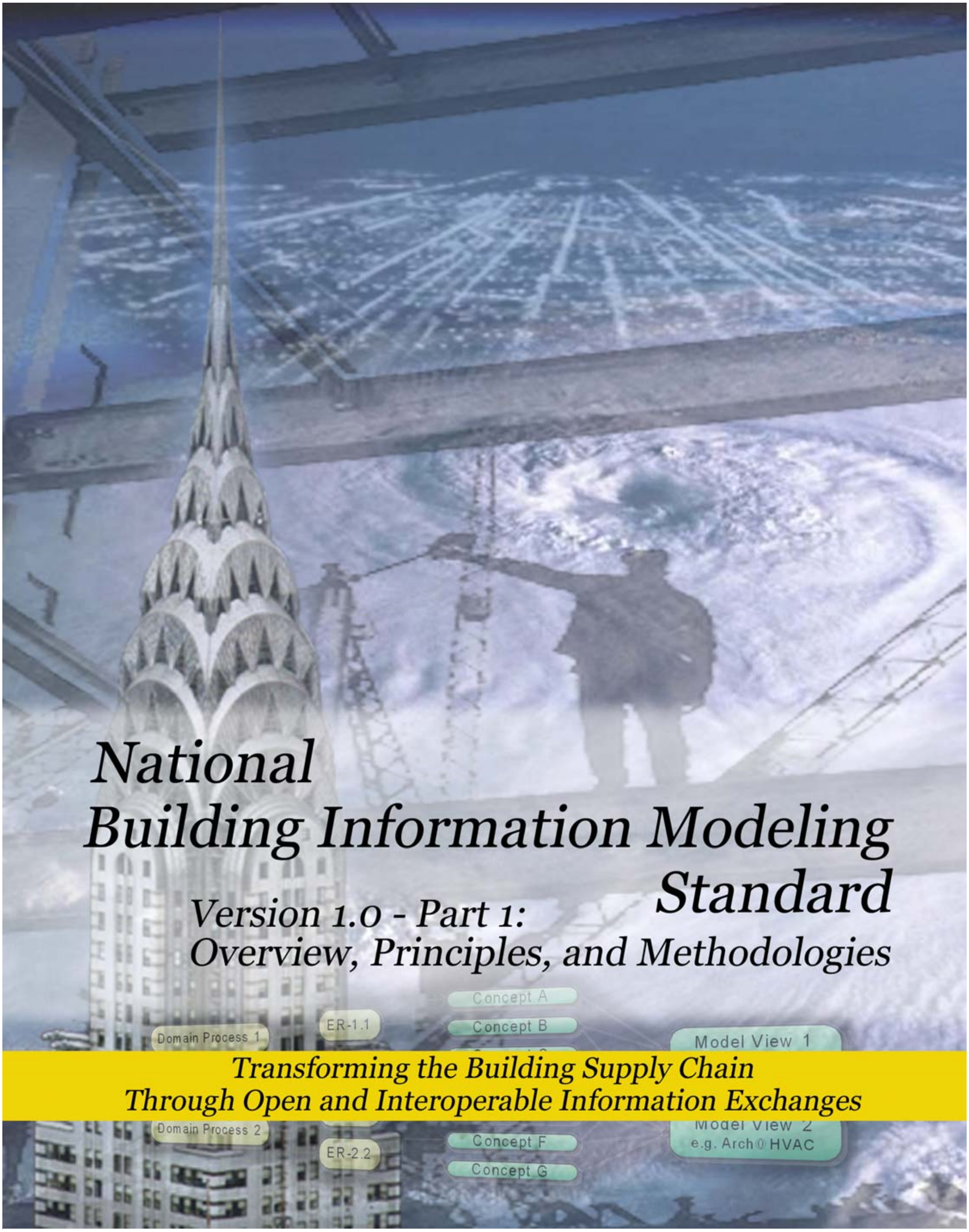

National Building Information Modeling Standard

Version 1.0 - Part 1: Overview, Principles, and Methodologies

Transforming the Building Supply Chain Through Open and Interoperable Information Exchanges

buildingSMART Initiative

National Institute of Building Sciences
Facilities Information Council
National BIM Standard

Foreword

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

Building Information Modeling (BIM) has become a valuable tool in some sectors of the capital facilities industry. BIM has also become a widely accepted misnomer for a much larger scope of work encompassing the entire facility lifecycle. To minimize confusion we recommend continuing with what people have come to accept. There are many examples of BIMs being implemented in design and during construction. To date, however, there is little transfer of information between the traditional facility industry stovepipes where we are essentially only creating cylinders of excellence. The National BIM Standard (NBIM Standard) is intended to provide the framework and foundation to encourage the flow of information and interoperability between all phases of a facility's life from inception onward. The NBIMS Committee believes we must overcome the impediments that this document begins to identify and provides guidance as to how to proceed. This document is Part 1 of the first version of the standard. It provides the basis upon which we will build the future. It also identifies the many items that need to go through the consensus process to become a standard. The Committee has begun that process and plans to be publishing Part 2 before the end of the year.

Background

The idea of BIM has been with the capital facilities industry for some time, yet progress to date has been slow despite the hard work of many in the industry. There are currently almost as many definitions for BIM as there are people implementing them. The NBIMS Committee will present in this document a very rich and comprehensive vision for what BIM can and should be in order to optimize the opportunities ahead of us. There are four primary tenants the Committee worked from:

- To build the facility virtually (electronically) prior to building it physically so that detailed analyses can be accomplished early in the process, problems can be worked out electronically, and decisions can be made earlier at lower cost prior to physical construction.
- To collect data at its point of creation and enter that data only once and then allow it to be used, improved, and passed along to others throughout the lifecycle of the facility.
- To make data entry and data maintenance part of the business process and not a separate step, or we will only add work.
- To recognize that detailed information can be summarized ultimately to a world view, but summary information cannot be broken down into detailed information; therefore, collecting detailed information is a foundational concept.

The document details the goals and principals and methods to ensure that these tenants are achieved.

Collaboration

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. 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. 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 capital 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 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 and every 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 the document in the acknowledgement section.

Subject matter expert authors who wrote the chapters, appendices, and references of NBIMS:

Alan Edgar	Andy Fuhrman	Susan Nachtigall	Damian Hill
Bill East	Bill Fitzgibbon	Calvin Kam	Charles Matta
Dave Hammond	David Jordani	Deke Smith	Tina Cary
Dennis Shelden	Dianne Davis	Francois Grobler	Greg Ceton
Francoise Szigeti	Gerald Davis	Howard Ashcraft	David Conover
Kimon Onuma	Kristine Fallon	Lou Dennis	Louis Hecht
Mark Butler	Mark Palmer	Patrick Suermann	Ric Jackson
Richard See	Steve Hagan	Vladimir Bazjanac	

NBIMS Executive Committee overseeing the development of NBIMS:

Deke Smith, RA, Chair	David Hammond (USCG)
David A. Jordani, FAIA, Vice Chair	Ric Jackson (FIATECH)
Bob Bank (USACE)	Earle Kennett (NIBS)
Bill Brodt (NASA)	Mark Reichardt (OGC)
Greg Ceton (CSI)	Tony Rinella (AIA)
Andy Fuhrman (OSCRE)	Louis Hecht, Co-Representative (OGC)
Thomas Gay (FM Global)	H. Michael Hill, Co-Representative (CSI)
Francois Grobler (IAI)	Markku Allison, Alternate (AIA)
Steve Hagan (GSA)	Calvin Kam, Alternate (GSA)

Task Team Chairs:

Scope	Dianne Davis	AEC Infosystems
Model	Richard See	Digital Alchemy
Development	Bill East	USACE
Testing	MAJ Patrick Suermann	University of Florida
Communication	Alan Edgar	FacilityGenetics, L.L.C.
Fundraising	Ric Jackson	FIATECH
Process Integration	David A. Jordani, FAIA	David Jordani Associates

Next Steps

The reader will find many definitive statements throughout this document, although some may not be attainable at this time. The Committee's goal is to identify the requirements for BIM not how to accomplish them. The solutions are left to the many vendors supporting the BIM effort worldwide. In each section the author will identify what exists to support the NBIMS initiative currently and also a list of next steps indicating what remains to be done.

For the entire NBIMS team,
Mr. Dana K. "Deke" Smith, RA
Chair, National BIM Standard, Version 1.0

Foreword

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Chapter 1.1 Executive Summary

National Building Information Modeling Standard

Version 1.0 – Part 1: Overview, Principles, and Methodology

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 comprise the NBIMS Initiative and the products of the Committee will be the National BIM Standard (or NBIM Standard), which includes classifications, guides, practice standards, specifications, and consensus standards.

This publication is the first of a series intended to communicate all aspects of the NBIMS Committee and planned Standard, including, for example, principles, scope of investigation, organization, operations, development methodologies, and planned products. This publication is a guidance document to be followed by future publications containing standard specifications that have been 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. 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.

BIM Overall Scope and Description

Building Information Modeling (BIM) has become a valuable tool in some sectors of the capital facilities industry; although, the current usage of BIM technologies tend to continue to be applied within vertically integrated business functions rather than horizontally across an entire facility lifecycle. While the term "BIM" is routinely used in association within the context of less effective vertically integrated applications, the NBIMS Committee has chosen to continue using the familiar term and evolve the definition and usage to represent horizontally integrated building information gathered and applied throughout the entire facility lifecycle, preserved and interchanged

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

efficiently using open and interoperable technology for business, functional and physical modeling, process support, and operations.

NBIM Standard Scope and Description

Specifically, the NBIMS Initiative recognizes that a BIM requires a disciplined and transparent data structure which supports the following.

1. A specific business case that includes an exchange of building information.
2. The users' view of data that is necessary to support the business case.
3. The machine interpretable exchange mechanism (software) for the required information interchange.

This combination of content selected to support user need and described to support open computer exchange are the basis of information exchanges in the NBIM Standard. All these levels must be coordinated for interoperability and this 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 users and machine readable approaches. These relationships must be at the detail levels relating, for example, a door to its frame or even a nut to a bolt, but maintain relationships from a detailed level to a world view. When working with as large a universe of materials as exist 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 and 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. This also carries to the world view of being able to translate to other international languages in order to support the multinational corporation. This will take time and ontologies will be the vehicles that allow this 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 be socialized in order to ensure that a viable and comprehensive end-product will be produced.

The Role of Interoperability

Software interoperability is seamless data exchange and sharing 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 (i.e. not proprietary), 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.

Central Repository of Shared Information

One of the innovations, demonstrated by some full service design and engineering firms as well as 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 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 National Building Information Model Standard operates.
The authors describe how 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

A central (physical or virtually aggregated) repository of information is a good thing for designing, constructing, operating, and sustaining a facility. However, the authors caution that, while the repository creates many opportunities for improved efficiency, data aggregation can also be a significant source of risk.

Managing the risks of data aggregation requires advance 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, and that only properly authorized users get access to the subset of information to which they should have access. There is 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 already commonplace in worldwide 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 (e.g. 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 USACE BIM Roadmap[2] is presented as a useful reference for building owners seeking guidance on identifying and specifying data to include in a BIM from a design or construction perspective.

NBIM Standard Process Definition

Section 5 is dedicated to describing in detail proposals for the processes the NBIMS Committee will employ to produce the NBIM Standard. In order to orient the user, a conceptual diagram is provided. Components of this diagram correspond to chapters that follow in the section. A smaller orientation diagram is provided within each chapter.

Since both the processes used to create the NBIM Standard and the products are meant to be open and transparent, NBIMS will employ a consensus process to invite industry-wide understanding and acceptance. End users and vendors will have the opportunity to participate in testing activities designed to evaluate both elements of the Standard and specific BIMs.

The Information Exchange Template, BIM Exchange Database, the Information Delivery Manual (IDM), and Model View Definition (MVD) together comprise core components of the BIM Standard production process. The Information Exchange Template and BIM Exchange Database are 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. The NBIMS Scoping and Requirements Definition 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 (ER) 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 IFC standard. The resulting generic and implementation-specific documentation will be published as Model View Definitions (MVD), as defined by the Finnish Virtual Building Environment[3] (VBE) project, the Building Lifecycle Interoperability Consortium[4] (BLIS), and the International Alliance for Interoperability[5] (IAI). The Committee will work with software vendors and the Testing task team to plan and facilitate pilot implementations, 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, final updates will be made to the MVD documents for inclusion in the next NBIMS release.

