup, IAI, buildingSMART, and industry groups.

At the end of the review period, the ERM will be revised by the information modeling task team to address comments. The resulting, final ERM will then be posted to the NBIMS portal and carried forward by the information modeling task team for integration into generic MVDs as described in the next section.

Developing Generic Model View Definition (MVD)

Over time, NBIM Standard development will document requirements for dozens if not hundreds of end user processes. This will result in hundreds of ERs and corresponding ERM. It is unreasonable to expect software vendors to support all of these as separate export configurations. Therefore, ERM from related processes, and particularly those that are used in exchanges between the same project stakeholders in a given phase of building projects, will be integrated into a single BIM exchange standard that meets all requirements in that group of ERMs. These integrated ERMs are called Generic Model Views Definitions (MVDs) which may be thought of as similar to traditional database views. As with database views, generic MVD include only the portions of a BIM that are relevant to the purpose of the Model View. For example, an MVD exchanged from the architect to the structural engineer would exclude objects like plumbing fixtures, cabinets, and furniture.

Examples of anticipated Model Views are: Architect to Structural Engineer during conceptual design, Architect to MEP Engineer during design development, and so on.

Integrating ERM to Create Generic MVD

As explained in other chapters, NBIMS makes use of, and in some ways attempts to harmonize, several existing standards, including information exchange models. Key among these is the IFC data model which provides a framework for integrating information generated by many applications and project participants throughout the project lifecycle. However, none of these applications can be expected to handle the entire breadth of information in a building information model.

To address this challenge, BLIS developed the concept of IFC Model Views in 2000. Model views serve the same purpose as relational database views by defining a logical and consistent subset of the complete model focused on a particular use or application type. Early BLIS examples included 'Architectural Design to Quantity Takeoff and Cost Estimating' and 'Architectural Design to Thermal Load Calculations/HVAC System Design.' From 2001 through 2004, BLIS and the Finnish ProIT[38] project took the idea of model views through implementation in over 60 BIM products and many pilot projects. In 2005, the Finnish VBE2 project and BLIS refined the tools and process for defining model views under the name Model View Definition (MVD).

MVDs are essentially an aggregation of concepts required for a given exchange scenario (sender, receiver, purpose of exchange). In 2005 and 2006, BLIS, IAI, and the buildingSMART initiatives came together to integrate the IDM process and tools (described in other chapters) with the MVD process and tools (described below). In the integration, BLIS exchange scenarios were mapped to IDM process maps and exchange requirements; IDM functional parts were mapped to MVD concepts. The integrated process and toolset that resulted can be used by any organization to define process, exchange requirements, model views, implementation guidance, and certification testing. This integration will ensure that supporting software satisfies the original requirements, is interoperable (at the model view level), and is consistent with other model views and software based on the same toolset.

The NBIMS Committee uses these tools and processes. Exchange requirements developed by the Requirements Development team serve as the basis for model view definitions. This process leverages a wide range of expertise to optimize the standard. While end user domain expertise is required to specify IDM processes and exchange requirements, data modeling and software implementation technology expertise is required to integrate these disparate requirements into a cohesive and normalized model view that can be implemented into software.

It is important to understand the many-to-one relationship between IDM exchange requirements and model views. While each IDM is focused on one of many specific end user processes, a model view is aligned to an exchange between two project stakeholders and/or application types (see BLIS View examples above). Therefore, each model view will integrate exchange requirements from one to many exchange requirements. Relating this to our concept graphic, this relationship can be diagrammed as shown in Figure 5.3-12.

[38] http://virtual.vtt.fi/proit

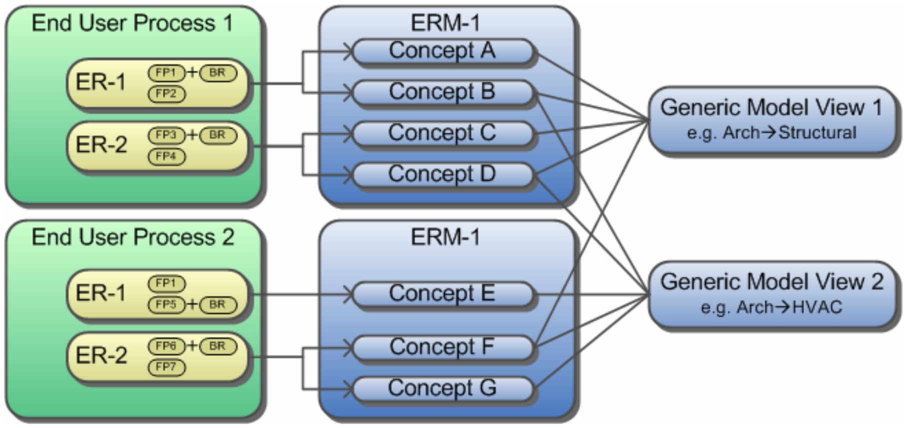


Figure 5.3-12 Exchange Requirements and Model View Relationships

Alignment of model views to application types is driven by pragmatism. One important consideration in designing a model view is to be clear about who will implement support for it and in what products. For this reason, software vendors must be involved in the process of formulating model views.

Generic MVD Documents

High Level View Description. This description, shown as an example template created using Microsoft Word, provides a quick overview of the concepts or ideas to be exchanged using the view. Descriptions should not go into detail but be focused and clear. Generally, the high level description should fit on a single page.

Generic AEC/FM View Description <Title field>					
Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
History					
Authors					
Document Owner	<Company field>				
Description					
1 - What type of data is exchanged between what type of software 2 - Diagram of the view 3 - What is in scope for the view 4 - What is out of scope for the view					
This document uses the official IAI View Definition Format version 1.0.6. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.					

Figure 5.3-13 Example Template for Generic View Description

Generic Concept Diagrams. These diagrams are created using the same example template using Microsoft Visio® as described above for ERM. The underlying format for generic concept diagrams is defined by an XML schema. This schema includes three styles: definition, configuration, and layout. This separation enables creation of multiple configurations and layouts for a given definition. Generally, there will be a separate diagram for each variable concept in the model view. Each diagram defines the static and group concepts that are related to the subject variable concept. These types of concepts are diagrammed as shown in Figure 5.3-15.

Generic AEC/FM Concept Description <Title field>					
Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
Relationships					
History					
Authors	<Author field>				
Document Owner	<Company field>				
Usage in view definition diagram **Definition**					
This document uses the official IAI View Definition Format version 1.0.7. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.					

Figure 5.3-14 Example Template for Generic Concept Description

Generic Concept Definitions. This definition, created using Microsoft Word in the example template shown, provides a verbal description of the idea or concept independent of any specific data exchange schema or format.

Examples from the GSA's Concept Design View (GSA 3D-4D-BIM Program)

Generic AEC/FM BIM View Specification

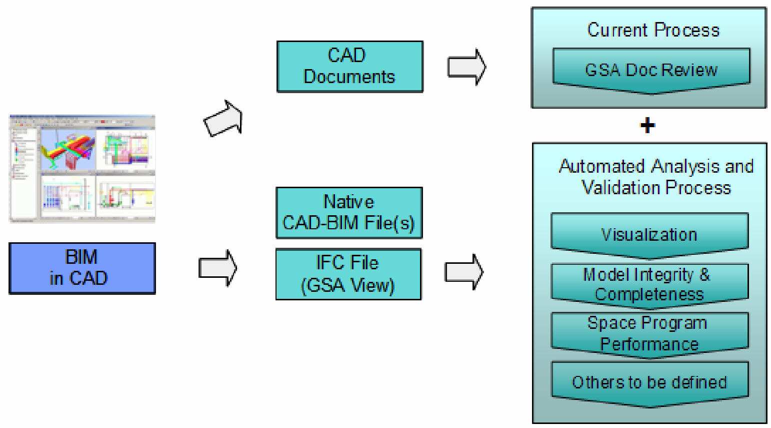
GSA Concept Design View (2006)

Reference	000	**Version**	1.0	**Status**	Final
History	Document created 1-Mar-06; v0.5 – 1-Jun-06; v0.9 – 1-Sep-06; v1.0 – 1-Nov-06				
Authors	Richard See (Digital Alchemy)				
Document Owner	GSA Public Building Service				

Description

Only part of information which is created by architects is needed for GSA's internal analyses of Conceptual Design Submissions. This Building Information Model (BIM) View Definition specifies the subset of the architect's BIM that must be submitted to GSA at Concept Design Submission milestones. This primary audience for this specification is software vendors creating BIM authoring applications that will be used to create such BIMs. Architects and Engineers (A-Es) creating such models are encouraged to review the GSA BIM Guide for end user instructions on how to create such models and what objects and information is expected.

BIM models conforming to this view will generally be created by design architects using architectural BIM authoring applications. Models will be submitted as .IFC model files structured according to the industry standard IFC 2x or 2x2 schema (see www.iai-international.org). These models will be uploaded to the GSA Project Information Portal at http://BIM-Submission.GSA.gov. GSA project managers will then load the models into various internal software applications to perform design analyses.



Version 1 of this BIM View is primarily focused on analysis of design performance relative to the GSA space program given to the architect at the outset of the project. While geometry and basic information is required for a primary set of building elements, emphasis has been put on properties of building spaces.

It is anticipated that future versions of this IFC Model View will expand both information and object requirements to support other analyses such as: early design based cost assessment, early design based energy performance simulation, and LEEDs simulation. GSA would prefer to work with other organizations with similar requirements to develop industry standard Views for these requirements.

Our approach to specifying an IFC Model view has been pragmatic. Our intent was to extend the existing Coordination View defined by the Implementer Support Group (ISG) in IAI because this view has been implemented in the architectural design applications most commonly used in North America. Our extensions are specific to Space objects in the IFC BIM.

This document uses the official IAI View Definition Format version 1.0.11. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.

Figure 5.3-15 High Level View Definition

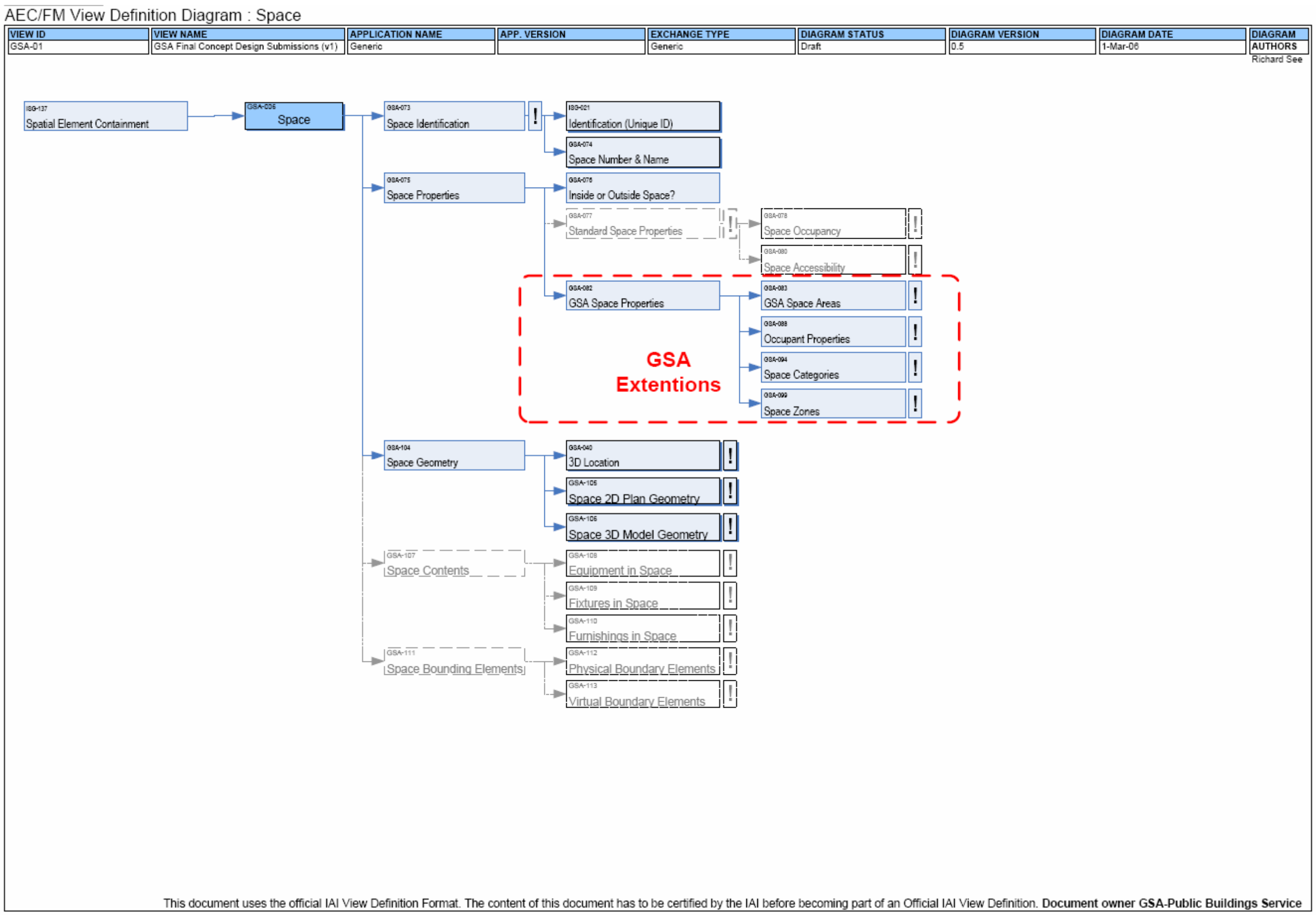


Figure 5.3-16 Generic Concept Diagram for Space

Generic AEC/FM Concept Description

GSA Space Properties

Reference	GSA-082	**Version**	1.0	**Status**	Final
Relationships	None				
History	Document created 1-Mar-06; v0.5 – 1-Jun-06; v0.9 – 1-Sep-06; v1.0 – 1-Nov-06				
Authors	Richard See (Digital Alchemy)				
Document Owner	GSA-PBS				

Usage in view definition diagram

Definition

A collection of properties used by GSA to describe space usage, occupants, classification, and areas, all of which are used in planning and management of spaces in GSA facilities.

Space Categories – 3 properties are used by GSA to categorize spaces in various systems are:

- GSA STAR Space Type – a 3 character descriptor, selected from a reference list.
- GSA STAR Space Category – a 2 digit numeric ID, selected from a reference list.
- ANSI/BOMA Space Category – a 2 digit numeric ID, selected from a reference list published by BOMA

Occupant Properties – 5 properties are used by GSA to describe space occupants. These are:

- Occupant Organization Code – a 4 digit numeric ID, selected from a reference list.
- Occupant Organization Abbreviation – a textual 'short name' for the organization, normally less that 20 characters.
- Occupant Organization Name – a textual 'name' for the organization.
- Occupant Sub-Organization Code – an alpha-numeric string, selected from a reference list.
- Occupant Billing ID – an alpha-numeric string using the pattern: LL-nnnnnnnn (where L=alpha characters and n-numeric digit). This is also selected from a reference list.

Space Zones – Spaces in GSA projects generally assigned to one or more Zones. Three of these are standardized across all projects and others are project specific. Standard Zones include:

- Security Zone – where the value is selected from a reference list for the project
- Preservation Zone – where the value is selected from a reference list for the project
- Privacy Zone – where the value is selected from a reference list for the project

Project specific zones are described by a textual Zone Name. Spaces are then made members of these zones.

Space Areas – GSA uses 4 types of space area measurements for various purposes like tenant billing and building efficiency assessment. Individual spaces are measured using:

- GSA BIM Area – This is defined in the GSA BIM Guide. The simple definition is the space area to the inside face of enclosing walls, less any columns or voids of 9 sq.ft. or more.
- GSA Usable Area – This is defined in the GSA Business Assignment Guide. The simple definition is the BIM Area, plus a pro rata share of common spaces on the building floor.
- GSA Rentable Area – This is defined in the GSA Business Assignment Guide. The simple definition is the BIM Area, plus a pro rata share of common spaces on the building floor.

Building floors are measured using:

- GSA Design Gross Area – This is defined in the GSA Business Assignment Guide. The simple definition is the building floor area measured to the outside face of the exterior walls.

This document uses the official IAI View Definition Format version 1.0.11. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.

Figure 5.3-17 Generic Concept Definition for GSA Space Properties

Project Workgroup Review/Comment on Generic MVDs

After a Generic MVD is complete, it will be posted for review and comment by members of the workgroup, IAI, buildingSMART, and industry groups.

At the end of the review period, the Generic MVDs will be revised by the information modeling task team to address comments. The resulting, final Generic MVDs will be posted to the NBIMS portal and passed over to the Models and Implementation Guidance team for further development into a technology specific MVD that can be implemented in software as described in chapter 5.3.

NBIMS Version 1 - Part 1 ERM and Generic MVD

Since the purpose of *NBIMS Version 1 - Part 1* is to define the processes and tools by which the National BIM Standard will be developed, and is NOT an actual standard, there are no ERM or Generic MVD included. ERM and MVD will be developed for Part 2, which will define the Version 1 standard using the development process defined in the V 1-P 1 document.

Next Steps

Next steps for development of User-Facing Exchange Models for the Version 1 of National BIM Standard will include the following.

- Development of ERM for the end user processes selected for Version 1 (see Chapter 5.2).
- Development of one or more Generic MVD (depending on the number of high level exchange scenarios that the ERM span, such as architectural design to structural design, architectural design to HVAC design, and others).
- Review and comment on the MVD by industry associations and vendors.

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

Introduction and Acknowledgements

This chapter describes vendor-facing model view definition, coordination of implementation, and facilitation of certification testing. To do so, this chapter summarizes some of the processes, tools, and templates which are being developed in a global project involving the International Alliance for Interoperability (IAI), several buildingSMART® alliances, the Virtual Building Lab at Tampere University of Technology, AEC3, and Digital Alchemy. The resulting system, which standardizes the processes, tools, and use of Information Requirements, Model View Definition, and Data Validation in building projects, is called the IMV Framework. Development of software tools and templates is being led by Jiri Hietanen at Tampere University of Technology in Finland and this chapter, with his permission, borrows heavily from his early drafts of documentation for v2 of Model View Definitions, which are not yet published.