Reference Standards

Reference standards in the NBIM Standard provide the underlying computer-independent definitions of those entities, properties, relationships, and categorizations critical to express the

[2] See https://cadbim.usace.army.mil/default.aspx?p=s&t=19&i=1 for the complete USACE BIM Roadmap.
[3] http://cic.vtt.fi/projects/vbe-net/
[4] http://www.blis-project.org
[5] http://www.iai-international.org

rich language of the building industry. The reference standards selected by the NBIMS are international standards that have reached a critical mass in terms of capability to share the contents of complex design and construction projects. This document includes two candidate reference standards; the IAI Industry Foundation Classes (IFC) and *OmniClass*™.

The IFC data model consists of definitions, rules, and protocols that uniquely define data sets which describe capital facilities throughout their lifecycle. 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 individual software application's internal data structure. 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 (known as *OmniClass* or OCCS) is a multi-table faceted classification system designed for use by the capital facilities industry and includes some of the most commonly used taxonomies in use in that industry. *OmniClass* is applicable for organizing many different forms of information important to the NBIM Standard, both electronic and hard copy, and can be used in the preparation of many types of project information as well as for communicating exchange information, cost information, specification information, and other information that is generated during the services carried out through the facility lifecycle.

Appendices and References

NBIMS Appendices are documents that will be reviewed through the NIBS consensus process. Consensus incorporates formal review processes which conclude with specific balloting in order to become official, essentially stand alone, standards under the NBIMS umbrella. Appendices will be compliant with all other aspects of NBIMS. They are reviewed through the consensus process so that vendors may write software specifically to and be able to cite compliance with the Standard. They shall also have IDM produced that are written to the NBIM Standard as defined elsewhere in the document. As noted in Chapter 2.3, there are many items that will go through the NIBS consensus process over time. Some of these items will show up in "Part 2" of this document, others will show up in future versions. The two appendices included are:

- **Early Design.** During the process of facility programming, planning, and early design, the owner's requirements are addressed in many forms: design and construction criteria, functional requirements, functional adjacencies, and programmatic area allowances. These requirements are handed off to the planner/designer to collate into a cohesive plan including building code, site, cost, and engineering requirements. The goal of creating an Early Design (ED) view is to capture early planning data in a comprehensive and computable exchange format to pass to down-stream technologies, such as design modeling and engineering analysis. Once in a standard computable format, this early design information can be used to validate proposed design solutions against the owner's requirements. It also provides the ability to compare alternative designs for lifecycle costing and other best practice design approaches.

- **Construction to Operations Building Information Exchange (COBIE).** This document contains the definition of the COBIE Pilot Implementation Standard. Example contract language needed to test the COBIE Pilot Implementation Standard is also provided in this document. General instructions for software vendors, needed to implement this standard, are also included in this document. The Industry Foundation Class (IFC) reference standard and associated IFC Model Views will be provided under a follow-on document to be published in Summer 2007.

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 three types of references.

- **Business Process Roadmaps.** These documents provide the business relationships of the various activities of the real property industry. Roadmaps 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 (IDM).
- **Guidelines.** Guidelines have been developed by several organizations and include some items that should belong in the NBIMS. Since NBIMS has not existed prior to this publication, there was no standard from which to work, resulting in a “chicken or egg” dilemma. When formal NBIMS exists, 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 may, in fact, be standards in their own right.

The References 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. Over time, each reference in the appendices will likely transform in order to harmonize with the standard and the standard will change to better support other parallel efforts. Since the standard did not exist before this publishing, these documents could not be expected to be in harmony; although, many of the authors have been working together for some time now. The documents are provided in their raw form with descriptions provided by the authors as to how and when they may change.

Chapter 1.2 How to Read the National BIM Standard Version 1 – Part 1.

Introduction

This chapter is provided to help readers understand the contribution provided by each element of the Version 1 – Part 1 publication. All readers are encouraged to read the Executive Summary and Table of Contents then scan through all sections of the publication regardless of previous experience or role in the capital facilities industry or the facility lifecycle. 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. However, 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 – Part 1 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 – Part 1* 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 and/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 *Central Repository of Shared 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.

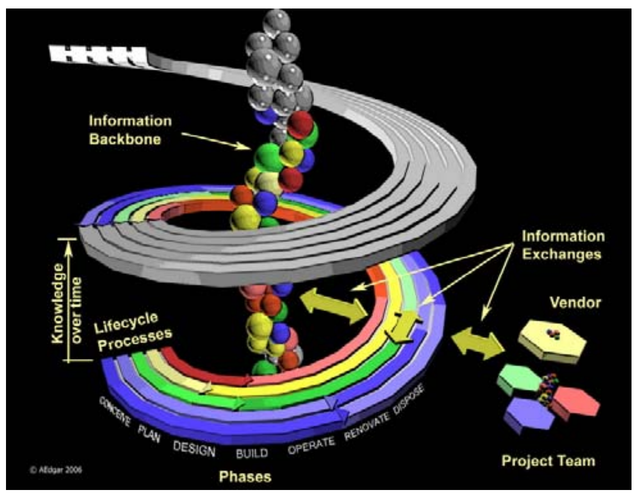


Figure 1.2-1 - Facility Lifecycle Helix
http://www.facilityinformationcouncil.org/bim/pdfs/LifecycleHelix.jpg

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

[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)

need to repeatedly redefine exchange agreements for each project or new set of participants. 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 early candidates for NBIM Standards development, 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 NBIMS create for developing and putting to work BIM standards. Throughout the Part 1 publication, readers will find references to this diagram as elements are discussed in greater detail.

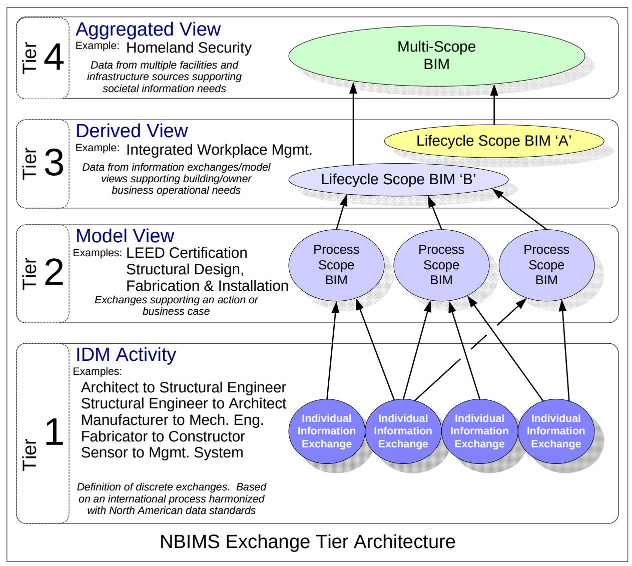


Figure 1.2-2 - NBIMS Exchange Tier Architecture
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

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 Standards. 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 data (meeting NBIMS) that is supplied from project BIMs and links to compatible operations systems. For example, Section 7 *Reference* has a discussion of 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 contents and exchange requirements are constructed to support the modeled task or requirement and typically do not need to represent an entire facility. Multiple Tier 2 Model Views 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 capable of being described for exchange by computers. The method NBIMS will use to identify and build Tier 1 exchanges is the Information Delivery Manual (IDM) process.

Chapters 5.1 through 5.4 discuss the processes that will be used to create the NBIM Standard, including IDM and MVD, in more detail focusing on the process and its components. Chapters 5.5 through 5.7 discuss the reference standards that will be used and/or created to control how information will be organized, described, and made to be machine interoperable.

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 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 Standards 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. In one sense, Section 5 describes the proposed 'factory' process for developing NBIM Standard products, many of which will be exchange definitions, such as IDM and MVD. NBIM Standard products will also include classifications, references, and guides.
- Having presented the process proposed for creating the NBIM Standard in Section 5, Section 6 presents two 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 partner 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.

Section 7 presents several references 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 issues including organizational changes, legal and insurance considerations, contracting, and related topics.

Finally, because it is clear that traditional computer-aided drafting will be a part of practice for the foreseeable future, another attached reference document discusses 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 high-level 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 and incorporate 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. Rather, the Committee believes that the Standard will help to reduce the risk of a BIM being a proprietarily defined product, which will likely reduce the sustainability of information for the life of the facility.

Tasks to Complete

This 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 single target for their BIM development efforts.

Chapter 2.1 Building Information Model Overall Scope

Introduction

The overall scope of Building Information Modeling (BIM) will impact most stakeholder activities supporting the capital facilities industry. BIM is a fundamentally different way of creating lifecycle data and supports a re-engineering of IT use in the capital facilities lifecycle. The stakeholders[7] 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.

The terms Building Information Model and Building Information Modeling are often used interchangeably. This reflects the term's growth to manage the expanded needs of the constituency. The NBIMS Initiative categorizes the Building Information Model (BIM) three ways, as **product**, as an IT enabled, open standards based, **collaborative process**, and as 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 category for BIM. This enterprise level scope of BIM is the area of focus for the NBIMS, bringing together the various BIM implementation activities within stakeholder communities.

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, 2D CAD drawings) and 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 facility 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 NIST report on the failure of the current process (2D and

[7] See list at end of chapter for additional detail on stakeholders.

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.

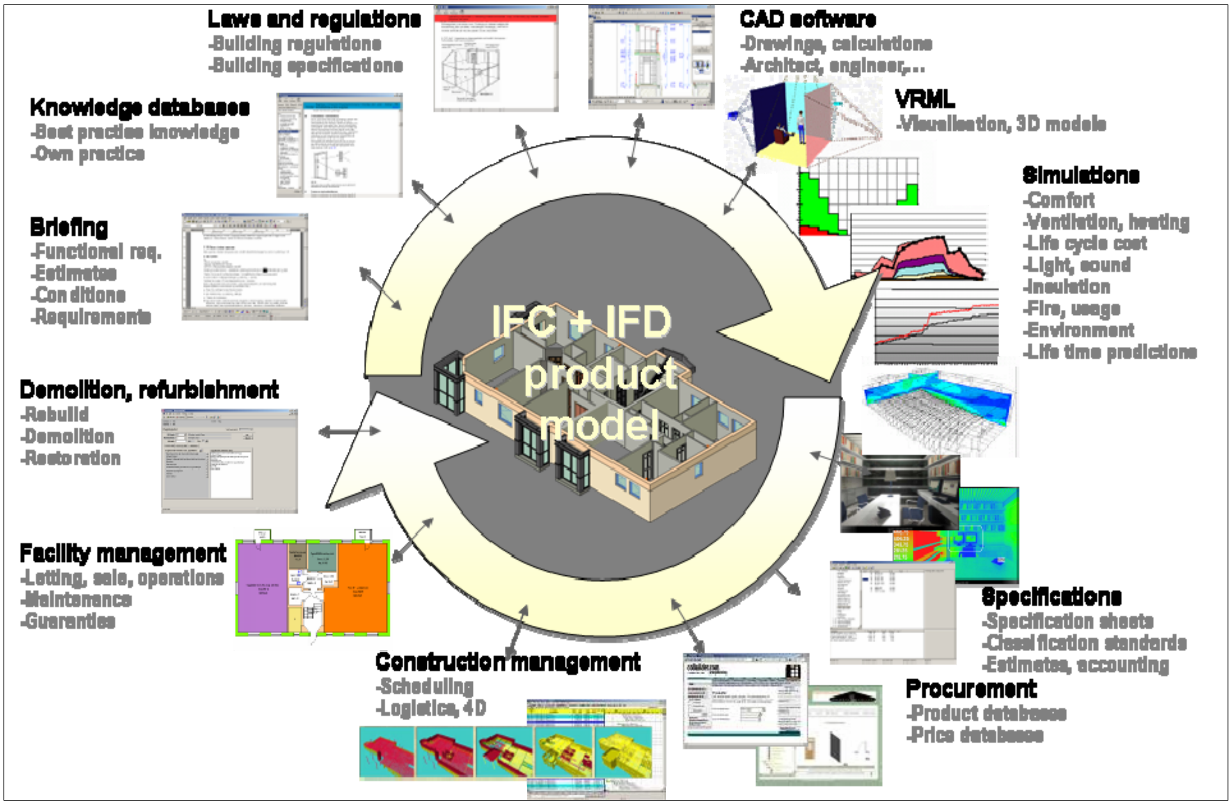


Figure 2.1-1 - IAI Nordic Chapter 2000 BIM Product Model

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.

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 silos. A major benefit of BIM is communication and BIM has demonstrated many times 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 as structured data, then risks inherent in the industry are reduced and new revenue and service opportunities are apparent.

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 this level of communication and interoperable data to support its highest 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 throughput in 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.

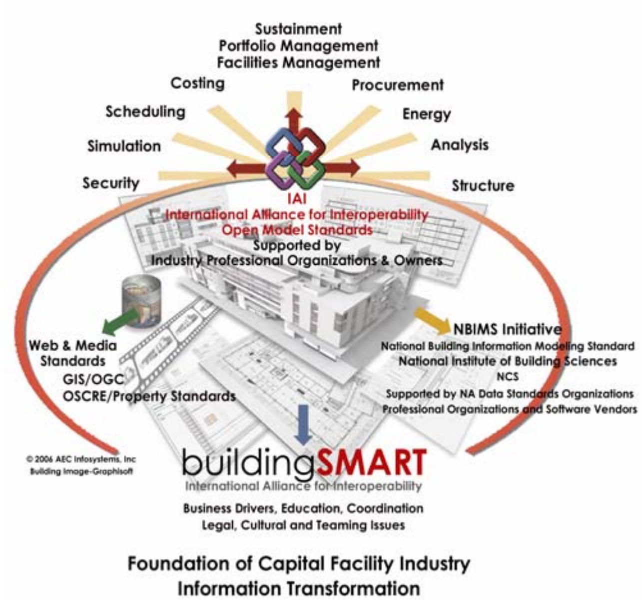


Figure 2.1-2- – buildingSMART construct (Drawing courtesy of AEC Infosystems and Graphisoft.)

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 had, before BIM, 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** 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.

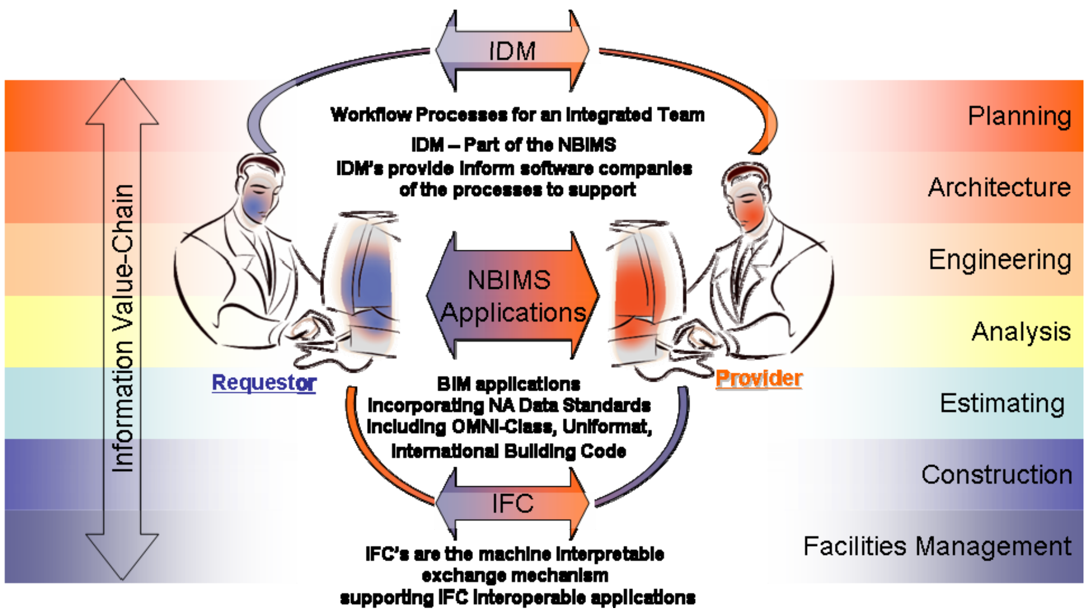


Figure 2.1-3 - National BIM Standard Definition
(Product, Process Supporting Collaboration)

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

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

reflect the roles of that stakeholder. The BIM is a shared digital representation founded on open standards for interoperability.

The U.S. 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). Over 300 software applications support IFC today and it is projected that this 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.

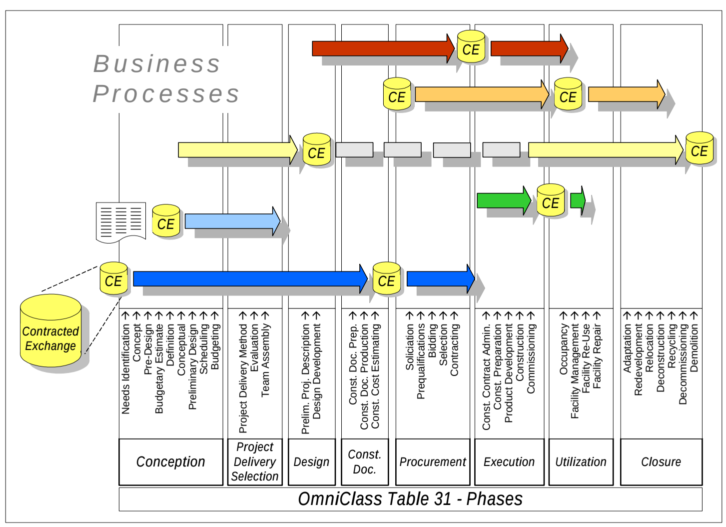


Figure 2.1-4 – Business Processes

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 the NBIMS activity is a publicly available, non-proprietary 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. The areas where work is in development include:

- *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 various others.
- *LEED.*
- *Construction Data Dictionary*. CSI.
- *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 SFCAM, 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 of $15.8 billion yearly 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 initiative 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 NBIMS, the NBIMS Initiative, and the National BIM Standard

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." 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

[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.

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 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:

- *Building Information Users and Building Information Modelers*: who will both determine the information that is required to support business needs and employ that information to carry out business functions.
- *Standards Providers*: who create and maintain standards for building information and building information data processing, and
- *Tool Makers*: who, for example, 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 NBIMS, the desired relationship of NBIMS 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 NBIMS, the NBIMS Initiative, and the NBIM Standard for committee members, the NBIMS community of interested parties, and those wishing to learn more about the Committee and its planned work.

NBIMS Vision, Mission, Scope, Goals, and Objectives

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

Vision: An improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, new or old, which contains all appropriate information created or gathered about that facility in a format useable throughout its lifecycle by all.

Mission: Improve the performance of facilities over their full lifecycle by fostering a common, standard, and integrated lifecycle information model for the Architect, Engineering, and Construction (AEC) and Facility Management (FM) industry. This information model will allow for the free flow of graphic and non-graphic information among all parties to the process of creating and sustaining the built environment and will work to coordinate U.S. efforts with related activities taking place internationally.

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

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

	information do so with the knowledge that the integrity of the source information is always protected.	Management Act is a foundation of Information Assurance approaches across the capital facilities industry.
Guiding Principle 6: *Building data needed for good public policy and corporate governance should be available on conditions that protect sensitive information, but otherwise do not restrict its extensive use.*	6.3 Open software standards for security are the preferred approach for protecting the integrity of sharable information.	6.3.1 Review OGC's GeoDRM process and other industry solutions.

Discussion – Makeup of NBIMS

"The National BIM Standard Committee shall be under the organizational structure of the National Institute for Building Sciences (NIBS), managed by the Facility Information Council (FIC). The National BIM Standard Committee shall have a Chair, Vice-Chair, Secretary and Treasurer elected by the National BIM Standard committee-at-large on an annual basis. There shall be an Executive Committee made up of the Chair, Vice-Chair, NIBS staff member supporting the committee, and representatives of the committee-at-large. The Executive Committee is established by the Chair and its purpose shall be the administration of the business affairs of the National BIM Standard Committee. Task groups may be established for specific purposes and durations as determined by the Executive Committee."[10]

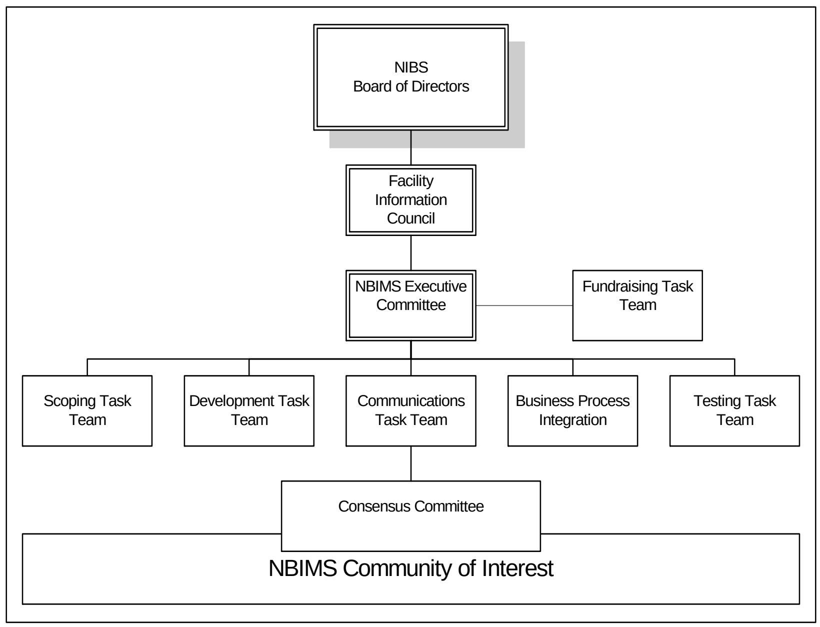


Figure 2.2-1 - NBIMS Organization Chart

Discussion - Relationships to Capital Facilities Industry Organizations and Activities

The NBIMS Initiative supports and, in a significant way, enables the movement within the capital facilities industry to adopt new technologies, industry enterprise workflows, and emerging communication capabilities in its method of work. Although the NBIM Standard is focused on open and interoperable information exchanges, the NBIMS Initiative contributes to all aspects of the facility lifecycle including procurement of work and metrics to evaluate change. NBIMS is chartered as a partner and an enabler for all organizations engaged in the exchange of information throughout the facility lifecycle.

[10] *Ibid*, pg. 3.

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 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, A/E/C 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.

NBIMS 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 NBIMS has primarily been provided through in-kind contributions of time and other resources, except for the Charles Pankow Foundation grant to develop the first NBIM Standard exchange definition, which is 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 sustaining funding to support specific projects and administrative costs.

Discussion - 'Information Users' and 'Information Modelers'

The envisioned NBIM Standard process 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 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 will 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, coalition-building, outreach and education, and by providing the NBIM Standard. The relationship between NBIMS and Tool Makers is seen as synergistic and symbiotic. 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 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, consensus review, publishing NBIM Standard products, testing of products and process quality assurance, and external functions such as working with software developers, professional associations, educational institutions, and other organizations with which NBIMS will coordinate standard development and harmonization activities. Section 5 introduces individual elements in this diagram and chapters that contain more specific details and discussions.