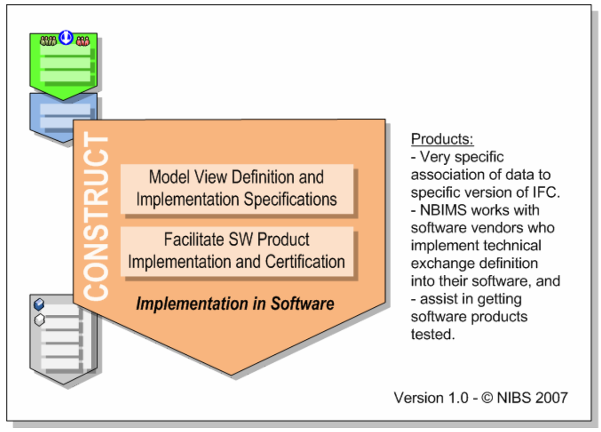


Figure 5.4-1 NBIMS Development and Use Diagram: Construction Phase

NBIMS Construction Phase Development Process

Generic MVD, as described in Chapter 5.3, will be developed into technology specific MVDs and implemented into pilot software development products using the following process.

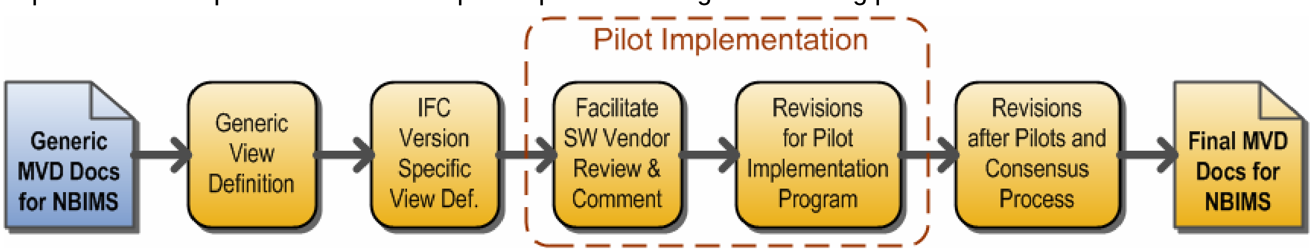


Figure 5.4-2 NBIM Standard Development Process showing Pilot Implementation Phases

Generic View Definition. The Generic MVD from the design stage of NBIMS development is the generic start for the development of a technology specific Model View that can be implemented into software products.

IFC Version Specific View Definition. IFC version specific representations for each Concept will be developed next. Version specific concept diagrams and implementation guidance will be defined using the templates introduced in the preceding sections. Concept definitions should include data instantiation diagrams, reference tables, and all information required for software vendors to implement support in their software products. For example, a toolset is being developed to facilitate diagram development in Microsoft Visio® and definition development in Microsoft Word.

Facilitate Software Vendor Review and Comment. It is important to involve potential software implementers in the definition of MVD. Therefore the NBIMS process includes a review and comment period to collect vendor input. Experience has shown that such feedback often does not come until vendors are engaged in implementation, so this period will extend well into the Pilot Implementation program.

Revisions for Pilot Implementation Program. About half way through the Pilot Implementation program, vendor feedback and recommendations will be evaluated, harmonized, and final revisions agreed to drive final changes to the candidate MVD. Final programmatic (automated) and end user testing of pilot implementations will be relative to the final candidate MVD definition. Use of these pilot implementations should be central to the consensus process that determines whether an MVD will be made a part of NBIMS.

Revisions after Pilots and Consensus Process. In cases where an MVD is accepted for inclusion in NBIMS, that acceptance may be accompanied by a list of changes or improvements. The final step in MVD development will be to incorporate the agreed upon changes into the MVD document set for inclusion in the standard document set. It is also possible that the consensus driven changes/improvement requirements may require changes to the IDM process and exchange requirements documentation.

Binding MVD to IFC to Enable Implementation

IFC Version Specific MVD

High Level View Description. This description, shown as a sample template created using Microsoft Word, documents high level decisions made in the binding to a release of IFC. Descriptions should not go into detail but be focused and clear. Generally, the high level description should fit on a single page.

IFC Release Specific AEC/FM View Description (<IFC Release field>) <Title field>					
Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
History					
Authors	Richard See				
Document Owner	<Company field>				
Description					
1 – Which version of the generic view definition is being used 2 – Basic principles applied when mapping the generic view to the specific IFC release, including implementer's agreements. 3 – Limitations relative to the generic definition					
This document uses the official IAI View Definition Format version 1.0.11 The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.					

Figure 5.4-3 Example of Template for IFC View Description

Release Specific Concept Diagrams. As with Generic Concept diagrams, IFC Description diagrams are created using software (the sample template shown uses Microsoft Visio®) that supports import and export of the underlying .xml schema. Each diagram defines a unique Variable Concept and the Static and Adapter Concepts that are related to it. These types of concepts are diagrammed as follows.

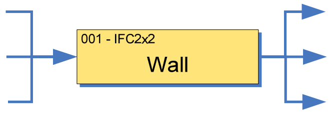
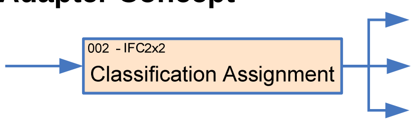
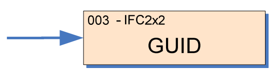
Variable Concept 	Variable Concepts are root concepts that have to be fully configured for each scenario. Examples: wall in architectural design to quantity take-off, wall in structural design to structural analysis
Adapter Concept 	Adapter Concepts are reusable parts of the IFC model that function as adapters between the variable concept and the static concepts. Examples: classification assignment, property set system
Static Concept 	Static Concepts remain the same in all scenarios in which they are used. They can be re-used without modification because they do not contain any options. Examples: GUID, bounding box geometry

Figure 5.4-4 Concepts Diagram

Release Specific Concept Descriptions

This definition, shown as a sample template created using Microsoft Word, provides requirements for implementing support for the concept in software with conformance to the IFC release specifications. This includes a software instantiation diagram showing the exact requirements for IFC objects, relationships, and properties. It also includes implementer agreements that clarify or extend the IFC specifications where there is room for interpretation.

IFC Release Specific Concept Description (<IFC Release field>) <Title field>					
Reference	<Reference field>	**Version**	<Version field>	**Status**	<Status field>
Relationships					
History					
Authors	<Author field>				
Document Owner	<Company field>				
Usage in view definition diagram					
Instantiation diagram					
Implementation agreements					
This document uses the official IAI View Definition Format version 1.0.7. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.					

Figure 5.4-5 Example of Template for IFC Concept Description

Examples from the GSA's Concept Design View

IFC Release Specific AEC/FM View Description (IFC 2x2) GSA Concept Design View for IFC 2x2					
Reference	GSA-000	**Version**	1.0	**Status**	Final
History	Document created 1-Mar-06; v0.5 – 1-Jun-06; v0.9 – 1-Sep-06; v1.0 – 1-Nov-06				
Authors	Richard See (Digital Alchemy)				
Document Owner	GSA-PBS				
Description					
This document describes the high level principles applied in mapping v1.0 of the generic view definition for "GSA Concept Design View (2006)". This view is based on the Coordination View for IFC 2x2, developed and published by the IAI's Implementer Support Group (ISG). This view only adds 3 property sets and 1 to 3 element quantities to all space objects in such a model. All other requirements are defined in the Coordination View. There are no known limitations in this binding, relative to the generic view definition.					
This document uses the official IAI View Definition Format version 1.0.11. The content of this document has to be certified by the IAI before becoming part of an Official IAI View Definition.					

Figure 5.4-6 IFC 2x2 High Level View Definition

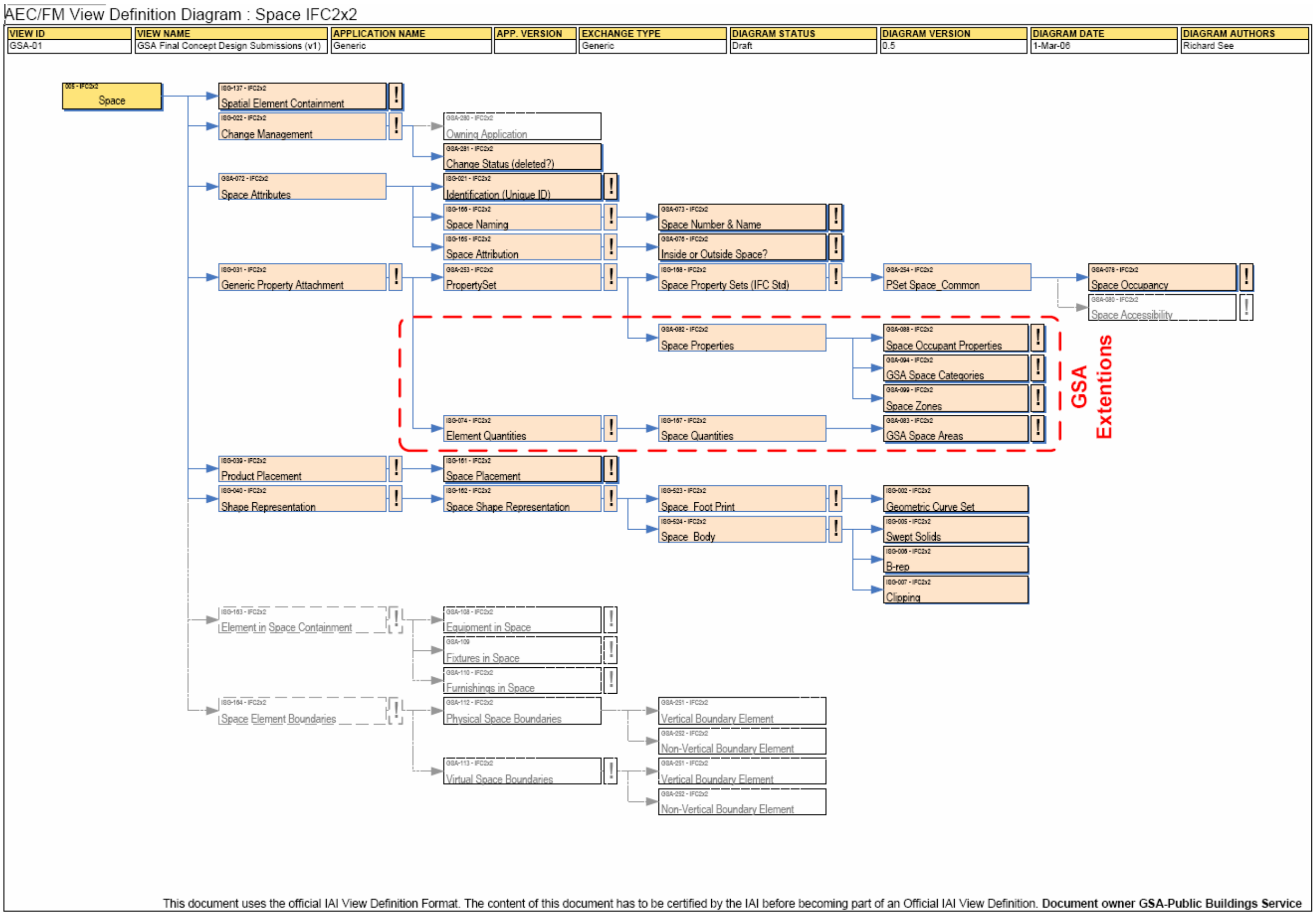


Figure 5.4-7 IFC 2x2 Concept Diagram for Space

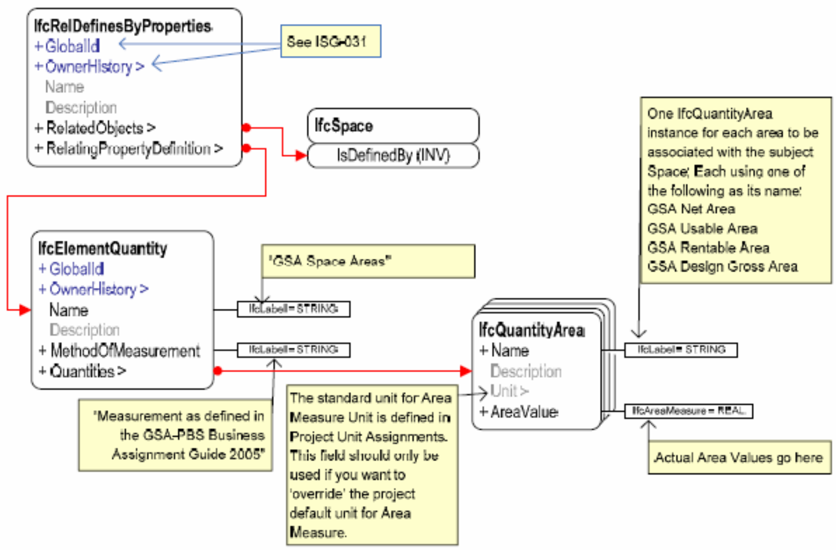
IFC Release Specific Static Concept Description (IFC2x2)

GSA Space Areas

Reference	GSA-083	**Version**	1.0	**Status**	Final
Relationships	Implements generic concept for "GSA Space Areas"				
History	Document created: 1-Mar-06 Updated: v0.6 – 13-Mar-06; v0.8 – 05-May-06; v0.9 – 16-May-06; v0.92 – 18-May-06; v0.94 – 22-May-06; v0.96 – 27-Jun-06; v0.98 – 31-Jul-06; v0.99 – 18-Sep-06; v1.0 – 1-Nov-06				
Authors	Richard See (Digital Alchemy/Solibri)				
Document Owner	GSA-Public Buildings Service				

Usage in view definition diagram

Instantiation diagram



Implementation Detail

As you can see above, each space will be related to an IfcElementQuantity container object that contains a set of one or more appropriately named area quantities (IfcQuantityArea).

Of the 4 Space Properties used by GSA to describe space areas, only 2 must be supported in application Export to IFC. The others are optional, but useful to GSA. Additionally, Rentable Area should be used only with spaces that have the ANSI/BOMA Category of 01 (Office) (see the resources section below for more information about space categories).

According to the IAI Implementers' agreement, building floors (IfcBuildingStorey) do not include geometry. To aid in visualizing such building floors, GSA has adopted the convention of including a 'Full Floor' Space object for each floor. This space extends horizontally to the outside face of building elements enclosing the spaces contained in the building floor and vertically from the building floor datum (IfcBuildingStorey elevation) to the building floor height. There shall be only one 'Full Floor' space for each building floor and these will have special areas associated with them, as outlined in the table below. A naming convention will be used to identify 'Full Floor' spaces, as described in the BIM Guide, these spaces will be named using the pattern: BuildingFloor_<Floor_ID>. For example: BuildingFloor_01 (for level 1), BuildingFloor_B1 (for basement level 1), or BuildingFloor_Mezzanine (for a mezzanine level).

Optimally, BIM authoring applications will create these 'Full Floor' spaces programmatically, so that they are always correct, in terms of location, extent, and name.

Implementation requirements and options can be summarized as follows:

Figure 5.4-8 IFC 2x2 Concept Definition for GSA Space Areas

Facilitating Implementation/Certification Testing of Software Products

The IAI has been facilitating software implementation of import and export for IFC models since about 1997, but the results have been questioned in numerous forums as not being reliable enough for production use. The BLIS Consortium had more success in its implementation program for its member organizations (between 1999 and 2003), largely because they prototyped early versions for both MVD and BIM Data Validation tools in that program. During the IAI International Conference in November 2007, the IAI concluded that more alternatives for improving the reliability of IFC BIM data exchanges should be considered. The proposed IMV Framework was developed largely in response to these concerns and requests.

1) Unambiguous specifications for the BIM data to be exchanged	• Rigorous MVD formats and tools, with detail down to software data instantiation diagrams.
2) Test cases for both import and export that cover the scope of the BIM data to be exchanged	• Test cases originally recommended by the domain team that developed the ERM will be further elaborated by the MVD team. • Data modeling tools will be used to ensure complete coverage of the exchange model schema by the test cases.
3) Thorough, objective, and conclusive methods/processes/tools for testing products' performance with these test cases	• For export, the most likely approach is to use data modeling tools that will load data exported by the subject application and 'check' the data against the MVD schema and all implementers' agreements. • Import is tougher because it involves assess the 'correct' interpretation and mapping of data into the internal data structures of the application. There is still a good deal of discussion about how to accomplish this in an objective and conclusive way.
4) Complete and unambiguous reporting of the test results	• The MVD format includes provisions for reporting performance by application at a data element level.

Figure 5.4-9 Requirements to Facilitate Software Implementation

Facilitated implementation leading to certification testing, whether administered by buildingSMART, the NBIMS committee, the IAI, or others, requires all of those shown in the left column. The IMV Framework as applied by NBIMS will address each of these as described in the right column.

Figure 5.4-10 provides an example, starting on January 1, 2008, of the expected process for facilitated software implementation leading to facilitated certification testing and reporting.