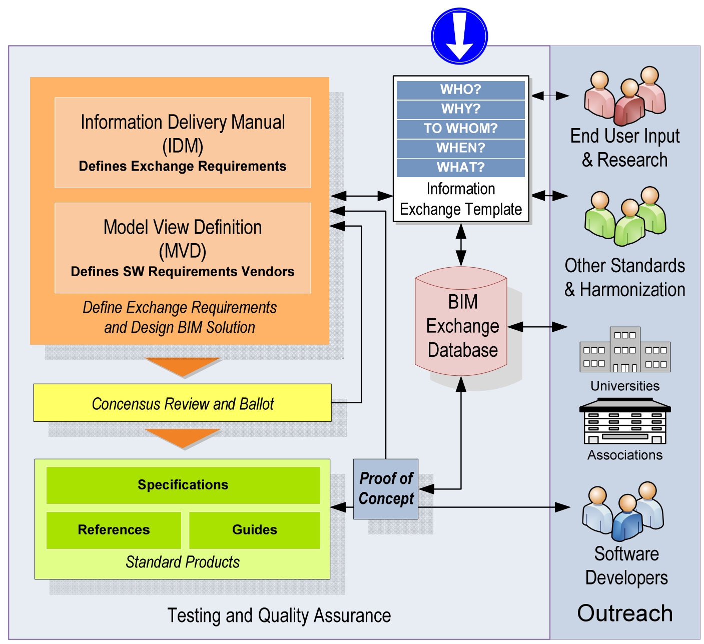


Figure 2.2-2 - NBIM Standard Process Overview
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

Discussion – The NBIM Standard Products

Chapters 4 and 5 describe planned NBIM Standard products in more detail. A summary includes the following:

- *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 described in Chapter 5.5.2 as a sample reference standard.
- *Guides*. "A compendium of information or series of options that does not recommend a specific course of action."[11] 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."[12] Version 1 – Part 2 will contain standard specifications.
- *Consensus Standards*. Most of the specifications that become part of the NBIM Standard will be reviewed and adopted through a consensus process. Chapter 5.1 provides more

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

information; however, the process that has been successfully used to create the National CAD Standard is seen as a viable model for the NBIM Standard as well.

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

Chapter 2.3 Future Versions

Introduction

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 Methodology* 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 tiers 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 stove piping, since many practitioners are only concerned with their phase of the project and do not recognize their 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. This can 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 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.

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 be matured.

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 properly 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 as quickly as possible. With many hands working 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 the requirements.

Discussion

The ultimate goal is to improve construction productivity in the United States. Many of the aspects of this overarching goal will be accomplished by a large consortium. 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 (Industry Foundation Classes (IFC)), information exchanges (Information Delivery Manual (IDM)), and model views (Model View Definition (MVD)) to create and sustain a BIM.

The table below is an extension of one originally provided by the Bureau of Labor and Statistics which shows a declining productivity rate for construction, while other segments of the economy were improving at record rates. NBIMS Initiative's goal is to implement some of the same techniques, used in other industries, in the capital facilities industry to achieve the same 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.

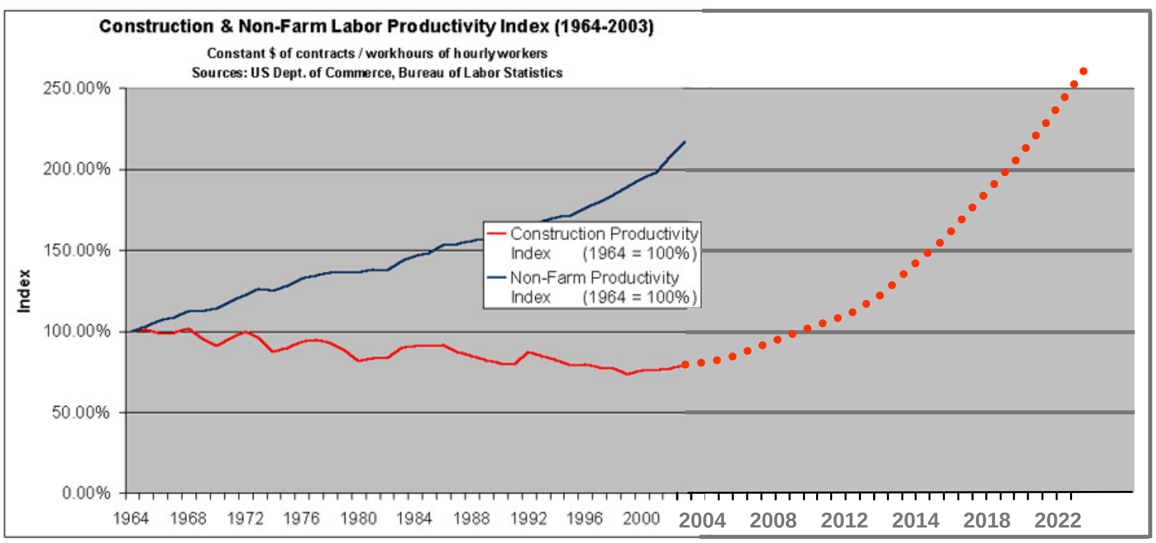


Figure 2.3-1 - Construction Productivity (Historical information courtesy of Bureau of Labor Statistics; future projection courtesy of DKS Information Consulting, LLC.)

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 and others have identified the loss of billions of dollars a year from inefficient business practices, we have not been able to identify those dollars in order to be able to redirect them to solve the problem. The primary reasons are that the dollars are widely distributed and that most practitioners have an accepted way of doing business such that the imbedded waste and ways to improve are not readily seen. Hence, the industry makes small incremental improvements to inefficient processes instead of the substantive changes required that involve the entire capital facilities industry.

Next Steps

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

Supporting Tier 4:

- Continued promotion of information relationships from the highest level, world view, 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 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, and IAI, but there are many others who also need to become involved in order to reach 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 in the capital facilities industry. Work must be done to ensure industry wide implementation.

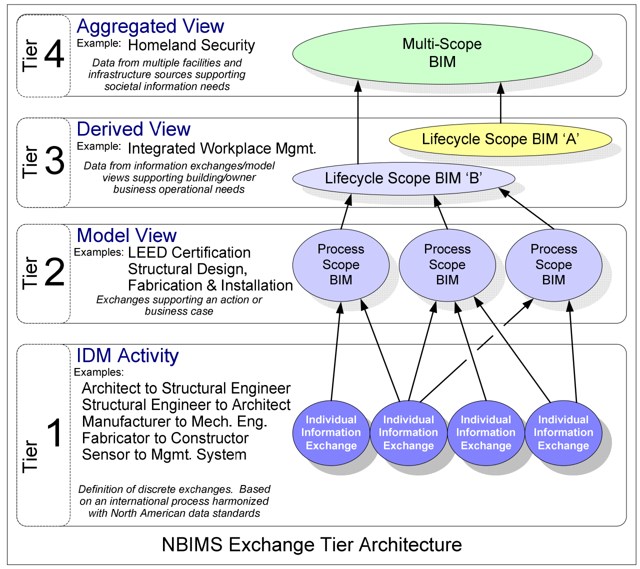


Figure 2.3-2 - NBIMS Exchange Tier Architecture
(Figure courtesy D. Davis, AEC Infosystems.)
http://www.facilityinformationcouncil.org/bim/pdfs/ExchTierArch.jpg

Supporting Tier 3:

- 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 for the capability maturity model are valid. There is concern that the bar may be set too high for most current BIMs to be "certified." The chapter *BIM Minimum* will be revised as required to reflect the current status of the industry.
- The *Capability Maturity Model* chapter has been coordinated with the minimum BIM chapter[13] to ensure that the certified level is in fact what is being described in that section. There are many so-called BIMs in existence that 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.

[13] See Section 4.

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:

- All of 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 future needs.
- Software vendors continue to incorporate the open standard IFC into products at various speeds. Some vendors see this effort as a potential way to lose market share. Therefore, pressure must be exerted to ensure that IFC remain a significant focus of 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.
- *UniFormat*™ harmonization and other *OmniClass*™ tables.
- 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

There are several related documents that will be produced over time in addition and supporting the National BIM Standard. One such document is the Generic Implementation Guidelines. Although not a direct part of the NBIMS, they will be based on the NBIMS and therefore updates to the 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.

It is estimated that new versions of the 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 May 2007
- NBIMS V1 – Part 2 December 2007
- NBIMS V2 July 2009
- NBIMS V3 July 2011
- NBIMS V4 July 2014

New version will be issued every three to five years after the 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 the 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.
- Consensus on the hierarchy from world view to detailed facility or structure view. (December 2007 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 Central Repository of Shared Information

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

Chapter 3.4 Information Assurance

- Establishment of Information Assurance procedures in new BIM.
- 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 and the FIATECH CETI Awards.

Chapter 5.1 NBIM Standard Process Description

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

Chapter 5.2 Testing

- The testing procedures will need to be coordinated but actual standards will likely not be identified in this section.

Chapter 5.3 Requirements Definition

- No specific standards are anticipated as a result of this section.

Chapter 5.3.1 Information Exchange Template

- The information exchange template itself needs to be standardized so all will be using the same product during the development process.

Chapter 5.3.2 Information Exchange Database

- Information classifications of *OmniClass* Tables, *UniFormat*, and IFC Entities definitions, workflows as they apply to the meaning of BIM elements is an important activity that has not been done to date in the U.S. There is a need to align what this information means to specifiers, contractors, designers, and owners.

Chapter 5.4 NBIMS Models and Software Implementation Guidance

- No specific standards are anticipated as a result of this section.

Chapter 5.5 Reference Standards

- NBIMS will adopt the reference standards that are developed and have gone through recognized consensus processes. If an item has not gone through a recognized consensus process then the NIBS consensus process may be used to ensure a referenced document has industry wide support. Each document will likely have specific avenues to follow in order to be included.

Chapter 5.5.1 IAI Industry Foundation Classes

- The IFC continue to be developed and expanded and new versions will come out. 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 in ISO and as such are not yet an ISO standard, although they are headed in that direction.

Chapter 5.5.2 *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 likely use the NIBS consensus process to incorporate these documents.

Chapter 5.6 Normative Standards

- 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.

Chapter 5.7 Implementation Standards

- As the IAI International formalizes its methodology for the harmonization of the IDM (bottom-up) and Model View (top-down) approaches, NBIMS will continue to serve as a framework to discuss the U.S. implementation of these issues.
- 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.

Appendix A Early Design

- This item is ready for the consensus process to make it a standard part of the NBIMS.

Appendix B Construction Operations Building Information Exchange (COBIE)

- This item is ready for the consensus process to make it a standard part of the NBIMS.

References

AGC Contractors Guide to BIM

- It is proposed that a GSA/AGC/USCG/Others task team be assembled to develop a generic set of guidelines for implementing the NBIMS. Some items may be taken from this document to be incorporated into the NBIMS. AGC will likely develop a companion document with specifics as to how to implement the full lifecycle approach developed in the generic guideline.

Coast Guard Information Model Guidelines

- It is proposed that a GSA/AGC/USCG/Others task team be assembled to develop a generic set of guidelines for implementing the NBIMS. Some items may be taken from this document to be incorporated into the NBIMS. USCG will likely develop a companion document with specifics as to how to implement the full lifecycle approach developed in the generic guideline.

Contract Language, Legal, and Access Issues

- NBIMS will not generate any standards for contract language since those will be developed in individual companies. The reference document will, however, be a reference to those developing their own contract language. That contract language may be developed by associations for their market sectors. Please contact the professional organizations for more information.

FIATECH Capital Projects Technology Roadmap

- Information flows are described in the Capital Projects Technology Roadmap (CPTR) documents within and between the nine elements and are precisely the information flows that must be addressed and modeled in the NBIMS as well as in the other leading standard for the construction and building industry: ISO 15926. They must be addressed in the other supporting standards, such as COBIE, and in the many XML schema development activities that abound in the industry. The Roadmap can and must be used as an organizational tool for addressing which of these information flows have been modeled, which are yet to be addressed, and which have too many overlapping and conflicting schema efforts addressing them. Our resources in the industry for solving the interoperability problem are too few and too precious to waste in standards competition. The industry must commit to organizing resources in the most efficient way possible, and the CPTR is the tool to use to do that.

General Buildings Information Handover Guide

- Further two-way coordination needs to be accomplished with this document and NBIMS.

GSA's National 3D-4D-BIM Program

- It is proposed that a GSA/AGC/USCG/Others task team be assembled to develop a generic set of guidelines for implementing the NBIMS. Some items may be taken from this document to be incorporated into the NBIMS. GSA will likely develop a companion document with specifics as to how they will implement the full lifecycle approach developed in the generic guideline

International Code Council Code Compliance Checking

- Further two-way coordination needs to be accomplished with this document and NBIMS.