Task Name	Duration	Start	Finish
Implementation Group Formation	**8 wks**	**Tue 1/1/08**	**Mon 2/25/08**
Advertise Implementation program	0 wks	Tue 1/1/08	Tue 1/1/08
Secure vendor participation commitn	8 wks	Tue 1/1/08	Mon 2/25/08
Model View Definition	**12 wks**	**Mon 2/25/08**	**Mon 5/19/08**
Post initial MVD	0 wks	Mon 2/25/08	Mon 2/25/08
Review & comment MVD	8 wks	Tue 2/26/08	Mon 4/21/08
Revisions	4 wks	Tue 4/22/08	Mon 5/19/08
Post Final MVD	0 wks	Mon 5/19/08	Mon 5/19/08
IECC Implementation & Testing	**30 wks**	**Tue 5/20/08**	**Mon 12/15/08**
Develop test cases	12 wks	Tue 5/20/08	Mon 8/11/08
Implementation	12 wks	Tue 5/20/08	Mon 8/11/08
Round 1 test cycle	6 wks	Tue 8/12/08	Mon 9/22/08
Round 2 test cycle	6 wks	Tue 9/23/08	Mon 11/3/08
Round 3 test cycle	6 wks	Tue 11/4/08	Mon 12/15/08
Pilot Projects	16 wks	Tue 12/16/08	Mon 4/6/09
Bug Fixes, Productization, Support	8 wks	Tue 4/7/09	Mon 6/1/09
Announce Certified Products	0 wks	Mon 6/1/09	Mon 6/1/09

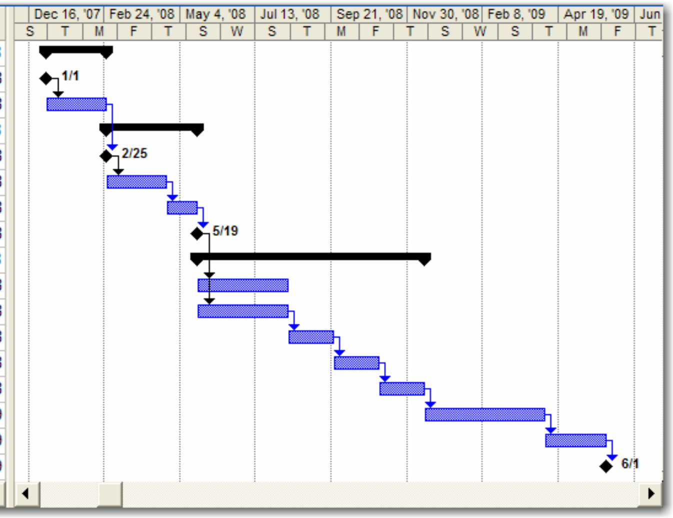


Figure 5.4-10 Process to Facilitate Software Implementation

BIM Data Validation Tools for use by Industry

The BIM Consortium, described above, developed an early prototype of a BIM Data Validation in 2000. Since that time, tools for validating data models have improved. One of the key new features of the IMV Framework is the inclusion of a strategy and existing technologies that will enable creation of BIM data validation tools that can be used by any end user of BIM software.

BIM Data Validation will be on an Exchange Requirements Model (ERM) level. To accomplish this, we will develop an IFC Constraint Model that compliments the BIM Guide for each ERM. Where the BIM guide provides human interpretable requirements for creation of the ERM, the IFC Constraint Model provides equivalent requirements that are computer interpretable. BIM data validation is accomplished by loading both the BIM to be validated and the IFC Constraint Model for the ERM into a data validation application (sometimes also called Model Checking Software). The data validation application checks all objects properties and relationships in the BIM for conformance to the constraints (or rules) in the IFC Constraint Model and then reports areas of non-conformance.

This process has been proven in the SMARTcodes project led by the International Code Council in 2006 and 2007. Applying the process and tools to the business rules and BIM Guide requirements of an ERM will begin in 2008.

NBIMS Version 1 - Part 1 MVD

Since the purpose of *NBIMS Version 1 - Part 1* is to define the processes and tools by which the National BIM Standard will be developed, and is NOT an actual standard, there are no MVD included in this document. MVDs will be developed in future releases of the Standard.

Next Steps

Next steps for the Models and Implementation Guidance task team in developing Version 1 of National BIM Standard include the following.

- 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 NBIMS Version 1 documents (together with all committees).

Chapter 5.5 Deployment

Introduction

Deployment refers to several activities having to do with end-user adoption of NBIM Standard concepts and products in project agreements, generic and application-specific BIM guides, certified software, validation of the construction and contents of a building information model, and using model exchange files in certified products to accomplish project goals. Engagement in deployment activities is seen as providing a complete end-to-end experience from user definition through to routine use in projects. Recent pilot projects have demonstrated that continuous engagement is an essential ingredient for providing an efficient and reliable standard.

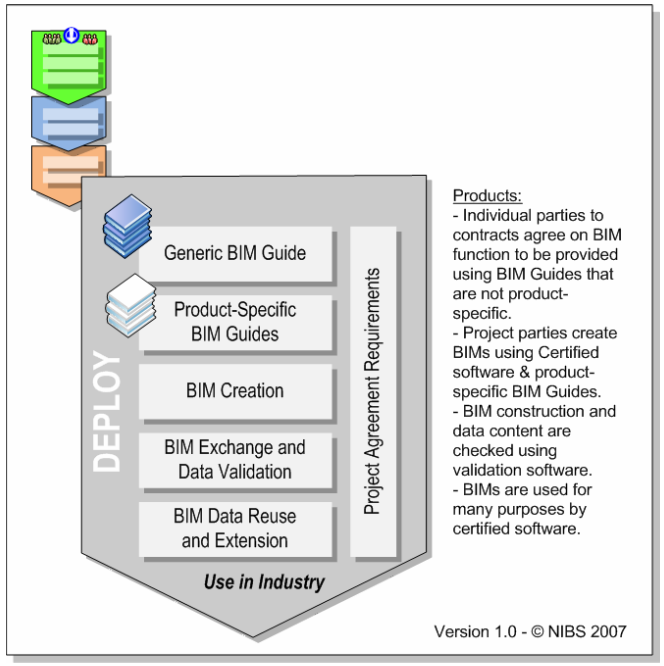


Figure 5.5-1 NBIMS Development and Use Process: Industry Deployment Phase

Project Agreements

Project Agreements are made between parties to a project and may include requirements for building information models or content derived from models. NBIMS will not include specific or prototypical contract language. However, during the IDM phase, process definitions, exchange requirements, and business rules are documented based on input from several experienced practitioners. This information is used in Model View Definition activities, and it may also be useful as parties negotiate the methods in which work will be performed and define project results.

Project agreements may be so specific as to define software certification requirements which will be available from the certification authority the NBIM Committee adopts. Similarly, project agreements may specify methods of testing that delivered building information models must meet. NBIMS will not provide testing of delivered models, but the parameters of an IDM or MVD may provide guidance for BIM commissioning.

Finally, information contained in a building information model may be useful to lifecycle phases beyond the current project scope. Examination of IDM for similar activities in subsequent phases or used by other actors could provide insight as to how to maximize the value of current BIM development and use.

Generic BIM Guide

Generic BIM Guides are human-readable and product-independent guides describing the scope, appropriate application, and requirements generally associated with the NBIM Standard. Generic BIM guides are written using process diagrams, exchange requirements (ER), and business rules (BR) created during IDM development. They provide guidance, without regard to specific software applications used to edit or analyze BIM, to the intended uses for the ER and BR information.

Product-Specific BIM Guide

A product-specific BIM Guide is human-readable and is written by software vendors to describe how a specific software application is to be used to accomplish the NBIMS specification. A product-specific BIM guide may resemble an operator's manual for the software with specific setup, step-by-step keystrokes, and example datasets for use with tutorials designed to assure that an application manager and/or user can accomplish BIM results that meet the requirements of the NBIM Standard.

BIM Creation with Certified Software

Once MVD specifications are implemented into software and the software has been certified for import and/or export of a specific IFC schema, the software is used to author, export and/or import, and edit building information models. The NBIM Committee may create or facilitate the creation by others of educational materials, educational classes, generic BIM guides, or direct consulting services directed at realizing the full potential value of the Standard. Lastly, by interacting with BIM users, the NBIMS Committee and software developers will identify opportunities to improve the Standard and, when necessary, suggest the formation of new task teams.

BIM Exchange and Data Validation

As project participants exchange BIM information using certified software they will need to address matters peripheral to the NBIM Standard specifications but necessary to reliable and efficient information exchanges. One of these matters is automated validation of data contained in a BIM. Data validation is seen as the 'third leg in the stool' that makes IFC BIMs relevant, useful, and even important to building projects.

One of the key new features of the IMV Framework[39] is the inclusion of a strategy and existing technologies that will enable others to create BIM data validation tools that can be used by any end user of BIM software.

BIM data validation will be on an Exchange Requirements Model (ERM) level. To accomplish this, an IFC Constraint Model will be developed that compliments the BIM Guide for each ERM. Where the BIM guide provides human interpretable requirements for creation of the ERM, the IFC Constraint Model provides equivalent requirements that are computer interpretable. BIM data validation is accomplished by loading both the BIM to be validated and the IFC Constraint Model for the ERM into a data validation application (sometimes also called Model Checking Software). The data validation application checks all objects properties and relationships in the BIM for conformance to the constraints (or rules) in the IFC Constraint Model and reports areas of non-conformance. This process has been proven in the SMARTcodes project led by the International Code Council in 2006 and 2007. Applying the process and tools to the business rules and BIM guide requirements of an ERM is envisioned to begin in 2008.

[39] See Chapter 5.4 *Vendor-Facing Model View Definition, Implementation, and Certification Testing.*

Chapter 5.6 Consensus-Based Approval Methods

Introduction

The NBIMS Committee will use several approval methods for the specific work products that will define, create, and support implementation of the NBIM Standard. These methods will be consensus-based with varying degrees of rigor as appropriate for overall productivity as well as the quality of individual processes and products. This chapter discusses the various NBIMS resources and review/approval methods to be employed.

This chapter follows the NBIMS Development and Use process introduced in Chapter 5.1 to describe the NBIMS' established methods of defining, creating, reviewing and approving NBIM Standard products.

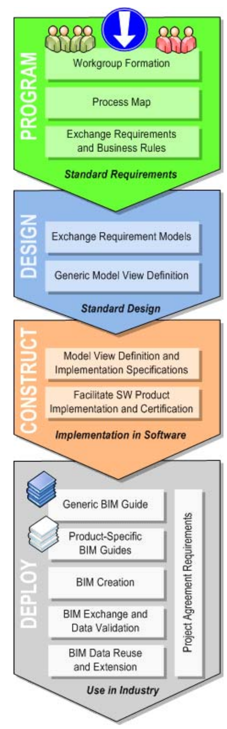


Figure 5.6-1 Approval Methods Apply to All Phases of the NBIMS Development and Use Process

Project Initiation

Workgroup formation, in Chapter 5.2, describes how industry practitioners will be able to find either existing exchange definitions or propose a new exchange concept. Both conditions will be supported by web-based forums and discussion groups where ideas can be collected and refined. During the Interest Group and Project Definitions phases, Committee resources will facilitate discussions and assist in formation of workgroups where formal development is suggested. The purpose of this phase is to identify concepts, connect people, knowledge and activities present in the community, explore community consensus around concepts, and determine if sufficient sponsorship and commitment for resources exist to sustain a concept through development, implementation, and initial use.

As a concept is reaching a sufficient level of community interest and demonstrating sponsorship, the interest group may use tools on the website to document the business case and to establish whether the development approach will be a new development, an adaptation of a current development, or support to an existing application. These tools will also assist in scoping the breadth of the concept, industry stakeholders, and existing or needed reference standards. The NBIMS Committee role during this phase will be to continue hosting, facilitating, and boosting, as the interest group refines the definition, methods, and intended outcomes for a development activity.

At the point where an interest group seeks to elevate the activity to a formal workgroup intending to define an NBIM Standard, the NBIMS Committee will accept a proposed Workgroup Charter to be reviewed by the NBIMS Program Manager for recommendation to an Executive Board of Review. The process of identifying, refining, and developing the Business Case and proposed Charter as well as the Program Management Review and a vote of the Executive Board of Review is designed to ensure that the fundamentals for a successful activity are in place and that the organization is prepared to manage the activity. At this point, community consensus should be well established.

Workgroup Consensus

Requirements Definition activities, described in Chapter 5.2, will employ Information Delivery Model (IDM) methodologies and workgroup-level consensus methods to review and approve content and products. IDM is a methodology developed by the Norwegian buildingSMART® organization and augmented by the NBIMS Committee to support the information exchange requirements for business processes within the building construction industry.[40] Workgroup Consensus relies on active workgroup membership composed primarily of domain subject matter experts and experienced practitioners to suggest, research, discuss, define, and vote internally to approve the requirements of a proposed standard. At this stage, information modelers and/or software developers may be present in the workgroup to provide context, but modeling and software implementation is not the primary purpose of this phase of development and workgroup consensus approval should focus on defining an IDM within the business context. Workgroups will elect their own leadership, establish their work plan, and divide the work among workgroup members. Completed sections of the draft IDM will be prepared and distributed to the entire group for review and comment. Comments will be addressed by the group as a whole. Members of the NBIMS Process and Product Assurance Task Team will assist workgroups if necessary, but experienced workgroups may function largely on their own and may require only monitoring.

All workgroups will be monitored by an NBIMS Program Manager and members of the NBIMS Process and Product Assurance Task Team. It is envisioned that a summary of workgroup health will be prepared regularly for review by the Executive Committee. Workgroups will need to continue to meet minimum criteria such as representative membership, active and productive participation, scope management, and adequate progress toward phase completion.

Workgroup Consensus will be used throughout the IDM process, which involves use-case definition, process mapping, definition of exchange requirements, grouping of reusable information groups (e.g. Functional Parts) and creation of context-specific constraints or reference standard (e.g. Business Rules). It is envisioned that, although workgroup activities and results will be visible through regular reporting, many workgroup activities will proceed in parallel at a pace appropriate to each workgroup and without the delay that might otherwise be caused by unnecessary community review and balloting.

When a workgroup has completed the IDM process, possibly including selected industry review and comment, a vote of the workgroup members will be taken on the question of promoting the IDM to an NBIMS Consensus Ballot or one of several alternatives, such as continuing phase development activity, putting development on hold, or terminating the workgroup.

NBIMS Consensus Vote

The NBIMS Consensus Vote is a formal process involving preparation of a ballot item, submission of the ballot item to NBIMS Committee members for a specified review period, a specified voting period during which NBIMS Committee members cast their votes on the ballot items, tallying of votes, review of the ballot by the NBIMS Executive Committee, and publication of results. It is envisioned that the NBIMS Consensus Voting method will be very similar to the method used by the National CAD Standard (NCS). Both NCS and NBIMS are governed by the consensus requirements of the National Institute of Building Sciences (NIBS). Details of the NBIMS Consensus Voting procedure will be provided in subsequent publications.

In general, NBIMS Consensus Voting will be used to move draft standards from one major development phase to another; including issuance of Standard specifications. Consensus Voting is believed to be essential in order to achieve an open and transparent, inclusive, and representative Standard.

[40] Refer to Chapter 5.2, *Requirements Definition*, and Chapter 5.3, *User-Facing Exchange Models*, for additional IDM discussion and references.

However, formal voting requires considerable time and resources and so must be used judiciously. Additional questions may be balloted when the Executive Committee considers endorsement of the Committee as a whole to be essential.

Specifically, the following items are planned to be balloted:

1. **Exchange Requirement Release for Public Use.** Exchange Requirements document the information that must be passed from one business process to enable another. At this stage, content is expressed in terms that are understandable by end-users rather than software developers and/or implementers. See Chapter 5.3 for additional information.

2. **Model View Definition (MVD) for Public Use.** At this stage Exchange Requirements have been assembled into reusable, software-friendly concepts and then mapped to objects, properties, and relationships present in a specific release of the International Alliance for Interoperability (IAI) Industry Foundation Classes (IFC) schema. The generic concepts and groupings will be ushered through the process via review and recommendations by MVD Specialists and Implementers and by Workgroup Consensus methods. It is only the final MVD which will be balloted by NBIMS Consensus before release as a Standard MVD Specification.

In its review of a balloted item, the Executive Committee determines whether all of the following have been met.

- The standard is in harmony with the policies of NBIMS standardization activities and has been developed according to NBIMS governance and operating procedures.
- The interests of all affected NBIMS subgroups have been considered.
- The standard is technically sound and accurately drawn.
- Any recommendations should be made to NBIMS Counsel concerning compliance of the standard with NBIMS policies and procedures.

The Executive Committee may determine that a proposed standard is of potential concern and defer further action until all concerns are resolved.

Once the Executive Committee approves the proposed standard, it is submitted to the NBIMS Communications Task Team, which edits the document in compliance the NBIMS Style Manual.

When completed, the proposed standard is returned to the responsible workgroup leader for final review and approval of content. Generally, an editorial committee conducts the final editorial review. Any changes requested by the editorial committee are implemented by the Communications Task Team and the document is then forwarded to the publisher for publishing via the NBIMS website.

NBIMS and Implementation Workgroups

Although implementation of a MVD Specification is the responsibility of software vendors, the NBIM Committee envisions that Workgroups, composed of software developers and representatives of the NBIMS Process and Product Assurance Task Team, will work together to facilitate implementation, implementation testing, and deployment activities (see below). These Workgroups will employ a form of consensus to develop, review, and approve MVD implementation into software.

In addition, the NBIM Standard Development and Use Process includes two types of BIM Guides.

1. **The Generic BIM Guide** describes the intent and requirements of an exchange definition without regard to a specific software implementation. The NBIMS workgroup developing the IDM and generic MVD will provide the content for and resources for production of the Guide, which will be facilitated and reviewed by NBIMS Process and Product Assurance Task Team.

2. **The Product-Specific BIM Guide** is a user-guide specific to the implementation of a MVD Specification in an individual software product and version. The software developer will produce this Guide and the NBIMS Process and Product Assurance Task Team will facilitate awareness by end-users of the availability and use of product-specific guides.

Software Certification

Software Certification testing determines the degree to which software products have fully implemented requirements in the MVD implementation specifications. The NBIMS Committee envisions that the NBIMS Process and Product Assurance Task Team will work with resources and methods developed by the IAI to facilitate testing of MVD implementation specifications. Implementation may include test-bed and pilot projects and pilot data testing. These activities may result in recommended practices and may indicate degree of compliance. However, the NBIMS Committee anticipates that IAI will be responsible for certifying a particular software product and version as having fully implementing a MVD Specification for a particular IFC release. More information is available at http://isg.buildingsmart.com.

Industry Deployment Activities

Industry Deployment Activities occur after publication of IDM and MVD specifications and after MVDs have been implemented into software. Industry Deployment Activities generally assist end-users to use specifications and certified software appropriately to accomplish project goals. Experience has shown that much of the success of interoperability standards depends on good implementation phase follow-though. For this reason, the NBIMS Committee includes Deployment Activities in the Standard.[41]

Industry Deployment Activities include the following:

- Project Agreements between parties to exchanges,
- Project BIM Creation in which certified software is used to author building information models,
- Project Data Validation in which delivered BIM data is checked for compliance with the Project Agreement, and
- Project BIM Use in which delivered BIM data is imported and used in certified software by exchange parties to accomplish project objectives.

These activities will be governed by Project Agreements but, if requested and subject to resource availability, NBIMS Process and Product Assurance Task Team will work with end-users to access and interpret BIM Guides, lists of certified software, access to and/or results from research activities, industry experts, experienced end-users, or other resources.

[41] See Chapter 5.5, *Deployment*, for more information.

Acknowledgements

National Building Information Modeling Standard (NBIMS) Version 1.0 - Part 1: Overview, Principles, and Methodologies

The NBIMS initiative has likely brought together the largest and most talented consortium of individuals in our industry to date. We have direct relationships with over 30 associations and agencies and have only scratched the surface of the opportunity available to us for collaboration. We continually encourage more organizations and individuals to become involved. It is hoped that the publishing of this document will bring others into the discussion to further this effort more rapidly both nationally and internationally. There is a lot of technology behind all this, but it is the people who will ultimately allow NBIMS to succeed. We are out to change the culture of how we have approached the facilities industry for at least the last 500 years. This will not be easy and will not happen over night, but through the continued dedication of folks like those listed later in this section and those who follow them it will, without question, be accomplished. It is hoped that specific projects can come from this initial document so that resources can be gathered to allow this effort to continue and even accelerate its amazing progress to date. There is just too much at stake and too much to be gained for it not to occur.

Our sincere appreciation goes to each one on the team pulling together the National BIM Standard. Their dedication and sacrifice has been immense, as nearly all the work to date has been accomplished with volunteer time or in kind contribution. The list is a "Who's Who in BIM." Their biographies can be found at the end of this section.

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It must be recognized that this contribution was developed on a volunteer basis and speaking for the National Institute of Building Sciences and in fact for the nation we are sincerely appreciative for their many hours of professional and personal time contributed in furthering the future of the capital facilities industry:

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Charles Matta is Director, Federal Buildings and Modernizations with GSA's Public Buildings Service, overseeing a program with 120 active buildings in planning and design. He represents PBS on Design Peer Reviews for Federal facilities nationwide. Before joining GSA, he founded Matta Architects in Virginia, with a diversified practice in municipal, recreational, and residential projects. His work was published in the Washington Post, House & Garden and received an AIA Award for Design Excellence for an embassy in DC. Charles holds an M Arch degree and is licensed in VA and DC. He is former President of AIA NOVA and a Fellow with the AIA.

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Susan Nachtigall, AIA is a registered architect. As a research architect, her main objective is to create and deliver innovative technologies in design automation that improves the cost, time, and quality of performance of the built environment. Her current research is in the Early Design process and using Owner criteria/requirements to jump-start the IFC-BIM. Susan served as the lead for the Early Design project for the International Alliance for Interoperability and is currently the lead of the newly formed North American Implementer Support Group. Susan received her Master of Architecture (1998) and Master of Science Civil Engineering, Construction Management (1998) from the University of Illinois.

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Richard H. F. Jackson is the founding Director of FIATECH, a not-for-profit industry consortium focused on fast-track development and deployment of technologies to improve substantially the design, engineering, build, and maintenance cycles in the capital projects industry. He personally led development of the Capital Projects Technology Roadmap. Dr. Jackson also personally directs the technical strategy, research agenda, and development initiatives of the consortium. Dr. Jackson served nearly 30 years with the prestigious National Institute of Standards and Technology (NIST). Dr. Jackson earned a bachelor's degree from Johns Hopkins University, a master's degree from Southern Methodist University, and a doctorate from George Washington University.

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Kimon Onuma is an Architect with a unique perspective that spans architecture, planning, programming, and software development; and he is a compelling spokesperson for open standards. He is one of the leaders in BIM since 1994 and the visionary that drove the creation of the Onuma Planning System (OPS), a web enabled BIM tool based on IFCs; which is now a charter listing in the GSA BIM Guide. In 2006 OPS was demonstrated as a web feature service, using Open Geospatial Consortium standards, linking the BIM and GIS world. Onuma has lectured on BIM worldwide and written multiple papers on the technology and process.

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Richard See is a registered architect in the state of Washington and practiced architecture in leading northwest design firms. Not content with the fractured, error-prone, and costly processes in the building industry, Richard began development of a dual-thread career soon after graduate school which ultimately led to several groundbreaking projects and software products at Autodesk, Visio, and Microsoft. Most notably, in the role of International Technical Directory, he led development of the first 3 releases of the Industry Foundation Classes (IFC) for the International Alliance for Interoperability (IAI). He is now Managing Director of Digital Alchemy, a company focused on BIM products, services, and consulting

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Deke Smith was the founder of the National Institute of Building Sciences (NIBS) Facility Information Council and initiated both the National CAD Standard and National BIM Standard. He participated in the beginnings of the NIBS Construction Criteria Base and on both American Institute of Architects (AIA) CAD Layering Guideline efforts. He was the U.S. representative for facility related CAD to the International Standards Organization (ISO) in the 1990's. He was a winner of the 1996 Federal 100 award and was the 2006 CAD Society Leadership award winner. He retired after thirty years with the Department of Defense. He is a registered architect in Virginia.

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Major Suermann is a graduate of the U.S. Air Force Academy with a B.S. in Civil Engineering. After serving as a combat and stateside engineer, he earned his M.S. in Construction Management from Texas A&M University and subsequently taught computer courses for engineers in the Department of Civil and Environmental Engineering at the U.S. Air Force Academy. Currently, he is pursuing his Ph.D. in Building Construction with an emphasis on technology at the University of Florida as the first ever Rinker Scholar at the M.E. Rinker, Sr. School of Building Construction in the College of Design, Construction, and Planning.

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Françoise is also Vice President, International Centre for Facilities (ICF). She is Vice Chair, ASTM Subcommittee E06.25 on Whole Buildings and Facilities, Past Chair, ASTM Subcommittee E06.94 Terminology and Editorial, and Past Chair, ISO Technical Subcommittee TC 59 / SC 2 on Terminology and harmonization of language, Building Construction. Szigeti has over 35 years of experience as a facility programmer. She is a pioneer in the development of standardized documents used to define user requirements and assess the quality and functionality of facilities and buildings. Szigeti is the recipient of the Environmental Design Research (EDRA) *Life time Achievement Award*, 1997.

Final Words of Acknowledgement

Our sincere appreciation goes to David Harris FAIA, President of the National Institute for Building Sciences, with whose vision and support this has been possible. Our appreciation also goes to Earle Kennett, VP of NIBS, without whose support we would not have made it this far. And last, but certainly not least, the one who made it all readable, Nanne Davis Eliot, our technical editor who received a whole new education from the effort.

References

Introduction

The references that follow represent the work of many parallel groups that are working to define BIM implementation for their areas of responsibility. Currently there are four types of references:

- **Business Process Roadmaps.** These documents 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 the NBIMS and the procedures defined in the Information Delivery Manuals (IDMs).
- **Candidate Standard.** These documents are candidates to go through the NBIMS consensus process to be accepted as part of the NBIMS in the future. It is envisioned that Part 2 or later releases of this standard will incorporate these documents once approved.
- **Guidelines.** Guidelines have currently been developed by several organizations and currently include some 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 and egg' dilemma. When formal NBIMS exist, there will need to be some harmonization, not only between the guideline and the NBIMS, but also in relating the various guidelines to each other. While guidelines are not actually a part of the NBIMS they are closely related and therefore included as references.
- **Other Key References.** These are parallel efforts being developed in concert with the NBIMS however are not part of the NBIMS and in fact, may be standards in their own right.

These brief descriptions are provided to give the reader a better understanding of how each of these documents will ultimately fit together to enhance the National BIM Standard. Since they are constantly being updated and improved, a reference link is provided. Specific points of contact are not provided, as these would be likely out of date the web site listed should provide the latest points of contact. Over time, each document in the reference section will transform to harmonize with the standard and the standard will change to better support their efforts. Since the standard did not exist before this publishing, the other documents could not be expected to be in harmony, although many of the authors have been working together for some time now. There will always be guidelines that describe how an organization intends to implement the U. S. National BIM Standard. This is especially true due to the overall scope of the document.

The references available at the time of publishing are provided below. Additional important documents are being produced throughout the industry continually. The most up to date lists are maintained on the NBIMS web site (http://www.facilityinformationcouncil.org/bim/index.php). Other important references are available at the buildingSMARTalliance™ web site. (http://www.buildingsmartalliance.org/)

What follows is an alphabetic list by name and very brief identification of each of the references:

AIA Integrated Practice (A Guideline)

Integrated Practice leverages early contribution of knowledge through utilization of new technologies, allowing architects to better realize their highest potentials as designers and collaborators while expanding the value they provide throughout the project lifecycle.

See also: AIA Integrated Practice http://www.aia.org/ip_default

American General Contractors Guide to BIM ***(A Guideline)***

The Associated General Contractors of America's (AGC) "Contractors' Guide to BIM" was written by contractors for contractors to provide a starting point for those seeking more information about Building Information Modeling.

The AGC Guide defines a Building Information Model as a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.

Access to the AGC Guide to BIM is a membership benefit or is available for a cost to non-members – click on the following link for more information.
http://iweb.agc.org/iweb/Purchase/ProductDetail.aspx?Product_code=2926E

Coast Guard Information Model Guidelines ***(A Guideline)***

This document is currently located behind the USCG firewall and is not accessible to the public. Please contact Dave Hammond for further information.

Construction Operations Building Information Exchange (COBIE) ***(Candidate Standard)***

The objectives of the Construction Operations Building Information Exchange (COBIE) project are two-fold. The first object is to reduce the cost of collating handover documents by providing a context within which those responsible for handover information may directly contribute that information. The second objective is to provide the handover information in a clearly defined format that can be utilized by facility maintainers, operators, and asset managers.

See also: Fact Sheet about COBIE
http://www.facilityinformationcouncil.org/bim/pdfs/bim_fs_cobie.pdf

Early Design ***(Candidate Standard)***

The objective of this work is to create a standard view definition based on Industry Foundation Classes (IFC) for the exchange of information between project planning, programming (Project Brief), and early design and downs-stream applications. The view will contain owner requirements as well as constraints (areas, non-graphic properties).

See also: Fact Sheet about Early Design
http://www.facilityinformationcouncil.org/bim/pdfs/bim_fs_ed.pdf

FIATECH Capital Projects Technology Roadmap ***(A Business Process Roadmap)***

The Roadmap is a cooperative effort of associations, consortia, government agencies, and industry, working together to accelerate the deployment of emerging and new technologies that will revolutionize the capabilities of the capital projects industry. The initiative is led by FIATECH and is open to all stakeholders who are committed to the future success of the capital projects industry.

See also: Roadmap Web Site
http://www.fiatech.org/projects/roadmap/cptri.htm

General Building Information Handover Guide: Principles, Methodology and Case Studies ***(A Guideline)***

The General Buildings Information Handover Guide, published in 2007, serves as a Part 2 of the Capital Facilities Information Handover published jointly by NIST, FIATECH and USPI-NL in 2006. The purpose of these guides is to provide recommendations to the capital facilities industry on techniques and standards to improve the quality and reduce the cost of information handovers throughout the capital facility life cycle.

See also: Capital Facilities Information Handover Guide, Part 1
http://www.fire.nist.gov/bfrlpubs/build06/PDF/b06016.pdf

See also: General Building Information Handover Guide: Principles, Methodology and Case Studies
http://cic.nist.gov/staff/NISTIR_7417_GBIHG_2007-08.pdf

GSA's National 3D-4D-BIM Program ***(A Guideline)***

In 2003, GSA's PBS Office of the Chief Architect (OCA) established the National 3D-4D-BIM Program. The primary goal of the program is to promote the value-added implementation of BIM technologies on design and modernization of Federal projects. BIM is primarily used during preliminary and final concept design to make design information explicit, and gain process efficiencies. All major projects that receive design funding in FY2007 and beyond are required to submit a spatial program BIM to GSA prior to final concept presentation. In addition, the implementation of various additional BIM technologies above the minimum requirements are encouraged and supported on a project-by-project basis and through an open and collaborative process.

See also: National 3D-4D-BIM Program
http://www.gsa.gov/bim

International Code Council Code Compliance Checking ***(Other Key Reference)***

The objective of the International Code Council (ICC) automated code compliance checking (ACcubed) project (the project) is to develop a format for SMARTcodes and implement an approach to use SMARTcodes to automate code compliance checking using the ICC International Codes and Federal, state and local amendments and additions to those codes. As most all government agencies with authority to regulate building design and construction adopt and use the ICC codes, the availability of ICC SMARTcodes can have significant impacts on US construction, in addition to opening up opportunities to better support building safety efforts in other countries.

See also: ICC SMARTcodes
http://www.iccsafe.org/SMARTcodes/faq.html

OGC® OWS-4 Testbed – CAD/GIS/BIM Thread ***(Other Key Reference)***

This appendix describes work accomplished by the membership of the Open Geospatial Consortium, Inc. (OGC®) to integrate Computer Aided Design (CAD), Geospatial Information Services, and Building Information Models (BIM) in the context of service-oriented architectures. This work was conduct as part of the OWS (Open Geospatial Consortium Web Services) Test Bed 4 during 2006 and was partially designed to address a number of issues raised by the Facility Information Council, National BIM Standard Project Committee and the International Alliance for Interoperability, Building Smart Initiative. OGC, NIBS and IAI have reciprocal participation agreements.

See also: Summary OGC® OWS-4 Testbed – CAD/GIS/BIM Thread
http://www.opengeospatial.org/projects/initiatives/ows-4

OGC® AECOO Interoperability Initiative *(Other Key Reference)*

The OGC, in cooperation with the buildingSMART alliance, IAI and several industry organizations and private firms, has initiated a testbed for an AECOO (Architecture, Engineering, Construction, Ownership, Operation) OGC Interoperability. This effort was originally conceived as a thread in the OGC's OWS-5 testbed activity, but the projected scope of the project has increased and the sponsors have decided to pursue a separate OGC testbed devoted entirely to building lifecycle requirements, some of which will relate to non-geospatial technical issues.

At time of publication this project does not have a web site – please contact Louis Hecht lhecht@opengeospatial.org) for more information.

OSCRE Real Property Standards *(Other Key Reference)*

The Opens Standards Consortium for Real Estate through their committee process have developed property standards for the real property industry that have a direct bearing on the organizational structure of BIM. Much of the information contained in this section is the basis for chapter 3.2.

See also: OSCRE Real Property Standards
http://www.oscre.org/

Pankow/NIBS/FIATECH - Architectural Precast Concrete *(Other Key Reference)*

The outcome of this study will include a better understanding of and clear documentation showing:

- The data exchange requirements and workflow scenarios for exchanges between architect and precast contractor, for architectural and structural precast concrete.
- Costs and benefits of using 3D modeling to pass information between architect, precast contractor and other process participants for complex precast concrete products, in comparison with 2D drawing exchanges.
- Parallel and comparable development of two substantial precast concrete buildings using both conventional and integrated three-dimensional processes clear and unequivocal data
- An economic analysis indicating comparative number of hours and employees required
- Impact on the project schedule of the alternative approaches
- Relative costs using the alternative approaches.

See also: Architectural Precast Concrete
http://www.facilityinformationcouncil.org/bim/pdfs/bim_fs_ap.pdf

United States National CAD Standard *(Other Key Reference)*

The U.S National CAD Standard (NCS) is the only comprehensive U.S. CAD Standard for the design, construction and facility management industries. The program's goal is broad voluntary adoption of the CAD Standard by the building design, construction and operation sectors, thereby establishing a common language for the building design and documentation process. Use of NCS eliminates the overhead costs that organizations now incur to maintain proprietary office standards, train new staff, and coordinate implementation among design team members. The 2-D standard plays a crucial role in easing the transition to new BIM software systems and the 3-D object-based standards.

See also: National CAD Standard
http://www.nationalcadstandard.org/

United States Army Corps of Engineers Building Information Modeling (A Business Process Roadmap)

Building Information Modeling (BIM) is a technology that is rapidly gaining acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge to the U.S. Army Corps of Engineers (USACE) is to proactively prepare for BIM, use it to drive down costs and delivery time, and maintain or even improve quality at the same time. This document outlines the strategic and implementation plans for using BIM technology to improve USACE planning, design, and construction processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is to focus on the implementation of BIM in the U.S. Army Corps of Engineer's civil works and military construction business processes, including the process for working with the USACE Architectural Engineering Construction (AEC) industry partners and software vendors

See also: USACE BIM Roadmap
https://cadbim.usace.army.mil/Myfiles/1/ERDC_TR-06-10.pdf

Whole Life Cycle Information Flows for Portfolio and Asset Management - International Centre for Facilities (A Business Process Roadmap)

This document outlines and diagrams the broad range of information flows needed during the whole life cycle of constructed assets. It identifies information about assets needed for portfolio and asset management. It notes the current availability of standardized formats for interoperability of some important categories of such information. It briefly summarizes:
(a) the overall information flows for decision-making in portfolio and asset management;
(b) the PAMPeR project and related IFC property set for demand and supply levels in the ASTM standardized method and metrics for whole building functionality and serviceability;
(c) the newly agreed standard method for measuring the floor areas in a building;
(d) methods for categorizing information about building condition, to facilitate parametric cost estimates; and
(e) what work is underway in ISO in this respect.