OGC© OWS-4 Testbed – CAD/GIS/BIM Thread

- Though much work remains, a solution for the difficult interaction between building information models (BIM) and 3D geospatial models was identified and in part implemented in the fourth OGC Web Services Test Bed (OWS-4). OWS-4 work began in June 2006 and culminated with a demonstration held December 7 and 8, 2006, at an emergency response center in the New York metropolitan area. The audience consisted mainly of high-level decision makers involved in disaster management. OWS-4 achieved web service-based access to IFC-BIM data using existing OGC Web Services standards. Slight modifications to the OWS standards will now be considered by the OGC specification committee with further refinement planned for OWS-5.

OSCRE Real Property Standards

- This document will need to go through the NIBS consensus process as it supports the data models in chapter 3.2.

United States National CAD Standard

- Both the NCS and the NBIMS work hard to remain vendor neutral; the NCS does not contain specific instructions for any specific vendor packages.
- The current NCS does not contain any standards for objects, other than what the representation is when plotted in 2D. Future versions of the Standards will need to address areas such as standard data structures and naming conventions for objects.
- NCS contains the CAD Layer Guidelines. Layers are a way to isolate or differentiate between objects in some packages. Future NCS versions may describe object isolation and differentiation in additional ways.
- NCS contains a great deal of information about file management, location, and naming. Through Version 4 this naming is individual CAD file based, in some applications. Similar concepts can be used for organization and navigation of projects even though they may not be individual files.

Whole Lifecycle Information Flows for Portfolio and Asset Management

- In the next generation of the IFC standard, IAI should add to the current property set the elements needed to store information about measured sizes of floor area that is called for in the emerging standard agreed to by IFMA and BOMA. This is summarized in Figure 7. It will also need to include elements required by CEN and ISO standards for the measurement of volume.
- In the next generation of the IFC standard, IAI should add a property set for the elements identified in *UniFormat II* for condition assessment and for parametric cost estimating.
- As the work progresses in the preparation of standards in ISO TC59 / SC3 and SC14 and in ASTM E06.25, other elements needed in the IFC standard will likely be identified.

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 in new BIM.
- Publish v1.0 NBIMS Model View Standard in conformance with IAI International.
- Initiate standard encryption-at-rest measures for NBIMS based products.
- Support *OmniClass*™ table 21 harmonization effort 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 with ISO NWI 241 to harmonize IFC 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 the NBIMS.
- Conduct consensus process to make COBIE a standard part of the NBIMS.
- Develop and implement testing procedures for Information Delivery Manuals.

Chapter 3.1 Information Exchange Concepts

Introduction

A BIM requires a disciplined and transparent data structure supporting both the user's view and the software machine interpretable exchange mechanism of that information. This structure must be clear at the computer based **mechanism of exchange** in software (machine interpretable) and at the **content** level of the exchange (data content exchanged). It must be based upon a structured or agreed upon exchange (business case) between parties (users) within a process.

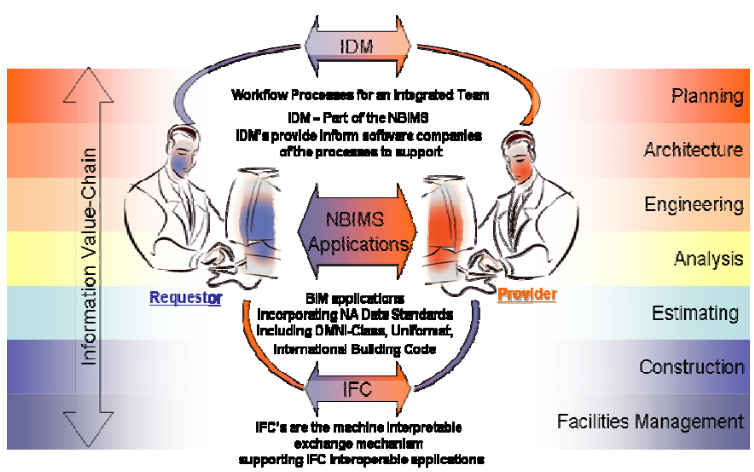
This combination of user needed structured content and open computer exchange are the basis of information exchanges in BIM. All levels must be coordinated for interoperability and this is the focus of the NBIMS initiative.

Background

While a human being may understand the drafting rules and conventions to know that two parallel lines and a cross hatch mean a wall, a computer program does not. However, in BIM authoring tools, levels of International Alliance for Interoperability (IAI) Industry Foundation Classes (IFC) intelligence are built into the software so that the computer can interpret a wall entity as a wall. Analysis can be done so that machine exchanged data carries more intelligence than simply lines, arcs, and circles.

The greatest benefits in using BIM technology are the ability to leverage computing power to aid in the production and use of better information for specific needs and to do analysis and calculation that would be too daunting without the technology.

The requirement for gaining the ability to create, discover, use, and re-use information at a BIM level is the development of content requirements, content retrieval, and reporting in ways that are known by all stakeholders including the computer applications manipulating and analyzing data. The English language, the Dewey Decimal System, the *UniFormat*™ Classification, and computer binary language are examples of systems and rules for communication and retrieval of information. Without these systems sharing of information would be almost impossible. Without structure and rules that can be learned and codified there would be a "Tower of Babel."



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 already been completed by the IAI and is supported by the IFC. Over 300 software applications support the IFC today and it is projected that the 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.

Relevance to Users

BIM has already demonstrated significant productivity gains over the traditional processes even at a limited data integration level, but the promise of data rich models will allow the industry to reach the level of business process re-engineering that will improve industry productivity.

Currently, data use beyond lines, arcs, and circles must be managed by data which requires human interpretation. Information exchanges offer a streamlined process with reduced risk in sharing more information in a project and process. Owners and capital facilities industry professionals see this activity as the single most important activity in BIM implementation.

Relevance to the National BIM Standard

Clearly defined Information exchanges with standardized structured data that is open and machine interpretable will define for the industry a well understood information value-chain for the facility lifecycle. These Information Exchanges are the basis of the standard and the reason it is an international activity.

Discussion

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 their equivalent classification scheme. The IFC allow the transfer of this information as a machine interpretable exercise.

Part of the NBIMS work on Information Delivery Manuals (IDM), Model Views, and Information Exchanges supports the North American implementation needs of this international effort. Our efforts align with the international effort since construction is a global enterprise.

An example of Information Exchanges is as follows: At a granular level the exchange of information about a window will change depending upon the need. Some of the information includes: size, material, color, glass area, installation recommendations, energy efficiency, manufacturer name, serial number, warranty, and cost.

The NBIMS effort 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 the NBIMS Initiative so that BIM objects can be robust enough to support the BIM process.

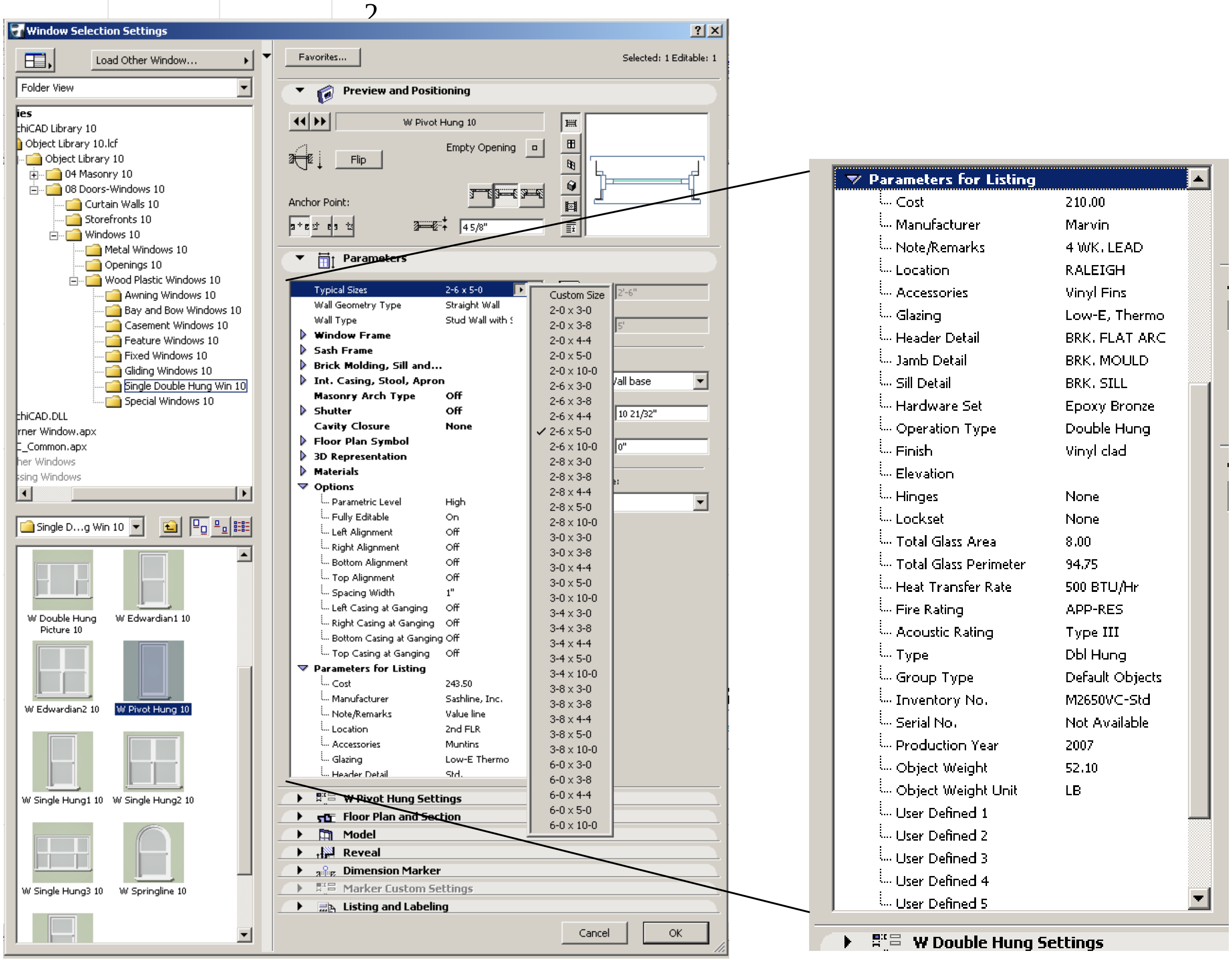


Figure 3.1-3 - Integrated Data in BIM Software
(Courtesy of Graphisoft)

Summary

Data rich objects are the requirement and the process for the future of BIM incorporated into well understood information exchange standards.

Next Steps

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

Introduction

Key to the success of a Building Information Model (BIM) is its ability to organize and relate information for both users and machine readable approaches. These relationships must be at the detail levels related to such items as a door to its frame, or even a nut to a bolt, but also carry up from that detailed level to a world view. When working in as large a universe of materials as the built environment there are many traditional stovepipes that must be crossed and many different "languages" that must be understood and related. Architects and 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. This also carries to the world view the ability to translate to other international languages in order to support the multinational corporation. This will take time and the ontologies developed will be the vehicles that allow this cross communication to occur. In order to standardize these many options, organizations need to be represented and allowed to have their input. There are several, assumed to be basic, approaches in place that must be socialized in order to ensure that a viable and comprehensive end product will be produced.

Background

The capital facilities industry has grown in recent history in continually more technically sophisticated stovepipes. An accepted handoff structure has evolved which allows one stovepipe to pass enough information to the next stovepipe for work to continue. This approach is very inefficient and was the basis for the NIST study on interoperability. It causes significant amounts of information to have to be re-collected and, although significant intelligence may exist in a stovepipe, it is not a collective intelligence. A significant amount of knowledge is lost with each exchange of information. Since data is expensive to collect, it often is not re-collected as well as it should be, shortcuts are taken, and assumptions about information are made. These shortcuts and assumptions can lead to catastrophic ends especially in emergency situations when detailed facility information is needed to make split second decisions in order to save lives and protect or save the facility. This was especially true in the World Trade Centers and the Pentagon on September 11. Not knowing which power and water cut-offs affect which parts of the facility or what or where hazardous materials are stored in the facility can have serious consequences. This is not information that can be gained at the time of the crisis but information that must be well planned from the beginning. On a more mundane level simply knowing what items are warranted and what maintenance is required to keep the warranties in place are things that affect every facility in existence. Yet, while the information is available during the construction process, it is typically not passed on to the operator of the facility in a usable fashion. The step of having to re-collect that information is typically seen as too expensive and, therefore, a more expensive replacement upon failure approach is often taken. This may have been more acceptable when equipment was not as technical or as well designed and lasted only as long as the warranty period. However, it is no longer an acceptable approach from either a fiscal, environmental, or life safety point of view.

The goal of NBIMS is to establish an approach to collecting data as part of the business process of creating the facility and being able to then use that information throughout the facility lifecycle and beyond. It will also support those organizations with large portfolios to manage their entire inventory more efficiently. There are significant opportunities in current business practices for more efficient operation that will enhance the entire capital facilities industry incrementally over time.

Relevance to User

Culture change will not come easily to any part of the capital facilities industry and, hence, any level of comfort by implementation of existing structures that can be endorsed will help with that transition. There are some ontologies that reasonably large segments of the industry have endorsed such as *MasterFormat*™ and *UniFormat*™; although practitioners in some sectors of the capital facilities industry will have not even heard of these widely accepted formats in the A/E/C community. In many cases, ontologies will be accepted because no other standard exists. In other cases, a widely endorsed ontology does not exist because portions have been rejected. In order to have a standard a group must be established to work out a compromise or translation between the two formats. The key element for the user is to be flexible and somewhat willing to accept different approaches as long as they will not negatively affect the product. This willingness to adopt new approaches will enhance their product because more information will be made available from more sources.

Relevance to National BIM Standard

Software and databases run on standard ontologies and taxonomies. In many cases, internal designations will need to be translated into forms that are more comfortable for the human users in order for them to be accepted. This is one of the benefits of a computer, since once something is mapped those relationships will carry on into the future. At this point in time, all the different ontologies and taxonomies that are going to need to be accommodated are not known. As the scope of BIM involves more entities, there will need to be additional translations. The translations will need to become standards over time.

Discussion

Interoperability vs. integration

Software interoperability is seamless data exchange and sharing 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.

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 serves 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.

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. Integration excludes interoperability with applications that do not share the (proprietary) data model.

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, have 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 (IDM), 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.

The basis for communication will be a controlled vocabulary. A controlled vocabulary is a list of terms that have been enumerated explicitly. This list is controlled by and is available from a controlled vocabulary registration authority. All terms in a controlled vocabulary should have an unambiguous, non-redundant definition. This is a design goal, however, that may not always be true in practice. It depends on how strict the controlled vocabulary registration authority is regarding registration of terms into a controlled vocabulary. At a minimum, the following two rules should be enforced.

- If the same term is commonly used to mean different concepts in different contexts, then its name is explicitly qualified to resolve this ambiguity.
- If multiple terms are used to mean the same thing, one of the terms is identified as the preferred term in the controlled vocabulary and the other terms are listed as synonyms or aliases.

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 (e.g. whole-building, natural and real property, type-instance such as space or level), but good practice limits all parent-child relationships to a single parent to be of the same type. Some taxonomies allow poly-hierarchy, which means that a term can have multiple parents. This means that if a term appears in multiple places in a taxonomy, then it is the same term. Specifically, if a term has children in one place in a taxonomy, then it has the same children in every other place where it appears. However, we are not supporting that construct in NBIMS.

A thesaurus is a networked collection of controlled vocabulary terms. This means that 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. CSI is currently developing a thesaurus for the capital facilities industry and it will eventually be incorporated into NBIMS.

People use the word ontology to mean different things, e.g. glossaries and data dictionaries, thesauri and taxonomies, schemas and data models, and formal ontologies and inference. A formal ontology is a controlled vocabulary expressed in an ontology representation language. This language has a grammar for using vocabulary terms to express something meaningful within a specified domain of interest. The grammar contains formal constraints (e.g. specifies what it means to be a well-formed statement, assertion, or query) on how a term in the ontology's controlled vocabulary can be used.

People make commitments to use a specific controlled vocabulary or ontology for a domain of interest. Our domain of interest ultimately encompasses all information views related to real property and 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, i.e. it has implicit rules that are not explicitly documented. It is important that there be a tight structure to the ontology so as to minimize misinterpretation between the many aspects of the capital facilities industry, yet at the same time various vendors may use terms that they have created to help their marketing and branding. It is hoped that they will link those proprietary terms back to the standard language presented in NBIMS over time. It does not serve the professional to continually have to make word substitutions depending on which vendor's product is being used. Creativity and uniqueness of a vendor's product should be based on the creative capability of the product and not in the creative use of words meant to obscure a common language. Currently, there are no products which can support the entire scope of BIM and likely never will be. As BIM expands the ability to create just one product to support all of BIM will always be just out of reach. Hence, it is even more important that we have a common language and relationships that all can understand so that all can work together to respond to the needs of the community.

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). 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 comparing meta-models to ontologies, we are talking about meta-models as models.

Models will be covered in a specific modeling section (Chapter 5.4) in more detail, but are mentioned here to relate them to ontologies. 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 the NBIMS is to provide the ontologies and their associated common languages that will allow information to be machine readable between one team member in the capital facilities industry to another. Ultimately, these boundaries will flow to everyone who interacts with the built and natural environment. In order for this to occur, all team members, or at least the two sharing the information, must use the same terminology. Common ontologies will allow this communication to occur. The two primary ontologies will be relationships and classes. The Industry Foundation Classes (IFC) is clearly the foundation on which we start building.

There is an additional natural relationship between various aspects of a BIM emerging which is in itself is another hierarchy. It is as depicted in figure 3.2-1:

- Societal View: The relationships at a world view.
- Lifecycle View: The relationships based on *OmniClass* table 31.

- Information Model View: Control to the access of information based on ones role in the model.
- Information Delivery Manual (IDM): Supporting the flow of BIM information.
- International Framework for Dictionaries (IFD): Allows IFC to be translated to other languages.
- Industry Foundation Class (IFC): The molecular level of a BIM.

The primary relationship of ontologies is depicted in the hierarchical relationships established in the following figure.

The primary relationship of ontologies is depicted in the hierarchical relationships established in Figure 3.2-1.

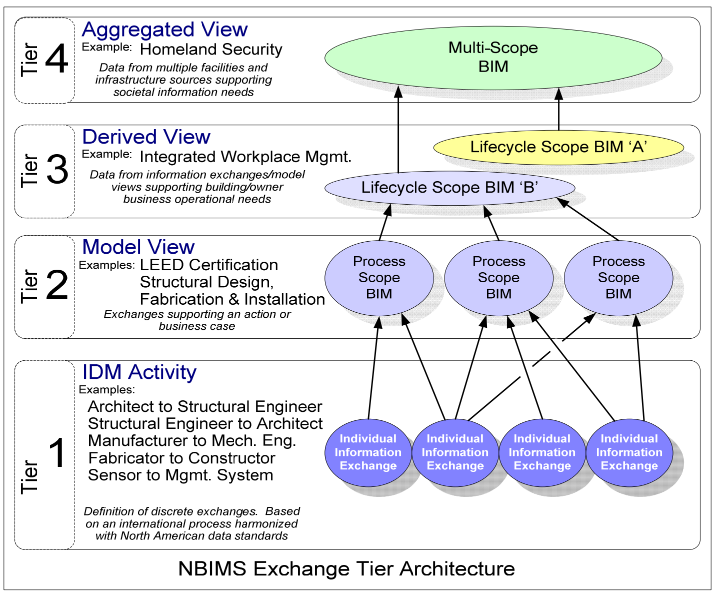


Figure 3.2-1 - NBIMS Exchange Tier Architecture (Diagram courtesy of AEC Infosystems, Inc.)

Tier 4 – Societal

The chart (figure 3.2-2) depicts the Tier 4 concepts and incorporates the combined efforts of the International Alliance for Interoperability (IAI) which provides a hierarchy at the building and structure level which is in alignment with the Federal Real Property Council (FRPC) ontology for facilities. The information above the facility level is in alignment and was developed by the Open Standards Consortium for Real Estate (OSCRE). These primary defining bodies alignment as depicted provide a continuity of information flow that has never before been clearly delineated for the capital facilities industry.

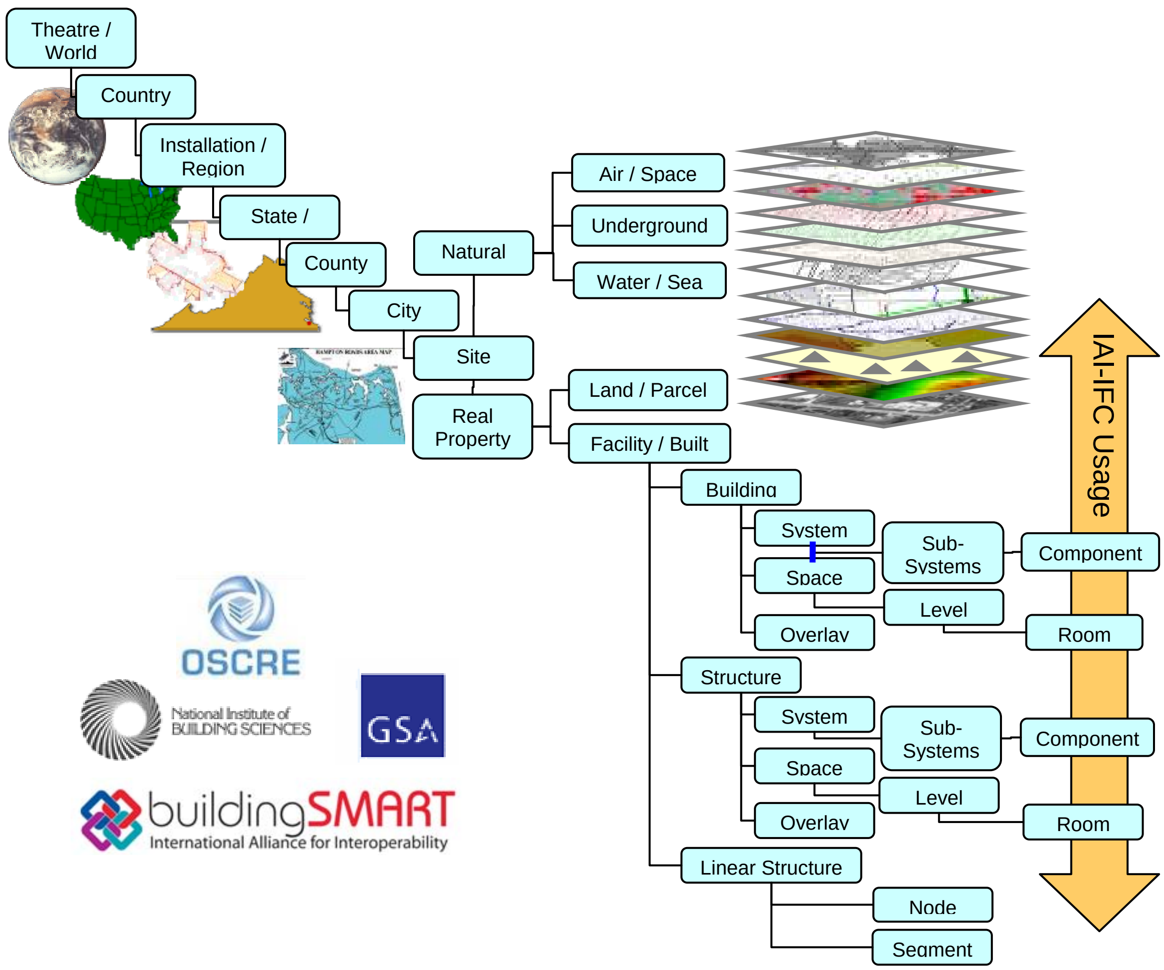


Figure 3.2-2 - NBIMS Hierarchical Relationship (Diagram courtesy DKS Information Consulting, LLC, OSCRE, GSA, and IAI International)

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 up to a world view or specific part of the world view. This also identifies the relationship between the traditional roles inside and outside facilities traditionally depicted as geospatial or GIS and CAD. One of the roles of this new environment is to melt away the lines artificially established by those two technologies. A prime example of where these two worlds collide and technology can in fact help is the fact that outside a facility engineers use a base 10 system of measurement, while inside the facility a base 12 system is used. The attempt to go to the metric system in the early 90s in the United States would have made this an easier transition, but for today, one is still stuck with the translation and must continue to work with both measurement systems. While inside the building and outside the building will always remain real boundaries environmentally, one must be able to easily share information between those two worlds. Figure 3.2-3 identifies these primary relationships and how they are currently dealt with in the real world. The unsuitability of the disconnect between spatial data types is beginning to be addressed by the government in the form of Executive Orders (EO). EO 12906 and A-16 establish requirements for geospatial information which includes building footprints and EO 13327 augments that with a need for real property lifecycle information about the facility. Although the government appears slow on the uptake of the true intent and opportunities afforded by these executive orders, they are truly steps in the right direction and will provide a firm foundation for interoperability. The information relationship potential depicted in figure 3.2-2 is the envisioned realm of the BIM as defined in the NBIMS. This range of informational interoperability is far beyond current cultural norms and will challenge implementers. However, they do depict the relationship and ontological requirements of the capital facilities industry.