See also: Whole Life Cycle Information Flows for Portfolio and Asset Management
(http://www.icf-cebe.com/)

Glossary

Term	Initials/ Acronym	Description
AGC Guide to BIM		The Associated General Contractors of America's (AGC) "Contractors' Guide to BIM" was written by contractors for contractors to provide a starting point for those seeking more information about Building Information Modeling.
Architects, Engineers and Contractors Extensible Markup Language	aecXML	A data representation standard designed for all the non-graphic data involved in the construction industries.
Army Research Lab	ARL	A government organization responsible for basic research for the army. An Infrastructure Operations Center was developed there to use building information models to operate facilities. The concept was validated but a true BIM was never used.
Associated General Contractors of America Extensible Markup Language	AGCxml	An exchange language dealing with transactional data normally exchanged in construction and business-to-business documents.
Authoritative Source		An information source considered the authority for that type of information. It is usually managed by an association that has as its charter sustaining that data. Authoritative data is required in the BIM process and must have a point of reference for data fidelity and validity in a BIM product. *OmniClass*™ and *IFDLibrary*™ are examples of authoritative references proposed for the NBIM Standard.
Automating Equipment Information Exchange	AEX	The Automating Equipment Information Exchange (AEX) project is developing, demonstrating and deploying XML specifications to automate information exchange for the design, procurement, delivery, operation and maintenance of engineered equipment.
Building Automation and Control Networks	BACnet	Defines an XML data model and Web service interface for integrating facility data from disparate data sources with business management applications. Conforms to Simple Object Access Protocol (SOAP) 1.1 over Hypertext Transfer Protocol
Building Information Model	Model	A Building Information Model (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 life-cycle from inception onward. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM process to support and reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.
Building Information Model (AGC Definition)		The AGC Guide defines a Building Information Model as a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.

Term	Initials/ Acronym	Description
Building Information Modeling	BIM	Building Information Modeling is the act of creating an electronic model of a facility for the purpose of visualization, engineering analysis, conflict analysis, code criteria checking, cost engineering, as-built product, budgeting and many other purposes.
Building Lifecycle Information/Interoperable Software project	BLIS	The BLIS project was conceived as a way to initiate the next logical phase in the widespread adoption of an object data model standard for the AEC/FM industry.
Building Lifecycle Interoperable Software	BLIS	A project of IAI-International, BLIS Project was conceived as a way to initiate the next logical phase in the widespread adoption of an object data model standard for the AEC/FM industry. Through implementation and cooperation commitment by a large number of software vendors the project has a goal of removing the 'wait and see' delays in implementing IFC-based software. See also: http://blis-project.org/
buildingSMART Alliance™		buildingSAMRT alliance™ is the home of the North American chapter of buildingSMART, but also the focal point and coordinator for all activities related to BIM in North America. The buildingSMART alliance has a goal of saving $200B annually by 2020.
buildingSMART®		buildingSMART® is an international collaboration of 30 countries organized into 15 chapters. Created to spearhead technical, political, and financial support for advanced digital technology in the real property industry—from concept, design and construction through operations and management
Business Enterprise Architecture	BEA	The latest version of the DoD Business Enterprise Architecture can be found here - http://www.dod.mil/bta/products/bea.html
Business process		The business process defines how business is accomplished. If the data and information is gathered as part of the business process then data gathering is a no cost requirement. If data is gathered as a separate process then the data will likely not be accurate. The goal is to have data both collected and maintained in a real time environment, so as physical changes are made they are reflected for others to access in their portion of the business process.
Business Process Execution Language	BPEL	A method of documenting business processes
Business Process Execution Language for Web Services	BPEL-WS	A method of documenting business processes usable on the world wide web
Business Process Modeling Notation	BPMN	A process and graphic notation conventions used to design and capture existing business processes, as well as the simulation of new ones. BPMN is used requirements definition and the Model View Definition processes.
Business Rules	BR	Business rules are appended to static concepts to provide context specific rules for how the concept must be applied. Business rules also set requirements to the concepts, e.g. regarding their data type. For example some business rules for the fire rating concept may require numeric values while other business rules require alphanumeric values.

Term	Initials/ Acronym	Description
Capability Maturity Model	CMM	The Capability Maturity Model was a concept adapted from the Information Technology Infrastructure Library developed in the UK to define the maturity of models. It is adapted to identify various aspects important to a mature building information model
Capital Facilities Industry Extensible Markup Language	cfiXML	Use of XML in the capital facilities industry. including industrial, commercial and institutional facilities, buildings and infrastructure. focuses on technical descriptions of facility items (such as pumps, heat exchangers and other equipment items) that participate in larger business processes such as Request for Quote, Quote, Purchase Order, etc.,
Change Management		Change Management identifies a methodology used to change business processes that have been developed by an organization. If a business process is found to be flawed on in need of improvement, one institutes a "root cause analysis" of the problem and then adjusts the business process based on that analysis. Since this is related to the following item, business processes it should come after it.
CIMSteel Integration Standard Release 2: Second Edition	CIS/2	Published by The Steel Construction Institute CIMsteel Integration Standards (CIS/2.1), a set of formal computing specifications that allow software vendors to make their engineering applications mutually compatible. See also: http://www.cis2.org/
City Graphic Markup Language	CityGML	Geographic mark up language and foundation for OGC Web Services for communication between geographic objects and enterprise applications and a common information model for the representation of 3D urban objects
Computer Emergency Response Team	CERT	The CERT Coordination Center was created by DARPA in November 1988 after the Morris worm struck. It is a major coordination center in dealing with internet security problems.
Construction drawings -- Designation systems -- Part 1: Buildings and parts of buildings	ISO 4157-1	An international standard for identifying buildings and parts of buildings (ISO 4157-1:1988)
Construction drawings -- Designation systems -- Part 2: Room names and numbers	ISO 4157-2	An international standard designation for room named and numbers (ISO 4157-2:1988)
Construction drawings -- Designation systems -- Part 3: Room identifiers	ISO 4157-3	An international standard designation for room numbering (ISO 4157-3:1988)
Construction Engineering Research Laboratory (of the US Army) - SEE also ERDC	CERL	One of the research laboratories of the United States Army Corps of Engineers where significant BIM research and development is taking place

Term	Initials/ Acronym	Description
Construction Operations Building Information Exchange	COBIE	The objectives of the Construction Operations Building Information Exchange (COBIE) project are two-fold. The first object is to reduce the cost of collating handover documents by providing a context within which those responsible for handover information may directly contribute that information. The second objective is to provide the handover information in a clearly defined format that can be utilized by facility maintainers, operators, and asset managers.
Construction Specifications Institute	CSI	CSI is a national association dedicated to creating standards and formats to improve construction documents and project delivery. The organization is unique in the industry in that its members are a cross section of specifiers, architects, engineers, contractors and building materials suppliers. See also: www.csinet.org
Data Models		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 data model will serve several roles: • A structure for people to find items for use in information exchanges / Information Delivery Manuals (IDMs) and other similar organizational structures • Normalizing information for efficient data maintenance • Common definition of data elements with synonyms to support various views of the information, which is the basis of standardization • A directory structure for the storage of collected information so that the information as it is collected can be stored in the data structure
Data Richness		Identifies the completeness of the building Information Model from initially very few pieces of unrelated data to the point of it becoming valuable information and ultimately corporate knowledge about a facility
Delivery Method		Data delivery is also critical to success. If data is only available on one machine then sharing can not occur other than by email or hard copy. In a structured networked environment if information is centrally stored or accessible then some sharing will occur. If the model is a systems oriented architecture (SOA) in a web enabled environment the netcentricity will occur and information will be available in a controlled environment to the appropriate players. Information assurance must be engineered into all phases.
Department of Defense	DoD	The Department of Defense is the largest property holder in the government and has a portfolio of approximately 571,000 facilities. There has not been much activity at high levels related to BIM at this point in time.
Digital rights management	DRM	An umbrella term that refers to access control technologies used by publishers and copyright holders to limit usage of digital media or devices. It may also refer to restrictions associated with specific instances of digital works or devices. To some extent, DRM overlaps with copy protection, but DRM is usually applied to creative media (music, films, etc.) whereas copy protection typically refers to software.

Term	Initials/ Acronym	Description
Early Design		The objective of this work is to create a standard view definition based on Industry Foundation Classes (IFC) for the exchange of information between project planning, programming (Project Brief), and early design and downs-stream applications. The view will contain owner requirements as well as constraints (areas, non-graphic properties).
Exchange Requirements	ER	Exchange Requirement - See Exchange Requirements Model
Exchange Requirements Model	ERM	The data model addressing requirements for a single industry process is known as an Exchange Requirements Model (ERM).
Executive Board of Acceptance		NBIMS Executive Committee reviews and votes whether to approve.
Facility Information Council	FIC	A council of the National Institute of Building Sciences established in 1993. The purpose of the Council is to improve the performance of the life-cycle of facilities including design, engineering, construction, operations, maintenance and retirement by fostering: a common integrated life-cycle information model for the A/E/C industry, and standards which allow for the free flow of graphic and non-graphic information through the information model. It has been the home of the National CAD Standard and the National BIM Standard since their inception. See also www.facilityinformationcouncil.org
Federal Facilities Council (US)	FFC	A council of the National Academy of Sciences oriented to coordinating the efforts of federal agencies involved with facility design, construction, operations and sustainment
Federal Real Property Council (US Federal group of senior execs)	FRPC	The Federal Real Property Council was established to implement EO 13327 Federal Real Property Asset Management
General Building Extensible Markup Language	GBxml	GBxml - transfer of building information between standalone CAD, engineering analysis and modeling software
General Building Information Handover Guide: Principles, Methodology and Case Studies		The General Buildings Information Handover Guide, published in 2007, serves as a Part 2 of the Capital Facilities Information Handover published jointly by NIST, FIATECH and USPI-NL in 2006. The purpose of these guides is to provide recommendations to the capital facilities industry on techniques and standards to improve the quality and reduce the cost of information handovers throughout the capital facility life cycle.
General Services Administration	GSA	The federal agency responsible for public buildings and one of seven federal agencies responsible for facility construction. The GSA is one of the leaders in the BIM effort as they have required that all new building starts are required to provide a BIM

Term	Initials/ Acronym	Description
Geospatial Information Systems	GIS	A geographic information system (GIS), also known as a geographical information system or geospatial information system, is a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth. GIS is referred to as geomatics in Canada. In the strictest sense, it is an information system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically-referenced information. In a more generic sense, GIS is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations.
Graphical Information		Often the starting point is a non-graphical environment. The advent of graphics helps paint a clearer picture for all involved. As standards are applied then information can begin to flow as the provider and receiver must have the same standards in place. As 3D images come into play more consumers of the information will have a common view and a higher level of understanding will occur. As time and cost are added then the interfaces can be expanded significantly.
GSA's National 3D-4D-BIM Program		In 2003, GSA's PBS Office of the Chief Architect (OCA) established the National 3D-4D-BIM Program. The primary goal of the program is to promote the value-added implementation of BIM technologies on design and modernization of Federal projects. BIM is primarily used during preliminary and final concept design to make design information explicit, and gain process efficiencies. All major projects that receive design funding in FY2007 and beyond are required to submit a spatial program BIM to GSA prior to final concept presentation. In addition, the implementation of various additional BIM technologies above the minimum requirements are encouraged and supported on a project-by-project basis and through an open and collaborative process.
Harmonization		Comparison and normalization of two or more similar standards including issues such as scope, specifications, guidance or implementation.
IAI Methods		NBIM Standards Committee anticipate adopting established IAI methods.
IFC 2X2		[Liebich 2004] 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
IFCxml	IFCxml	xml which has been developed to map to the IFC data model. See also: http://www.iai-international.org/Model/IFC(ifcXML)Specs.html
IFDLibrary™		International Framework for Dictionaries (ISO 12006-3) is a library with terminology and ontologies assisting in identifying the type of information being exchanged. It is developed with the purpose of adding value to the IFCs and is language and culture independent. The International Framework for Dictionaries (IFD) (ISO 12006-3) standard is developed by ISO TC 59/SC 13/WG 6. Many of the members of the work group are also members of International Construction Information Society (ICIS). The IFD standard has many similarities with the EPISTLE standard for the Oil and Gas industry.

Term	Initials/ Acronym	Description
Industry Foundation Classes	IFC	The Industry Foundation Classes (IFC) specification is a neutral data format to describe, exchange, and share information typically used within the building and facility management industry sector (AEC/FM). The IFC specification is developed and maintained by the International Alliance for Interoperability (IAI) as part of its buildingSMART mission. For more information see http://ifc.buildingsmart.com
Industry Foundation Dictionary	IFD	Created by IAI-International, this international construction thesaurus currently supporting several languages. CSI is managing this activity in the US. It is used to support various NBIMS Initiative activities. See also: http://www.ifd-library.com/
Information Accuracy		Having a way to ensure that information remains accurate Is only possible through some mathematical ground truth capability. Having a mathematical product will also allow for better management by supporting difficult to game metrics. These numbers can be used for occupancy, information collection completeness and overall inventory calculations.
Information assurance	IA	The practice of managing information-related risks. More specifically, IA practitioners seek to protect the confidentiality, integrity, and availability of data and their delivery systems. These goals are relevant whether the data are in storage, processing, or transit, and whether threatened by malice or accident. In other words, IA is the process of ensuring that the right people get the right information at the right time.
Information Delivery Manual	IDM	Information Delivery Manual (IDM) is a methodology developed by the Norwegian buildingSMART organization and augmented by the NBIM Committee to support the information exchange requirements for business processes within the building construction industry. The intent is that it should do so using the capabilities of the IFC model and the extended property definitions declared within the IFD dictionary. See also http://idm.buildingsmart.com.
Information Delivery Manual	IDM	The exchange definition written in non-technical prose for use by end-users. Describes the business process, stakeholders, exchange points, information requirements and business rules.
Information Value-Chain		As with other industries, an information value-chain needs to be developed around well understood workflows in order to have a collaborative environment. The incorporation of NBIMS into software applications supports this value-chain development
Integrated Practice / Integrated Project Delivery		Integrated Practice leverages early contribution of knowledge through utilization of new technologies, allowing architects to better realize their highest potentials as designers and collaborators while expanding the value they provide throughout the project lifecycle.

Integration		Software integration is a special case of interoperability when the same data model is part of a group of applications' internal data structure. Typically, the group consists of a limited set of applications that each serve a different discipline, industry process or business case. Data sets are directly imported and/or exported from one application in the group to another and reused without any transformation or mapping. Traditionally, integrated data models and applications are both proprietary.
Interactive Capability Maturity Model	I-CMM	An interactive version of the NBIMS Capability Maturity Model tool.
International Code Council Code Compliance Checking		The objective of the International Code Council (ICC) automated code compliance checking (ACcubed) project (the project) is to develop a format for SMARTcodes and implement an approach to use SMARTcodes to automate code compliance checking using the ICC International Codes and Federal, state and local amendments and additions to those codes. As most all government agencies with authority to regulate building design and construction adopt and use the ICC codes, the availability of ICC SMARTcodes can have significant impacts on US construction, in addition to opening up opportunities to better support building safety efforts in other countries.
Interoperability		Software interoperability is seamless data exchange among diverse applications which each may have their 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 (i.e. not proprietary), any application can participate in the mapping process and thus become interoperable with any other application that participated in the mapping.
Interoperability/ IFC Support		NBIMS ultimate goal is to ensure interoperability of information. Getting accurate information to the party requiring the information. There are many ways to achieve this, however the most effective is to use a standards based approach to ensure that information is in a form that can be shared and software are available that can read that standard for information.
ISO 15926		The ISO project similar to ifcs that is more oriented toward the oil and gas and process industry. The work is also being accomplished under ISO TC 184.
ISO Standard (Standard for Exchange of Product Model Data) See also STEP	EXPRESS	EXPRESS is the data modeling language of STEP and standardized as ISO 10303-11. An EXPRESS data model can be defined in two ways, textually and graphically. For formal verification and as input for tools such as SDAI the textual representation within an ASCII file is the most important one. The graphical representation on the other hand is often more suitable for human use such as explanation and tutorials. The graphical representation, called EXPRESS-G, is not able to represent all details that can be formulated in the textual form.
ISO 12006-2		Organization of Information about Construction Works - Part 2: Framework for Classification of Information provides a basic structure of information about construction that is grouped into three primary categories composing the process model: construction resources, construction processes and construction results.

ISO/PAS 16739		The ISO project tile for the Industry Foundation Class (ifc) under Technical Committee 184 of the International Standards Organization
IT Infrastructure Library	ITIL	Information Technology Infrastructure Library - a framework outlining worldwide accepted best practices for IT Service Management. The concepts within ITIL support IT service providers in the planning of consistent, documented, and repeatable processes that improve service delivery to the business.
Leadership in Energy and Environmental Design.	LEED	An initiative of the U.S. Green Buildings Council. See also: www.usgbc.org/leed
Lean Construction Institute	LCI	An organization dedicated to eliminating waste or non-value added effort for the construction industry by applying lean concepts
Life-cycle Views		Views refer to the phases of the project and identifying how many phases are to be covered by the BIM. One would start as individual stove pipes of information and then begin linking those together and taking advantage of information gathered by the authoritative source of the information. This category has high cost reduction, high value implications based on the elimination of duplicative data gathering. The goal would be to support functions outside the traditional facility management roles, such as first responders.
MasterFormat™		MasterFormat™ is the pre-eminent means for organizing commercial and institutional construction specifications in North America. Initially published in 1963 by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC), it has been revised many times since then, and has been used by individuals and companies in all sectors of the construction industry for filing and organizing specifications, product data, and other construction information.
Meta Model		A meta-model is an explicit model of the constructs and rules needed to build specific models within a domain of interest. 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.
Model View Definition.	MVD	The technical exchange definition for use by software developers.
MVD Specialist and Implementers		Model View Definition Specialists and/or trained implementers perform tasks and determine fitness of completed products. Guidance by NBIM Standard policies may control Specialist or Implementer actions.
National Aeronautics and Space Administration	NASA	
National Building Information Model Committee	NBIMS Committee	The NIBS FIC Committee responsible for developing, managing and sustaining the NBIMS.