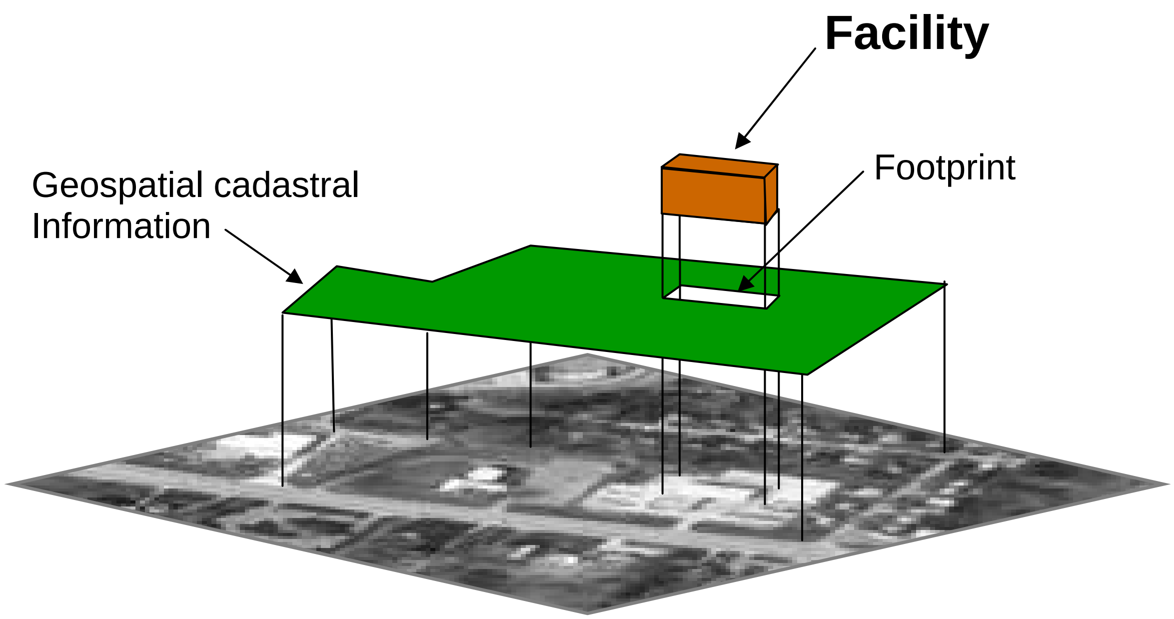


Figure 3.2-3 - GIS-BIM Relationship (Diagram courtesy DKS Information Consulting, LLC)

Building Information Models will define what is inside the outside skin of a facility yet will need information defined in the geospatial world outside the outside skin of a facility in order to perform many types of analysis. This is also true of GIS systems where they need information from inside a facility to accomplish their analysis, such as power distribution requirements. This specific issue is being addressed by three groups. The first is the International Alliance for Interoperability (IAI) Industry Foundation Class (IFC) link to Geospatial Information Systems (GIS) and the second is the Open Geospatial Consortium (OGC) Web Standard (OWS-4/5) specification which is looking at the relationship between GIS-BIM-CAD as one of the threads in that standard. There is a reference section in this document addressing that relationship and standards development effort. The Open Standards Consortium for Real Estate (OSCRE) is looking at both issues and is working to harmonize these interests in an effort to provide information to the ultimate beneficiaries the owners, operators, investors, and tenants of facilities.

Tier 3 – Lifecycle

The hierarchy has many lifecycles involved. There are in fact many lifecycles associated with each entity in figure 3.2-2. The interaction of these lifecycles will need to be mapped using business process models. If one looks at a facility as depicted in figure 3.2-3 then these interactions are a little more manageable between the world inside and outside a facility. Then there only need be one information exchange, albeit a complex one, to act as the conduit to the geospatial world. It should also be noted that we are only dealing with buildings or structure types of facilities at this point. A separate activity will be required to develop BIMs for linear structures, largely because of the even more integrated relationship between the geospatial world and linear structure itself. It is felt that once the building/structure relationships can be developed then we can more easily apply those concepts to linear structures.

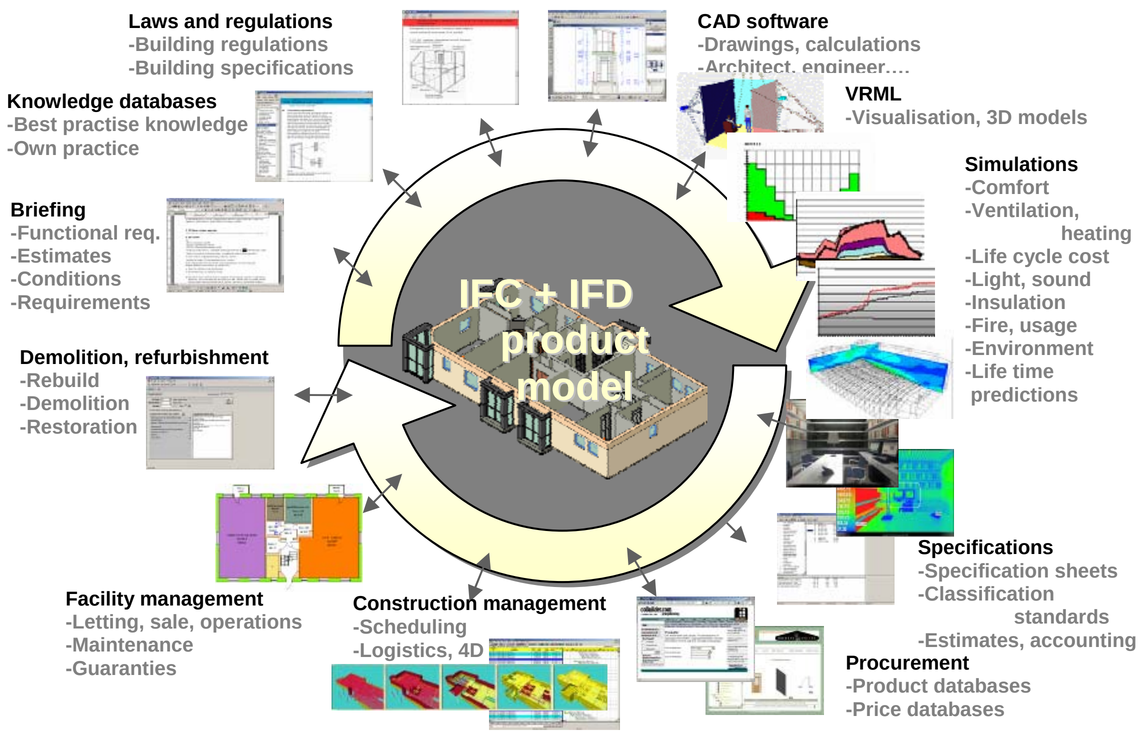


Figure 3.2-4 - BIM Relationships (drawing courtesy IAI International and AEC Infosystems, Inc)

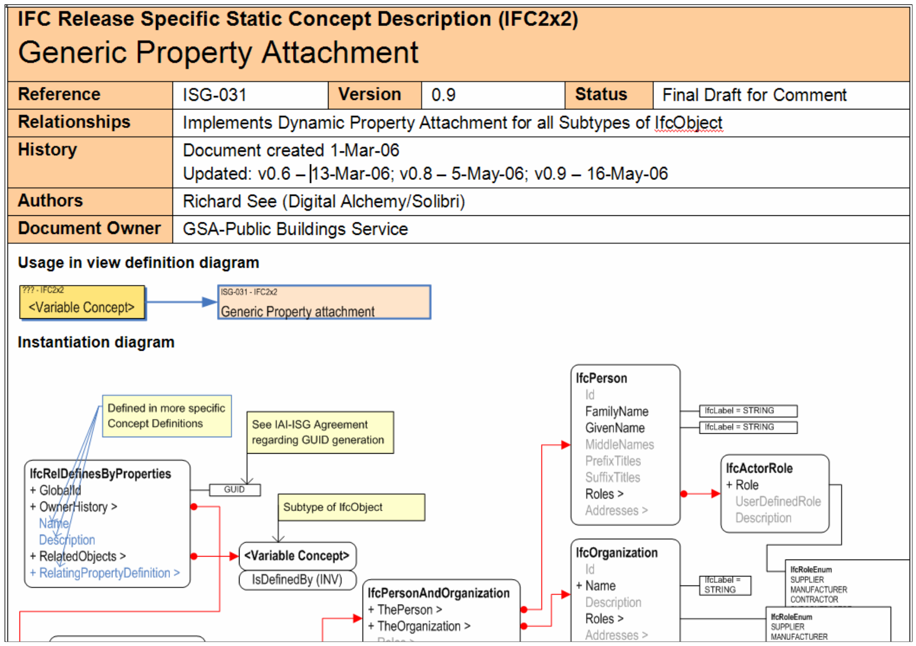
In figure 3.2-4 many of the facility lifecycle relationships are displayed. We discuss systems, space, and overlays. Each of which can operate dependant or independent of each other. The ontologies used at this point are focused on the Construction Specifications Institute (CSI) *OmniClass* tables.

OmniClass is discussed in detail in chapter 5.5.2 of this document. There is also significant use of those tables in the chapters related to Information Delivery Manuals (IDM).

It should be noted that in all of the ontologies discussed here the primary goal is to create a human interface to the Industry Foundation Class (IFC) objects and their associated characteristics. Figure 3.2-4 identifies many of the traditional functions and activities that occur related to a facility lifecycle and are all ontologically related to each other in the BIM.

Tier 2 – Model View

The next level of the tier diagram provides additional structure to the BIM. It is also the level that defines how each activity or group views the information in the model. For example, the designer can 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. On the other hand a CFO may wish only a spreadsheet proforma to make the decisions necessary for involvement in the project. Later in the lifecycle the operator will want a very different view of the model. The first responder and 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 hundreds if not, 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 his or her own view. While this is certainly possible, it would not be cost effective or desirable. Hence, it is recommended that practitioner representatives such as associations define these views.


IFC Release Specific Static Concept Description (IFC2x2)

Generic Property Attachment

Reference	ISG-031	Version	0.9	Status	Final Draft for Comment
Relationships	Implements Dynamic Property Attachment for all Subtypes of IfcObject				
History	Document created 1-Mar-06 Updated: v0.6 – 13-Mar-06; v0.8 – 5-May-06; v0.9 – 16-May-06				
Authors	Richard See (Digital Alchemy/Solibri)				
Document Owner	GSA-Public Buildings Service				

Figure 3.2-4 - Model View (Diagram courtesy of Digital Alchemy and GSA)

Tier 1 – Information Exchanges and Objects

This layer of organization is what ties all the pieces together that are necessary for BIMs to function and information to be logically related.

Information exchanges which are defined using Information Document Manuals (IDM) are the definition of 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 the closest we come to these definitions. As an industry, we need to codify these exchanges so that all understand the relationship and there emerge best practice approaches to information exchange. It is critical that the fruit 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 to that effort, it may be of significant value to someone else later in the lifecycle. If the information is not held onto at the point of information collection then it will have to be collected later at an additional cost. In some cases that information may be very difficult to collect and cause destructive means to do so.