National Building Information Modeling Standard 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.
National Building Information Model 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.
National Institute of Building Sciences	NIBS	The National Institute of Building Sciences was established by Public Law 93-383, Sect. 809 in 1974. The unique 501c3 organization was established to build bridges between the public and private sector to encourage the flow of information related to the construction industry.
NBIMS Consensus Ballot		Formal NBIM Standard Consensus Committee balloting and voting procedure. Planned to be similar to National Institute of Building Sciences National CAD Standard process.
NBIMS Construction Phase		Construction phase of development and implementation of NBIMS describes the work in this phase to link generic information concepts with specific elements that are available in standard schema. A standard schema is a widely agreed 'family' of related information. If a concept is related to a known family structure then it's easy for everyone to use the information in a consistent way to achieve predictable results. A primary purpose of this phase is to prepare and express the data so that it is familiar and easy for software developers to implement the Standard in their applications.
NBIMS Deployment Phase		Deployment phase of development and implementation of NBIMS refers to a wide range of products and activities; all focused on facilitating the successful implementation and use of NBIM Standard exchanges. Whether it be during project planning and contracting, BIM creation with the confidence of a predictable result, easy and reliable BIM model exchanges, or models that can be readily reused and/or repurposed; deployment is where the value of BIM Standards is realized
NBIMS Design Phase		Design phase of development and implementation of NBIMS refers to organizing information concepts needed in the Exchange in much the same way as Architects organize physical and spatial elements needed in a facility. Exchange designers take into account concepts that already exist and those that are new to this particular exchange requirement.
NBIMS Programming Phase		Programming phase of development and implementation of NBIMS is to support research and discovery of needed exchanges and to set the requirements for a useful exchange standard. Research and logistics activities are included in this phase as well in order to assure an efficient activity and set the stage for a successful deployment when the Standard is released.

NBIMS/IAI Methods		International Alliance for Interoperability (IAI) methods as adapted to NBIMS regional and organizational context.
NBIMS/Vendor Team Consensus		Vendor teams, with NBIMS oversight, will determine approval using a team-oriented majority voting process.
OGC© AECOO Interoperability Initiative		The OGC, in cooperation with the buildingSMART alliance, IAI and several industry organizations and private firms, has initiated a testbed for an AECOO (Architecture, Engineering, Construction, Ownership, Operation) OGC Interoperability. This effort was originally conceived as a thread in the OGC's OWS-5 testbed activity, but the projected scope of the project has increased and the sponsors have decided to pursue a separate OGC testbed devoted entirely to building lifecycle requirements, some of which will relate to non-geospatial technical issues.
OGC© OWS-4 Testbed – CAD/GIS/BIM Thread		This appendix describes work accomplished by the membership of the Open Geospatial Consortium, Inc. (OGC®) to integrate Computer Aided Design (CAD), Geospatial Information Services, and Building Information Models (BIM) in the context of service-oriented architectures. This work was conduct as part of the OWS (Open Geospatial Consortium Web Services) Test Bed 4 during 2006 and was partially designed to address a number of issues raised by the Facility Information Council, National BIM Standard Project Committee and the International Alliance for Interoperability, Building Smart Initiative. OGC, NIBS and IAI have reciprocal participation agreements.
OmniClass™		OmniClass is a multi-table faceted classification system designed for use by the capital facilities industry. OmniClass has been developed by the OCCS Development Committee, an all-volunteer group of individuals and representatives of organizations assembled for this purpose. The Committee's work on OmniClass is administered by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC). The OmniClass tables and introduction can be downloaded from http://www.omniclass.org/.
Ontology		In both computer science and information science, an ontology is a data model that represents a domain and is used to reason about the objects in that domain and the relations between them.
Open Building Information Xchange	OBIX	Standard web services protocol for communication between building mechanical and electrical systems and enterprise applications

Open Geospatial Consortium	OGC	The Open Geospatial Consortium, Inc.® (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. See www.opengeospatial.org
Organization for the Advancement of Structured Information Systems	OASIS	OASIS is a not for profit consortium that drives the development, convergence, and adoption of open standards for the global information society. See www.oasis-open.org
OSCRE Real Property Standards	OSCRE	OSCRE develops and publishes open exchange standards to enable an efficient global real estate Industry creating great value through a common business language and ready information exchange. OSCRE's workgroup process is providing a model for collaborative standards development to the NBIMS Committee. See www.oscre.org
Owner/Architect/Engineer/Contractor/	OAEC or A/E/C/O	Common term used to describe as a group the principal actors/stakeholders during building design and construction projects.
Pankow/NIBS/FIATECH - Architectural Precast Concrete		A project funded by a grant to define the data exchange requirements and workflow scenarios for exchanges between architect and precast contractor, for architectural and structural precast concrete.
Project Team Contract Agreements		Signed contract agreements made between members of a project team
Roadmaps		The overall implementation strategy documents from various groups used to set the definition, direction, sequence and usually milestones for an initiative. For example, the FIATECH Capital Facilities Technology Roadmap. See also: http://www.fiatech.org/projects/roadmap/cptri.htm .
Roles Or Disciplines		Roles refer to the players involved in the business process and how the information flows. This is also critical to reducing the cost of data re-collection. Disciplines are often involved in more than one view as either a provider or consumer of information. Our goal is to involve both internal and external roles as both providers and consumers of the same information so that data does not have to be re-created and that the authoritative source is the true provider of the information.
Spatial Capability		Understanding where something is in space is significant to many information interfaces and the richness of the information. Energy calculations must know where the heat gains will come from; first responders need to know where water supplies and utility cutoffs are located in relation to the facility.
Standard for the Exchange of Product model data	STEP	The root of most of the work being done in defining objects for construction. Its home is in the International Standards Organization
Taxonomy		A collection of controlled vocabulary terms organized into a hierarchical structure
Thesaurus		A thesaurus is a networked collection of controlled vocabulary terms
Timeliness/ Response		While some information is more static than other information it all changes and up to the minute accuracy may be critical in emergency situations. The closer to accurate real time information you can be the better quality the decisions that are made. Some of those decisions may be life saving in nature.

UniFormat™		UniFormat™ provides a standard method for arranging construction information, organized around the physical parts of a facility called systems and assemblies. These systems and assemblies are characterized by their function without identifying the technical or design solutions that may compose them. Because UniFormat organizes the structures in the built environment by their component elements, a modified version of it was used as a legacy source for the basic organization and contents of OmniClass™ Table 21 – Elements. See also: Construction Specifications Institute
United States Army Corps of Engineers Building Information Modeling		Building Information Modeling (BIM) is a technology that is rapidly gaining acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge to the U.S. Army Corps of Engineers (USACE) is to proactively prepare for BIM, use it to drive down costs and delivery time, and maintain or even improve quality at the same time. This document outlines the strategic and implementation plans for using BIM technology to improve USACE planning, design, and construction processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is to focus on the implementation of BIM in the U.S. Army Corps of Engineer's civil works and military construction business processes, including the process for working with the USACE Architectural Engineering Construction (AEC) industry partners and software vendors
United States National BIM Standard	NBIM Standard or NBIMS	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. NBIMS will a.) Publish exchange specifications for use in specific business contexts within a holistic facility lifecycle framework; and b.) Publish encodings for the exchange specifications employing internationally acceptable open standards as normative references; c.) Facilitate implementation by software developers of encodings in software; d.) Facilitate use of certified software by end-users to create and use interoperable building information model exchanges.
United States National CAD Standard	NCS	The U.S National CAD Standard (NCS) is the only comprehensive U.S. CAD Standard for the design, construction and facility management industries. The program's goal is broad voluntary adoption of the CAD Standard by the building design, construction and operation sectors, thereby establishing a common language for the building design and documentation process. Use of NCS eliminates the overhead costs that organizations now incur to maintain proprietary office standards, train new staff, and coordinate implementation among design team members. The 2-D standard plays a crucial role in easing the transition to new BIM software systems and the 3-D object-based standards.
WG Consensus Vote		Workgroup Consensus Vote. Approval by majority vote of a workgroup.

Whole Life Cycle Information Flows for Portfolio and Asset Management - International Centre for Facilities	This document outlines and diagrams the broad range of information flows needed during the whole life cycle of constructed assets. It identifies information about assets needed for portfolio and asset management. It notes the current availability of standardized formats for interoperability of some important categories of such information.
Workflows	The identification and diagramming of how and why an exchange of data from one application/party to another is made. The NBIM Standard workflow will use the information exchanges, IDM process and model views to support a collaborative environment for lifecycle management

Appendices

Introduction

The appendices included in NBIMS Version1 - Part 1 are foundational to the document but are works being accomplished by others that may be adopted as normative standards and/or harmonized with the NBIM Standard.

That the NBIMS Committee may adopt and/or harmonize the NBIM Standard with these international standards and specifications is consistent with the goals of the International Alliance for Interoperability; which is transitioning to buildingSMART®. buildingSMART® is an international effort which comprises nearly thirty countries, organized into fifteen chapters.

Appendix A Industry Foundation Classes (IFC)

IFC is the most mature and wide-spread building industry domain schema. It supports the open standards approach required by NBIMS. A product of the International Alliance for Interoperability (IAI), IFC defines the objects and relationships between objects used throughout the Standard. Objects can be defined consistently across international contexts with units appropriate to the country in which they are being used.

Appendix B *OmniClass™*

While *OmniClass*™ is not yet widely recognized by practitioners, some of the tables contained therein should be familiar. *MasterFormat*™, which is incorporated into *OmniClass*, has been the work breakdown schedule used most often for specification writing, construction estimating, and documenting work completion for project invoicing in the U. S. construction industry. Another relatively recognized table is *UniFormat*™. *UniFormat* is currently going through a consolidation, as there are four splinter versions of *UniFormat* in use today in the United States. The remaining tables are used to standardize the classification and definition of all types of objects in the building industry domain. Though *OmniClass* is specific to the United States, it is based on and consistent with international constructs as described in the attached document.

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

The International Framework for Dictionaries is a relatively new aspect of the Standard. It provides a consistent ‘name’ for things wherever they are used in the world and in whatever local language they are expressed. Consistent naming of things is essential to support knowledge applications and management in connection with BIM.

The following lists additional initiatives that may be considered for inclusion in or harmonization with NBIMS in the future.

- **AGCxml** from AGC is an exchange language for transactional data normally exchanged in construction and business-to-business documents.

- **aecXML** from AEC is a data representation standard designed for all the non-graphic data involved in the construction industries

- **AEX** is the Automating Equipment Information Exchange (AEX) project developing, demonstrating, and deploying XML specifications to automate information exchange for the design, procurement, delivery, operation, and maintenance of engineered equipment.

- **BACnet** from ASHRAE defines an XML data model and Web service interface for integrating facility data from disparate data sources with business management applications. It conforms to Simple Object Access Protocol (SOAP) 1.1 over Hypertext Transfer Protocol.

- **cfiXML** is the use of XML in the capital facilities industry, including industrial, commercial and institutional facilities, buildings, and infrastructure. It focuses on technical descriptions of facility items (such as pumps, heat exchangers, and other equipment) that participate in larger business processes such as Request for Quote, Quote, Purchase Order, and others.

- **GML/CityGML** is the geographic mark-up language and foundation for OGC® Web Services for communication between geographic objects and enterprise applications. It is a common information model for the representation of 3D urban objects.

- **GBxml** permits the transfer of building information between standalone CAD, engineering analysis, and modeling software.

- **OBIX** is the standard web services protocol for communication between building mechanical and electrical systems and enterprise applications.

- **ISO 4157-1:1988** *Construction drawings – Designation systems – Part 1: Buildings and parts of buildings*

- **ISO 4157-2:1988** *Construction drawings – Designation systems – Part 2: Room names and numbers*

- **ISO 4157-3:1988** *Construction drawings – Designation systems – Part 3: Room identifiers*

Appendix A IAI Industry Foundation Classes (IFC or ifc)

Introduction

The International Alliance for Interoperability (IAI) Industry Foundation Classes (IFC) define the virtual representations of objects used in the capital facilities industry, their attributes, and their relationships and inheritances. Properly implemented, they are the mechanism which makes Building Information Modeling (BIM) interoperable among the software applications that currently support IFC world wide[42]. IFC are the foundation for the open standards approach to BIM. While IFC may be the single most important ingredient for the success of BIM, they are transparent to the user - the user does not need to be aware of how they are used in software.

In order to achieve interoperability, NBIMS information exchange requirements must be encoded in a machine-readable format that maintains the semantic meaning of the information throughout the facilities lifecycle. NBIMS is using the IFC data model of buildings as the data model for encoding information exchange because it constitutes an interoperability-enabling technology that is open, freely available, non-proprietary and extensible.

Background

IAI is a not-for-profit global alliance of organizations in the capital facilities industry, buildings related research, and information technology fields working to enable and promote software interoperability: the seamless exchange and sharing of information across disciplines, technical applications, and the facilities life-cycle. Members include architectural, engineering and construction organizations, building owners and operators, facility managers, product manufacturers, software vendors, information providers, government agencies, trade and professional associations, research laboratories, and universities.

The IAI was formed in North America in 1994 as Industry Alliance for Interoperability, and became international in 1995. Currently the organization has 14 regional chapters; the latest member to join was China. IAI vision is the improvement of communication, productivity, delivery time, cost, and quality related to facilities throughout their life-cycle. Its mission is to provide a universal basis for process improvement and information sharing and exchange in capital facilities industry by defining a universal, comprehensive, intelligent, extensible and open lifecycle data model of buildings – Industry Foundation Classes (IFC).

Relevance to User

IFC are at the heart of the BIM concept and are a foundation element within the open standards approach to NBIMS. The reliance on an open standards approach will ensure that all information is sustainable throughout the long life of a facility. Basing BIM on proprietary models or technology could put its consistency in jeopardy – it may leave the user at the mercy of a vendor regarding timely product updates or may cause serious problems to the user should the vendor go out of business. Because of the enormous volume and diversity of information generated and used in facilities lifecycle, no single software vendor is likely to be able to offer applications that can provide the necessary services throughout the entire facilities lifecycle. An IFC based open standard will allow the user to select any

[42] See the buildingSMART Implementer Support Group website: http://www.iai.fhm.edu/

IFC compatible application available on the market to perform a desired function or services in support of a capital facilities industry process.

Relevance to the National BIM Standard

One of the critical functions of a BIM is to consistently maintain the semantic meaning of all encoded information throughout the facilities lifecycle. NBIMS is using the IFC data model of buildings as the data model for encoding information exchange and sharing because it constitutes an interoperability-enabling technology that is open, freely available, non-proprietary and extensible, and is also applicable throughout the lifecycle phases of a facility.

The IFC data model consists of definitions, rules and protocols that uniquely define data sets which describe capital facilities. These definitions allow industry software developers to write IFC interfaces to their software that enable import and export of data in a format that is unambiguously understandable to other software applications, regardless of individual software application's internal data structure. In short, software applications that have IFC interfaces are able to exchange data with other application that also have IFC interfaces.

Discussion

Objects defined in the IFC data model allow the sharing of intelligent information contained in a BIM. These objects support the entire facility lifecycle from planning, design and construction, through facility operations and facilities management, to demolition or disposal. They represent real capital facilities industry objects, such as doors and windows, as well as abstract objects, such as construction costs. All objects can have a number of properties such as geometry, materials, finishes, product name, costs, etc., as well as relationships to and data inheritances from other objects.

In this context IFC objects could be thought of as "buckets" in which project data are stored and retrieved when needed for exchanged with other project participants. NBIMS' task is to define which data "buckets" must be filled in order to have a successful exchange of data in a specific data exchange scenario. While this might sound complicated to a novice user of the technology, in reality the user only has to use the application software to accomplish a building modeling or analysis task then use features of the application to provide the required data sets as defined by NBIMS. The software application does the rest without requiring the user to directly interact with IFC.

NBIMS will specify, in encodings understandable to software programmers, the exact vocabulary to use in the description of the data content of these data "buckets" to avoid possible misunderstandings. NBIMS is relying on OmniClass™ object classification and International Foundation for Dictionaries (IFDLibrary) resources to provide consistency and semantic clarity. (See the Appendices for information on *OmniClass* and *IFDLibrary*.)

The first version of the IFC data model was released in 1997; the latest release is IFC2*x*3. XML based implementations of the IFC data model are available as ifcXML; the latest published version is ifcXML2, the implementation of IFC2*x*2.

The IFC data model covers the entire facilities lifecycle, but no single software application needs to implement the entire data model. Implementation of IFC is more appropriately based on a particular view or a combination of views of IFC that define data set requirements in support of specific industry processes, a given organization's work practice, or typical business cases (see Sections 3 & 5 for information on the concepts behind and methods of defining and implementing model views).

IFC are currently the only international specification for data modeling of buildings recognized by the International Standards Organization (ISO) - ISO/PAS 16739 - and are the only non-proprietary, comprehensive and extensible model of the kind in existence. As such, IFC provide the only available data definitions, rules and protocols for populating any open standards based BIM.

Next Steps

The IAI is currently certifying the implementation of the Coordination View of IFC. Additional views are under development; many more are needed. NBIMS will be a mechanism for actively supporting development of model views that represent capital facilities industry processes throughout all facility lifecycle phases.

Some United States developers of software products for the capital facilities industry report that, in the past, market demand and the maturity of software specifications was not adequate to compel them to implement IFC interfaces to their software. This has begun to change, but some appear to remain concerned that interoperability based on an open standard will cost them part of their current market share. Others may see financial risk in expending resources to make their software interoperable using open standards. Consequently, implementation of IFC in software has been significantly slower in the United States than in some other countries; potentially putting the United States capital facilities industry at a competitive disadvantage. The NBIMS Committee believes that this no longer need be the case and will work to enable and promote the timely implementation of an open and extensible data model in the United States.

Items Needing Standardization

Data exchange facilitates the automated use of software in industry processes throughout facilities lifecycle. As the IFC data model is continuously expanded, new versions of the data model will be published and these will require regular incorporation into software. But this is true of all software and it will be significantly easier to update software which relies on a single, open and vendor-neutral exchange standard than it would be to maintain many proprietary interfaces to individually evolving software applications.

Similar to all schemas, IFC is known to be growing as new requirements are discovered through exchange definition processes. The NBIMS Production and Use Process includes a capability to identify new and evolutionary requirements in IFC, make these known to the IFC administrators and facilitate the timely incorporation of new capabilities into exchange specifications.

References and Links

General, publicly available documentation of the IFC data model is available at the international IAI web site http://ifc.buildingsmart.com/. Software developers interested in developing IFC interfaces to their software should contact the Coordinator of the IAI international Implementation Support Group (ISG) at http://isg.buildingsmart.com/.

Appendix B *OmniClass™*

Introduction

The dramatic increase in the amount and types of information that are now generated throughout the facility lifecycle and the capital facilities industry's reliance on access to it demands an organizational standard that can address the full scope of this information throughout that lifecycle. It has become clear that a greater degree of harmonization in classifying this information will make it retrievable, communicable, and usable by all parties involved in performing all the activities that take place throughout the facility lifecycle. The need to harmonize and reuse this information for multiple purposes is at the heart of the value and cost savings presented by virtual building modeling. The OmniClass™ Construction Classification System (known as OmniClass or OCCS) provides a way to address these demands and make this harmonization a reality. OmniClass is intended to be a tool for organizing, sorting, and retrieving information and establishing classifications for and relationships between objects in a building information model. OmniClass classification will enable transfer of and add certainty to information communicated between parties no matter the purpose it is to be put to, even when they are separated by distances, borders, languages, and years.

OmniClass is a multi-table faceted classification system designed for use by the capital facilities industry. OmniClass has been developed by the OCCS Development Committee, an all-volunteer group of individuals and representatives of organizations assembled for this purpose. The Committee's work on OmniClass is administered by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC).

Background

OmniClass is designed to provide a standardized basis for classifying information created and used by the North American architectural, engineering, and construction (AEC) industry, throughout the full facility lifecycle from conception to demolition or reuse, and encompassing all of the different types of construction projects that make up the capital facilities industry throughout the facility lifecycle. It is anticipated that all *OmniClass* tables will have application in the ordering of BIM information in the National BIM Standard, though some may be more central to the process of organizing information for exchange throughout the facility lifecycle than others.

Relevance to Users

OmniClass is applicable for organizing many different forms of information, both electronic and hard copy, and 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 during the services carried out through the facility lifecycle. *OmniClass* includes some of the most commonly used taxonomies in use in the capital facility industry as the basis for some of its tables, among them *MasterFormat*™ and *UniFormat*™. Significant effort is underway by CSI, CSC, and the OCCS Development Committee to expand the scope and use of the various tables in *OmniClass*. It is anticipated that other *OmniClass* tables will also enjoy the same level of acceptance as the more well-known ones through the efforts of both CSI and NBIMS.

Relevance to the National BIM Standard

Material suppliers, specification writers, cost engineers, and many others recognize the formats, terminology, and concepts included within *OmniClass.* As a result, these tables are already being used in many cases to store, retrieve, and analyze facility and material information. Use of all of the

OmniClass tables is anticipated to grow with the demand for structured access to and reports based on BIM information.

Discussion

OmniClass and International Standards

OmniClass is, in simple terms, a standard for organizing all construction information. The concept for *OmniClass* is derived from internationally-accepted standards that have been developed by the International Organization for Standardization (ISO) and the International Construction Information Society (ICIS) subcommittees and workgroups from the early-1990s to the present.

ISO 12006-2

OmniClass follows the international framework set out in International Organization for Standardization (ISO) Technical Report 14177, *Classification of information in the construction industry,* July 1994. This document was later established as a standard in ISO 12006-2: *Organization of Information about Construction Works - Part 2: Framework for Classification of Information*.

ISO 12006-2: *Organization of Information about Construction Works - Part 2: Framework for Classification of Information* provides a basic structure of information about construction that is grouped into three primary categories composing the process model: construction resources, construction processes, and construction results. The *OmniClass* Tables correspond to this arrangement of information:

- Tables 11-22 to organize construction results.
- Tables 23, 33, 34, and 35, and to a lesser extent 36 and 41, to organize construction resources.
- Tables 31 and 32 to classify construction processes, including the phases of construction entity life cycles.

The fifteen tables of *OmniClass* also map to the suggested tables in Section 4 of ISO 12006-2 as shown below.

OmniClass Table 11 – Construction Entities by Function	*ISO Table 4.2 Construction entities (by function or user activity)* *ISO Table 4.3 Construction complexes (by function or user activity)* ISO Table 4.6 Facilities (construction complexes, construction entities and spaces by function or user activity)
OmniClass Table 12 – Construction Entities by Form	ISO Table 4.1 Construction entities (by form)
OmniClass Table 13 – Spaces by Function	ISO Table 4.5 Spaces (by function or user activity)
OmniClass Table 14 – Spaces by Form	ISO Table 4.4 Spaces (by degree of enclosure)
OmniClass Table 21 – Elements (*includes Designed Elements*)	*ISO Table 4.7 Elements (by characteristic predominating function of the construction entity)* ISO Table 4.8 Designed elements (element by type of work)
OmniClass Table 22 – Work Results	ISO Table 4.9 Work results (by type of work)
OmniClass Table 23 – Products	ISO Table 4.13 Construction products (by function)
OmniClass Table 31 – Phases	*ISO Table 4.11 Construction entity life cycle stages (by overall character of processes during*

	the stage) ISO Table 4.12 Project stages (by overall character of processes during the stage)
OmniClass Table 32 – Services	ISO Table 4.10 Management processes (by type of process)
OmniClass Table 33 – Disciplines	*ISO Table 4.15 Construction agents (by discipline) (OmniClass Table 33 and Table 34 are both drawn from different facets of Table 4.15, which then can be combined for classification)*
OmniClass Table 34 – Organizational Roles	ISO Table 4.15 Construction agents (by discipline)
OmniClass Table 35 – Tools	ISO Table 4.14 Construction aids (by function)
OmniClass Table 36 – Information	ISO Table 4.16 Construction information (by type of medium)
OmniClass Table 41 – Materials	ISO Table 4.17 Properties and characteristics (by type)
OmniClass Table 49 – Properties	ISO Table 4.17 Properties and characteristics (by type)

ISO 12006-3 and ICIS

In much the same way that ISO 12006-2 has been implemented in the UK in *Uniclass* and in North America in *OmniClass*, the object-oriented framework standardized by ISO/PAS 12006-3 has been adopted by ICIS members in the Lexicon program, and both standards are followed by groups in several other countries that are developing similar classification standards, including Norway, Netherlands, UK, and others in Europe, in concert with the Nordic chapter of the International Alliance for Interoperability (IAI) and the Japan Construction Information Center (JACIC) which is currently working to develop the Japanese Construction Classification System (JCCS), modeled in part on *OmniClass*.

The OCCS Development Committee believes that following these ISO standards will promote the ability to map between localized classification systems developed worldwide and that the object-oriented framework of 12006-3, implemented alongside and in concert with 12006-2-based standards, will multiply the degree of control available over construction information. The Committee hopes that organizations in other countries pursuing initiatives similar to *OmniClass* will also strive to be ISO-compatible, thereby enabling smoother exchange of information between them.
As stated by ISO in the text of ISO 12006-2, "Provided that each country uses this framework of tables and follows the definitions given in this standard, it will be possible for standardization to develop table by table in a flexible way." For example, Country A and Country B could have a common classification table of elements, but different classification tables for work results without experiencing difficulties of 'fit' at the juncture.

OmniClass Development

In addition to following the ISO standards, *OmniClass* has been developed under the auspices of the following guiding principles established by the OCCS Development Committee at their inaugural meeting, September 29, 2000.

OmniClass is an open and extensible standard available to the AEC industry at large.
There is a full and open exchange of information between participants in *OmniClass* development.

OmniClass is being developed and updated with broad industry participation.

OmniClass development is open to any individual or organization willing to actively participate.

The industry as a whole, rather than any one organization, will govern development and dissemination of *OmniClass*.

OmniClass is focused on North American terminology and practice.

OmniClass is compatible with appropriate international classification system standards.

Applicable efforts in other parts of the world are reviewed and adapted as appropriate.

Existing legacy classification systems, references, and research materials applicable to *OmniClass* development are considered in the formulation of the *OmniClass*.

As a result, *OmniClass* incorporates other extant systems currently in use as the basis of many of its Tables – *MasterFormat*™ for work results, *UniFormat*™ for elements, and EPIC (Electronic Product Information Cooperation) for products. *OmniClass* consists of 15 tables, each of which represents a different facet of construction information. Each table can be used independently to classify a particular type of information, or entries on it can be combined with entries on other tables to classify more complex subjects.

The 15 *OmniClass* tables are:

Table 11 – Construction Entities by Function
Table 12 – Construction Entities by Form
Table 13 – Spaces by Function
Table 14 – Spaces by Form
Table 21 – Elements (*includes Designed Elements*)
Table 22 – Work Results
Table 23 – Products
Table 31 – Phases
Table 32 – Services
Table 33 – Disciplines
Table 34 – Organizational Roles
Table 35 – Tools
Table 36 – Information
Table 41 – Materials
Table 49 – Properties

OmniClass development is an ongoing effort. Not all *OmniClass* tables when published are at an equal level of completion. All tables are expected to receive commentary and to have their contents augmented in response to this commentary, but the nature of these expected changes is different for different status tables. In short, the tables that are being published at ‘Release’ status are ready for implementation; others have contents that members of the OCCS Development Committee think are likely in need of more input, commentary, and development. Comments will be accepted and acted upon for all tables regardless of publication status.

OmniClass Table Publication Status

There are three table publication statuses for *OmniClass*.

1. **Release.** Contents of these tables are expected to grow, but the OCCS Development Committee has a high degree of confidence in the framework and contents of the table as presented, and as a result the basic organization of the table is not expected to change. These tables have a good ‘foundation.’
2. **Draft.** The basic framework of these tables is not viewed as complete. As a result, it is possible that the basic structure of the table may undergo some measure of significant revision in response to commentary before the table is published as a ‘Release.’
3. **Conditional Draft.** This status is identical in most respects to Draft status, but the likelihood of dramatic change to the basic structure of the table is much higher, due to conditions outside the direct control of the OCCS Development Committee, such as changes in legacy resource documents that may be taking place.

As of the March 28, 2006, release of *OmniClass* Edition 1.0, this is the status of the *OmniClass* Tables:

Table 11 – Construction Entities by Function	2006-03-28 **Release**
Table 12 – Construction Entities by Form	2006-03-28 **Release**
Table 13 – Spaces by Function	2006-03-28 **Release**
Table 14 – Spaces by Form	2006-03-28 **Release**
Table 21 – Elements	2006-03-28 **Conditional Draft**
Table 22 – Work Results	2006-03-28 **Release**
Table 23 – Products	2006-03-28 **Draft**
Table 31 – Phases	2006-03-28 **Release**
Table 32 – Services	2006-03-28 **Release**
Table 33 – Disciplines	2006-03-28 **Release**
Table 34 – Organizational Roles	2006-03-28 **Release**
Table 35 – Tools	2006-03-28 **Draft**
Table 36 – Information	2006-03-28 **Draft**
Table 41 – Materials	2006-03-28 **Release**
Table 49 – Properties	2006-03-28 **Draft**

MasterFormat

MasterFormat™ is the pre-eminent means for organizing commercial and institutional construction specifications in North America. Initially published by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC) in 1963, it has been revised many times since and has been used by individuals and companies in all sectors of the construction industry for filing and organizing specifications, product data, and other construction information. Because of this widespread use and long history of development and refinement, including the 2004 edition that expanded its coverage dramatically, making it suitable for use in a broader variety of construction types, *MasterFormat* is the obvious legacy source for the contents of *OmniClass* Table 22 – Work Results. *MasterFormat* 2004 Edition was also the first published application of *OmniClass*. As published, it integrates information from other tables in *OmniClass* (chiefly ‘Products’ and ‘Information’) and classifies other information important to its use in construction projects that are not work results. Some content of *MasterFormat* is not included in *OmniClass* Table 22, though all information in *MasterFormat* has classifications located somewhere in *OmniClass*.

UniFormat

UniFormat™ provides a standard method for arranging construction information, organized around the physical parts of a facility called systems and assemblies. These systems and assemblies are characterized by their function without identifying the technical or design solutions that may compose them. The current edition of *UniFormat*, first published in 1998, was developed jointly by ASTM International (formerly the American Society for Testing and Materials), CSI, and CSC. Because *UniFormat* organizes the structures in the built environment by their component elements, a modified version of it was used as a legacy source for the basic organization and contents of Table 21 – Elements.

Next Steps

UniFormat is currently undergoing revision by CSI and CSC with the active participation of ASTM, GSA, and others. The end result will be a harmonized, updated version of *UniFormat*, bringing together the contents of CSI/CSC *UniFormat*, GSA *UniFormat*, and ASTM *UNIFORMAT II* and expanding the content as needed to address a broader array of project types throughout the full lifecycle. When the new version of *UniFormat* becomes available, currently anticipated for some time in early 2008, the OCCS Development Committee intends to use its applicable contents as the source for *OmniClass* Table 21, in a similar fashion to the current relationship between Table 22 and *MasterFormat*.

Items Needing Standardization

- The fifteen *OmniClass* tables need to 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.

References and Links

The *OmniClass* tables and introduction can be downloaded from http://www.omniclass.org/.

NOTE: Contents of Appendix B adapted from the Introduction to *OmniClass* Release 3/28/2006, ©CSI.

Appendix C *IFDLibrary™*

Introduction

The construction industry will increasingly apply building information modeling methods in developing design, procurement, construction, and operation/maintenance of facilities. Building information models internally apply schema that define the templates for the information that they can process. Schemas also define the way in which different BIM software applications communicate with each other.

A schema requires a consistent set of 'names' of things to be able to work. Names could refer to a particular construction (e.g. wall type 1), system (e.g. low voltage electrical supply), material, property set, property, or other. Each of these names must have a controlled definition that describes what it means and the units in which it may be expressed. Having a controlled vocabulary of construction terminology is essential to support data exchange.

Perhaps even more important, 'names' of things may be used more widely to support knowledge application and management in connection with BIM. For instance, building codes also refer to items by name (both in terms of a concept and attributes or properties that a concept may possess). An application of a controlled construction vocabulary is being developed with the International Code Council.

A 'dictionary' is used to define names. A dictionary of construction terminology will then define the use of a particular 'name' (type, property, etc.) in a consistent manner for whomever is using the schema and wherever it is used. Properties used in different places need to be expressed in the language of choice for that place. To be useful in the increasingly globalized construction industry, a dictionary needs to be able to handle multiple language versions.

Background

At ISO meetings in Vancouver in 1999, a variety of organizations developing IT standards for the building industry (leading to what we are today calling BIM) agreed that some sort of standardized global terminology was necessary and that its structure must be useful for computers to reliably exchange data irrespective of language. As a result, the ISO committee TC59/SC13/WG6 was tapped to develop the standard now known as *ISO 12006-3 – Framework for Object-oriented Information Exchange*.

Once ISO 12006-3 was published, *STABU LexiCon* in Holland and *BARBi* in Norway each focused their development of terminology databases to be compatible with the standard. In January 2006, the organizations signed an agreement that they would combine their separate efforts into the *IFDLibrary* to produce a single terminology database that they would share between themselves for mutual benefit.

Following the IAI buildingSMART® conference held September 2006 in Lisbon, Portugal that included a two-day workshop on IFD, the Construction Specifications Institute, Construction Specifications Canada, buildingSMART Norway, and the STABU Foundation (the Netherlands) signed a Letter of Intent to share unified object libraries, developed under ISO 12006-3, as a structure for a controlled dictionary of construction terminology.
The Letter of Intent established an informal consortium of organizations, each representing a geographic region (a country), that wish to adhere to the concept of harmonizing object libraries.

The focus of this collaboration is long-term. Each member of the consortium, signatory to the document, shares the following objectives:

1. Preparing the work necessary to make national object libraries electronically available to the consortium.
2. Undertaking to assist in mechanisms for the harmonization of the Global Unique Identifier (GUID), as defined in the ISO 12006-3 (IFD) standard, in all databases.
3. Making unified construction terminology available to the consortium.

Relevance to Users

In order for a real free flow of information to occur, three factors need to be in place:

- The format for information exchange,
- A specification of which information to exchange and when to exchange the information, and
- A standardized understanding of what the information you exchange actually is.

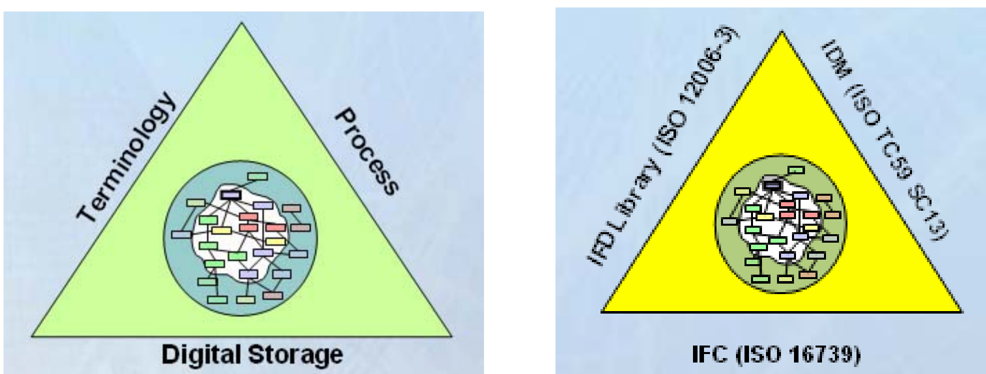

Figure App C-1: Interoperability through Standards
(Courtesy Janne Aas-Jakobsen, Jotne EPM Technology AS)

Having these three fundamental items in place allows for a true computerized interoperability between two or more information parties. This approach has been used with success in other industries, most notably the oil and gas industry, to support application and data interoperability.

In the building industry, material suppliers, specification writers, cost engineers, and many others recognize the formats, terminology, and concepts included within *OmniClass.* As a result, these tables are already being used in many cases to store, retrieve, and analyze facility and material information. Use of all of the *OmniClass* tables is anticipated to grow with the demand for structured access to and reports based on BIM information. *IFDLibrary* provides a structured standards-based methodology to define and reuse the information categories in *OmniClass*.

Relevance to the National BIM Standard

Design of the National Building Information Modeling Standard (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 widely, enabling reliable automated communications between applications, a primary goal of NBIMS.

Relationship between IFC, IFD, IDM, and MVD

The open international IFC standard defines an exchange format for information related to a building and its surroundings. The upcoming (September 2008) release of version 2x4 of the IFC standard will include facilities (currently available for preview in the 2x3g Preview Release) to exchange GIS data (such as, where the building is located and information about surrounding buildings) and facilities to tag all information with a globally unique ID from an internationally agreed ontology. With this added functionality the IFC will provide a computer understandable format in which all relevant building information can be exchanged between two parties. The IFC allows various data to be exchanged in various ways. If a receiver of information wants to be sure he or she can utilize the information received, the sender and receiver need to agree on exactly which information to exchange.

The aim of the Information Delivery Manual (IDM) and Model View Definition (MVD) is to specify exactly which information is to be exchanged in each exchange scenario and how to relate it to the IFC model. For example, an architect designing a building needs to be sure that she receive information from the structural engineer about which walls and columns are load bearing and which are not. At the same time, the structural engineer needs to know the function of each of the spaces in the building in order to calculate the right design loads for the structure. IDM along with MVD explains the exchange scenario in plain text for human readability and in a technical way to enable implementation of automatic checks and validations in applications. Continuing the example above, the engineer can run a quick test through a computer based on the requirements established in the IDM/MVD to verify that the architect has sent enough information to get started on the work.

In order to automatically verify the information in an exchange process (as described above), the information needs to be detailed further than the general level of the IFC standard. For example, if an architect wanted to supply information about the type of materials in the beams and columns this would be done in IFC using a plain text string. Even if all words are spelled correctly there is no guarantee that the receiving application will understand exactly what this text string means. And if a different language, dialect, or form of the word is used, there is no reliable way to achieve verification. Ideally, the computer should be able to understand even this type of information in the IFC formatted information received. This is typically the scenario addressed in semantic searches on the web but, in order to automatically interpret the semantic, the semantic needs to be described first. The International Framework for Dictionaries (IFD) (ISO 12006-3) together with the upcoming version of the IFC standard 2x4 provides a means to make this possible. IFD is a supplement to IFC; it cannot and is not trying to replace IFC.

IFD is an open library, where concepts and terms are semantically described and given a unique identification number. This allows all the information in the IFC format to be tagged with a Globally Unique Identifier (GUID). The architect can then provide the materials in, say Chinese, while the receiver can understand it in Norwegian. Likewise, a synonym or plural form of a name of a material can be correctly understood by the receiving application, as long as the correct GUID is given. While strings such as names and descriptions are exchanged in textual form and used by humans, the underlying GUID is used by the computers.

IFDLibrary and International Standards

IFD, the International Framework for Dictionaries, is, in simple terms, a standard for a terminology library. The concept for the *IFDLibrary* is derived from internationally-accepted standards that have been developed by the International Organization for Standardization (ISO) and the

International Construction Information Society (ICIS) subcommittees and workgroups from the early-1990s to the present.

ISO 12006-2

The related standard, *OmniClass,* follows the international framework set out in International Organization for Standardization (ISO) Technical Report 14177 - *Classification of information in the construction industry,* July 1994. This document was later established as a standard in ISO 12006-2: *Organization of Information about Construction Works - Part 2: Framework for Classification of Information*.

ISO 12006-3 and ICIS

In much the same way that ISO 12006-2 has been implemented in the UK in *Uniclass* and in North America in *OmniClass*, the object-oriented framework standardized by ISO/PAS 12006-3 has been adopted by ICIS members in the Netherlands with *LexiCon* and in Norway with the *BARBi* programs.

Following these ISO standards will promote the ability to map between localized classification systems developed worldwide and the object-oriented framework of 12006-3, implemented alongside and in concert with 12006-2-based standards, will multiply the degree of control available over construction information.

ISO 12006-3 and ISO 15926 (EPISTLE)

EPISTLE is a dictionary development used in the oil and gas industry that has a similar top level structure to ISO 12006-3. While IFD and EPISTLE share many of the same concepts and have the same core structure, the initiatives are different. IFD only defines types of things. EPISTLE will also store instances or individuals. To cover the same functionality as EPISTLE, IFD relies on the IFC standard. Entries in IFD would be, for example, types of doors, while an instance of a door in a particular building project would be established using IFC. IFD does not aim to hold such individual records. For that we rely on the IFC standard. IFD will on the other hand hold all *classes* or *types of concepts* that in turn can be used to instantiate individuals. In other words, IFD holds the templates while IFC (or also other standards and conforming databases) are used to fill in the information.

IFDLibrary Development

Development of the *IFDLibrary* is in two primary areas: content and technology. To date the Norwegian and Dutch efforts have independently focused on developing both fronts. With the creation of the IFD Partners and the release of the IFD API by the Norwegians, all technology development is being focused on this platform which is now in limited release. Efforts are also underway to harmonize all of the content developed to date into the common core context within the IFD.

IFDLibrary Status: Content

Content within IFD are of two basic types:

1. **Concepts (Terms)** are something that can be distinguished from other things and that can be recognized as such and are represented by a name. In IFD a concept is distinguished as an object, where objects are defined by formal characteristics.
2. **Characteristics (Properties)** are concepts that cannot be defined using other concepts; their meaning is provided through a description. Characteristics are distinguished into the

following types (in alphabetic order): Behavior, Environmental influence, Function, Measure, Property, and Unit.

Concepts are related to other concepts through objectified relationships. Relationships are collected into contexts based on how they came into the library and where they originated. Concepts can relate to other concepts in multiple contexts. For example, the concept Door might have the following relationships to other concepts depending on the context in which it is being viewed.

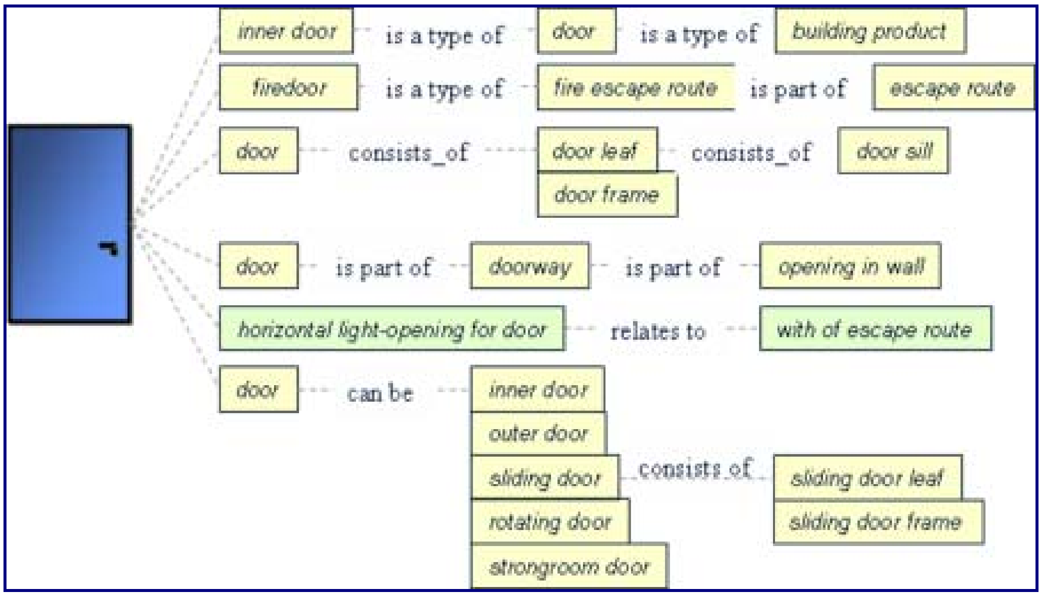

Figure App C-2: Door Concept and Relationships
(Courtesy Lars Bjørkhaug and Håvard Bell, *IFD in a Nutshell*, IFD Developers wiki, www.ifd-library.org)

All concepts are assigned a Global Unique Identifier (GUID) by the IFD to allow them to be readily identified and reused by applications. A goal for entering terms into the *IFDLibrary* is to resolve duplicates and synonyms so that multiple entries with the same or similar meanings are not created. The processes and procedures for achieving the common use of terms across multiple contexts are still being refined to help those using the IFD efficiently search for similar terms already in the library.

The following graphic illustrates how a concept (for example, Window) can be described by a set of characteristics in IFD. The relationship between a concept and its characteristic can also be captured in a context allowing the relationship between the particular use of a concept and its properties in that use to be captured within a given context.

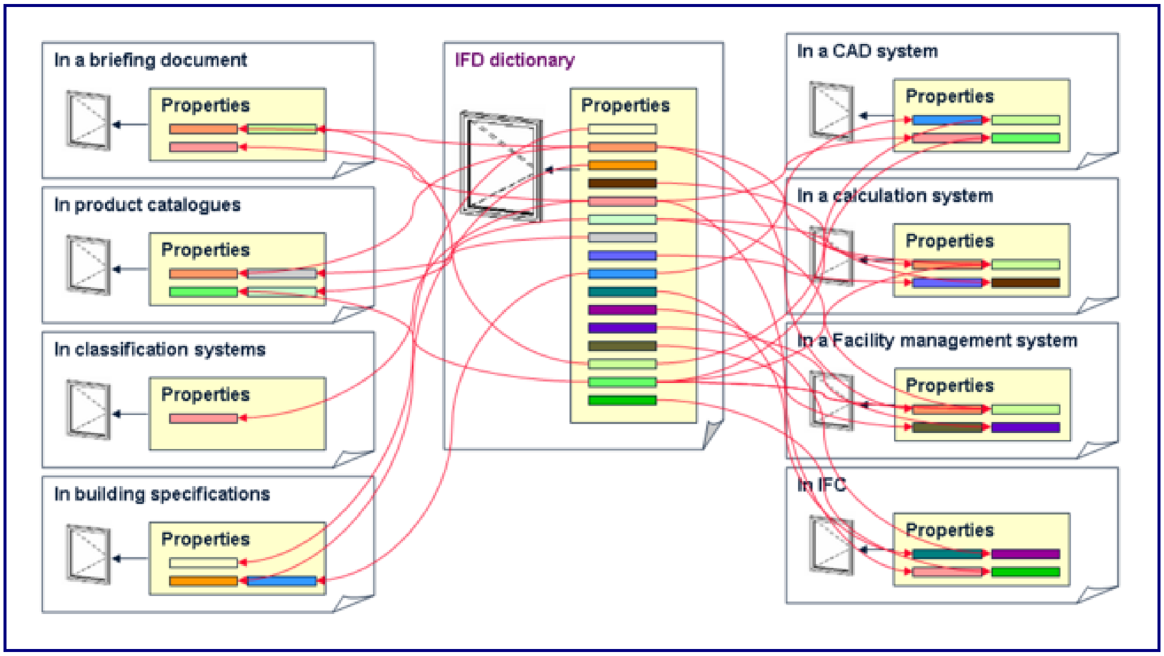

Figure App C-3: IFD as a Mapping Mechanism
(Courtesy Lars Bjørkhaug and Håvard Bell, *IFD in a Nutshell*, IFD Developers wiki, www.ifd-library.org)

Currently both the Norwegians and Dutch have created terminology in the IFD. The Dutch are leading a project to harmonize the existing terms in the Dutch and Norwegian contexts. As new projects are initiated the goal will be to make use of terms already in the IFD to the greatest extent possible so that a shared global and multilingual dictionary can be created. The partners have agreed that any terms entered into the IFD must be accompanied by an international English translation to facilitate connection to equivalent concepts in other languages.

In North America, we are planning to organize entries into the IFD based on the *OmniClass* schema. The goal is to identify where concepts fit into *OmniClass* as they are brought into IFD. This will allow us to identify and relate concepts that have been assigned a persistent definition to the classification systems commonly used to structure documents and applications. Currently, CSI is working with the ICC to bring the terms used in the codes into IFD in this way. This project is serving as a pilot to help define the requirements for tools to support term identification and input and to further validate the concept of using the IFD to enrich the concepts and property sets of the IFC model.

IFDLibrary Status: Technology

The core of the system is an object oriented database, based on the EXPRESS standard hosted on EPM Technology's EDM Server™. Although proprietary as a product, all data are stored and manipulated using the ISO originated EXPRESS standard. The database resides on one physical server in a well guarded and maintained datacenter.

A Standard Web Service based approach is utilized to communicate with the library independent of the actual technology chosen for the database in a way more suited for application developers. A set of objects and a set of methods that use the objects to pass information back and forth are defined. These objects and methods fit into a normal object oriented programming setting and can thus be easily utilized from within an application. The API is clearly versioned through its access point, so newer versions of the API can be provided in parallel with the old.

An offline option will also be available in which the entire library will be located on the local disk of the application. The data will be accessible through the same objects and methods as for the Web Service. In addition, it will be possible for the application, when online, to download the latest version of the library and, thus, stay up to date as often as needed.

The Web Service API and offline API will enable any application to access the library. The set of objects and methods defined in the API greatly simplify accessibility to the library. The Web Service API is in its initial release and will be accessible at www.ifd-libray.org. The first applications to use the API, an input tool and a browser, are now being developed.

The input tool will allow for selecting or entering concepts and associating them with definitions, synonyms, classifications, and properties. buildingSmart Norway has developed the *Propertylizer* input tool and is utilizing it for projects in Norway. CSI is working with the developer to adapt the current version to support projects in North America and is aiming to have something available early in 2008. The *Propertylizer* will support the content authoring process by providing access to existing concepts and properties through an interface that can be used to prepare them for input to the IFD. New concepts and properties can also be entered through the *Propertylizer*. An early version of the application illustrating these functions is shown in Figure App C-4.

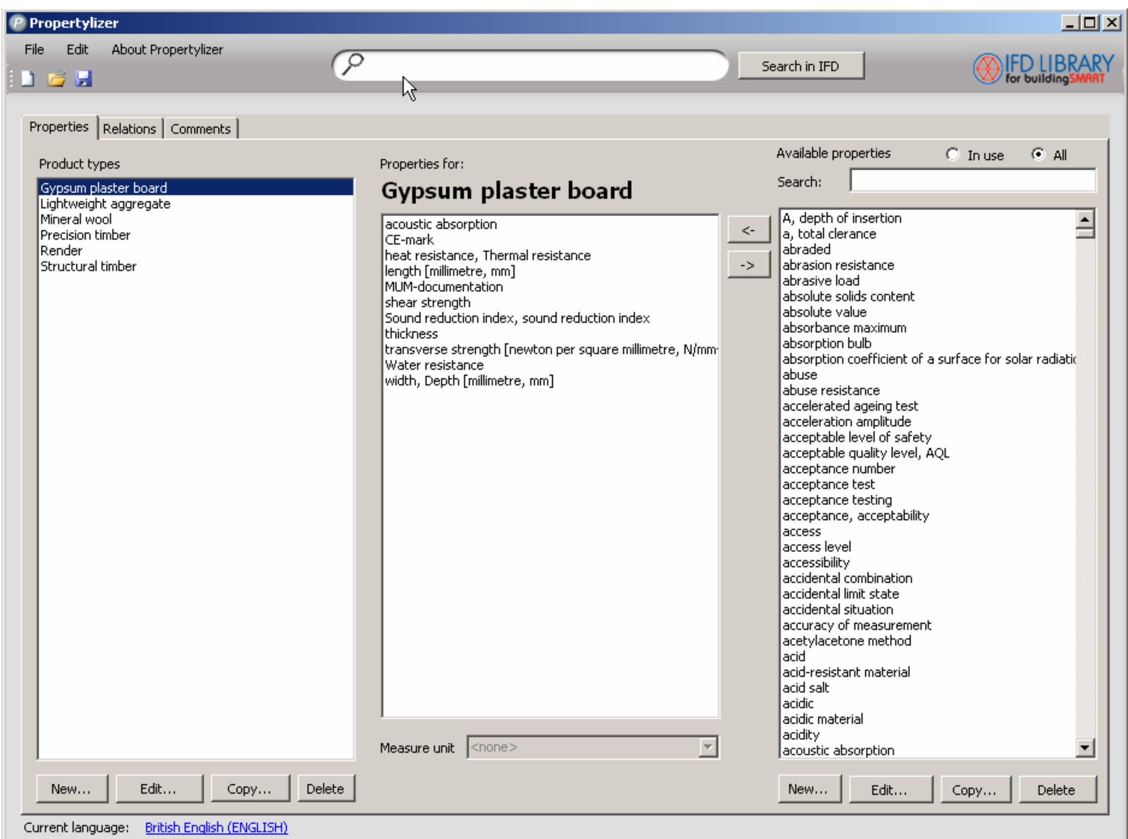

Figure App C-4: Propertylizer User Interface (Courtesy Aleksander Bjaaland, Holte Byggsafe)

Another class of tools being developed for the IFD is browsers to enable access and review of terms in the IFD. The Dutch have developed the *IFDLibrarian* for internal content access and management. A public access web version of *IFDLibrarian* as well as several other browser tools is currently under development to provide on-line access to look up and make use of content in the IFD.

IFDLibrary Status: Projects

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. Here in North America, we are currently pursuing the following projects:

1. **ICC Smart Codes.** 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. We are using this work 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.
2. **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.

Organizations wishing to use the IFD will be invited to file a Project Plan and join the IFD Partners as an Observer organization. Details will be available soon at the *IFDLibrary* web site.

BIM Applications

OmniClass, *MasterFormat*, and *UniFormat* are all currently used to index, organize, and retrieve a variety of different information types throughout a project lifecycle. The consistent use of standard classifications from any of these, applied to objects, will enhance the ability of users to sort data and roll up or drill down through data based on the hierarchy upon which all of these classifications are built. A standard implementation of any of these classifications within a BIM model will allow for this same information sorting and retrieval across multiple platforms and by all users at any stage in the facility lifecycle.

In conjunction with the *IFDLibrary*, the structure of the classification systems can be explicitly applied to the information used in model-based design, analysis, and management systems. A more consistent naming system for objects captured in a BIM has the potential to support the goal of buildingSmart to improve interoperability of systems and processes.

References and Links

Additional information about the *IFDLibrary* and access to the developer's wiki can be found at www.ifd-library.org or by contacting Roger Grant (rgrant@csinet.org) or Aaron Titus (atitus@csinet.org) at CSI.

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