Figure 3.2-6 depicts the information exchange. Each exchange requires a requestor and a provider. These agreements must 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 used to the fullest advantage.

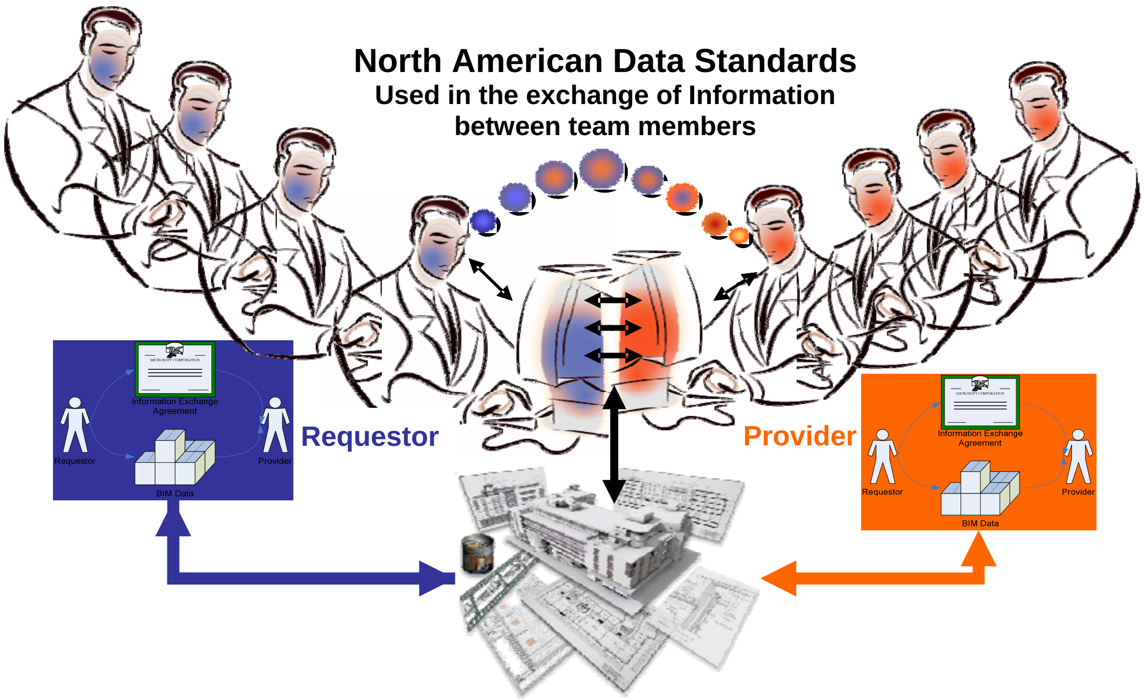
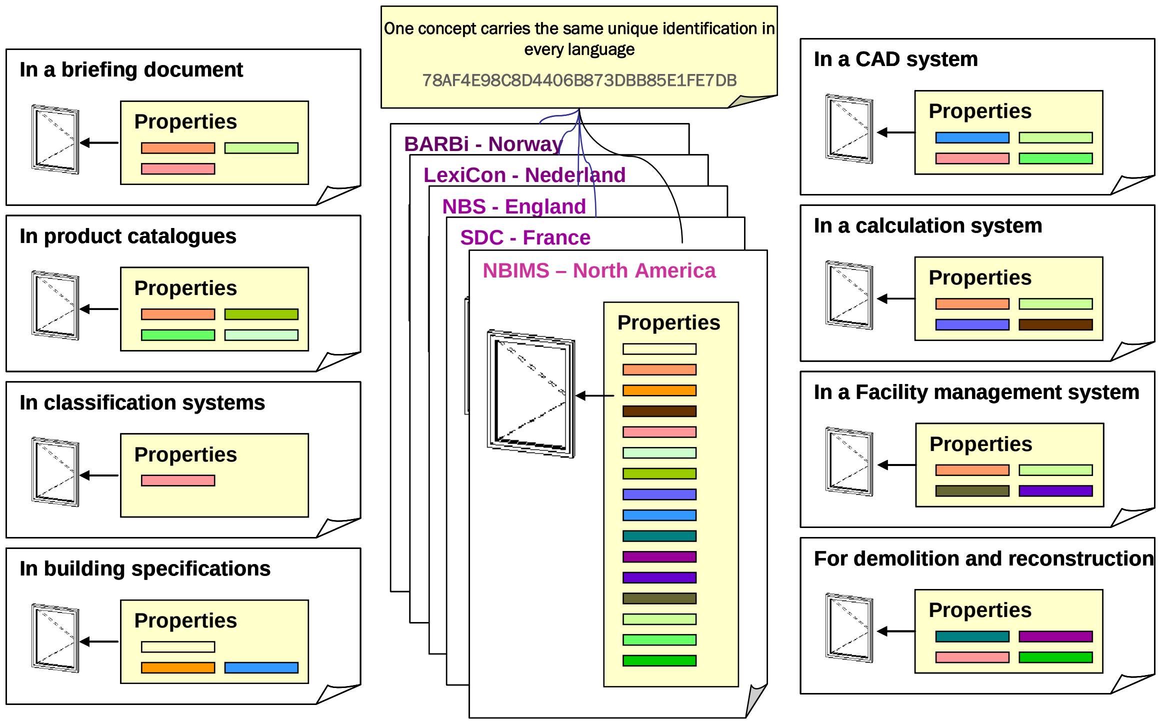


Figure 3.2-6 - Figure Information Request & Delivery BIM Data Transferred by IFC (Figure courtesy AEC Infosystems)

These exchanges are beginning to be defined and are described in detail later in this document in section 5.

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



Courtesy of Lars Bjørkhaug, Norwegian Building Research Institute

Figure 3.2-7 - Relationship of IDM 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 has been established. The Express-G models provide the necessary structure to ensure that information is relational and usable by machine [Liebich 2004]. Unfortunately, the number of humans who fully appreciate this structure is limited, which has hindered progress in the adoption of BIM. This situation is similar to the original adoption of many other data structures, such as *MasterFormat*™ or, more recently, transformation to the new *MasterFormat*™ or *OmniClass*™ Table 22 from the more familiar 16 Division MasterFormat™.

A sample of an Express-G data structure is provided below. 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 as being either a product occurrence (i.e. a subtype 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 contained in a separate instance of IfcShapeRepresentation, but all are placed by a single instance of IfcObjectPlacement.[14]

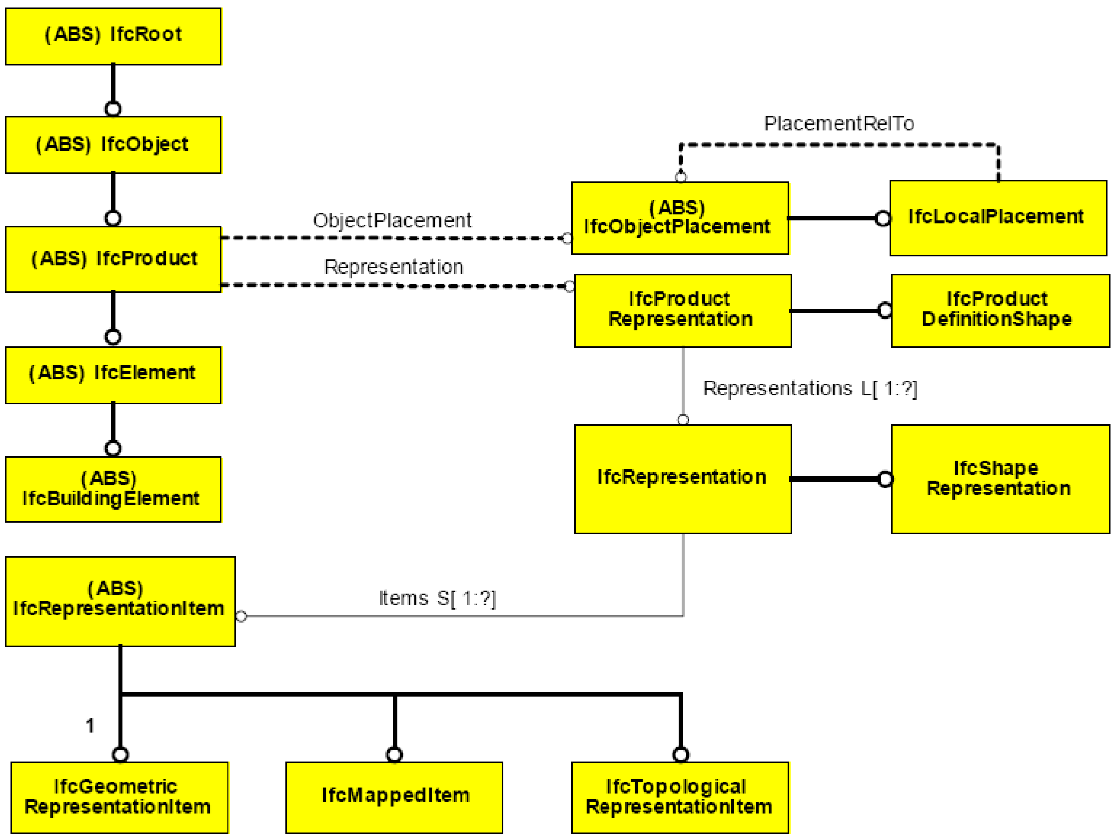


Figure 3.2-8 - Representation of Data Structures in IFC 2x (Courtesy of IAI International)

Implementation Data Structures

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

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

Next Steps

The implementation of the ontologies and taxonomies presented in this document are in their infancy as far as cultural acceptance in the capital facilities industry. There are several active steps that must be taken to ensure a strong foundation for BIM is created.

- Work with and further support OSCRE's effort to link the planning, design, and construction world to the owners, operators, investors, and tenants of facilities.
- 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 efforts that are going on 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 our capital facilities industry to a consensus level to ensure that all are speaking the same language.

NBIMS efforts are based on the IFC reference standard being developed internationally. Implementations will use that IFC model and will map to locally used data structures. While the basics are in place for data structures and there is agreement on the basis for the use of IFC, a significant amount of work remains in order to get to a standard level of agreement on NBIMS. Hence the following steps are required.

- Completion of the work involved with NWI 241 to harmonize IFC and ISO 15926.
- Consensus on the hierarchy from detailed facility or structure view to world view. (December 2007 as part of NBIMS V1, Part 2)
- Overall consensus on use of a procedural lifecycle roadmap for the capital facilities industry based on one of the existing best practices. (NBIMS V2)
- Incorporation of the accepted procedural best practice into software. (NBIMS V3)

References and Links

[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

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

[OWL] Web Ontology Language - http://www.w3.org/2004/OWL/
[Wikipedia]
NOTE: 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 Central Repository of Shared Information

Introduction

A primary goal of the National Building Information Model Standard (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 imply 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.

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 proprietary repositories which 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.

Relevance to Users

BIM technologies may be effectively used in a many different ways by project stakeholders. 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 have found that the content of the BIM data required is virtually the same regardless of the process. The process through which data exchange takes place will, however, impact 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 for 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 an impact on the framework under which NBIMS operates.

Discussion

There are many settings in which Building Information Models may be shared during a project. 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 are established within these firms. Checks based on the contents of the BIM for completeness, consistency, and collisions are also enabled when sufficient progress is made on the shared building model.

Since the greatest cost associated with capital facilities occur 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 internally 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. Owners will also be able to incrementally create building models of existing facilities through the accretion of information from smaller renovation or maintenance projects. Over time, the internally maintained building model repositories can provide a full digital representation of an owner's infrastructure. 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 sector.

An owner's repository is likely to begin with the completion of one or two new projects. The bottleneck in this approach is that it may take fifty or one hundred years before facility turn-over results in a fully populated repository. To back-fill repositories some owners have "seeded" their repositories with general building location 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.

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 a more transparent picture of asset condition.

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 building. Such information should be captured during the 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 the model. In some cases this information may be linked into the model but contained in separate files. In cases where proprietary information is applied during the design, only the design-specific information is likely to be part of the model.

Over multiple construction, renovations, and upgrades, information about the building will be transformed from as-built to as-is data. Given concerns over the historical use of real estate and material composition of facilities, the information backbone will assist property owners to more fully evaluate future risks and opportunities.

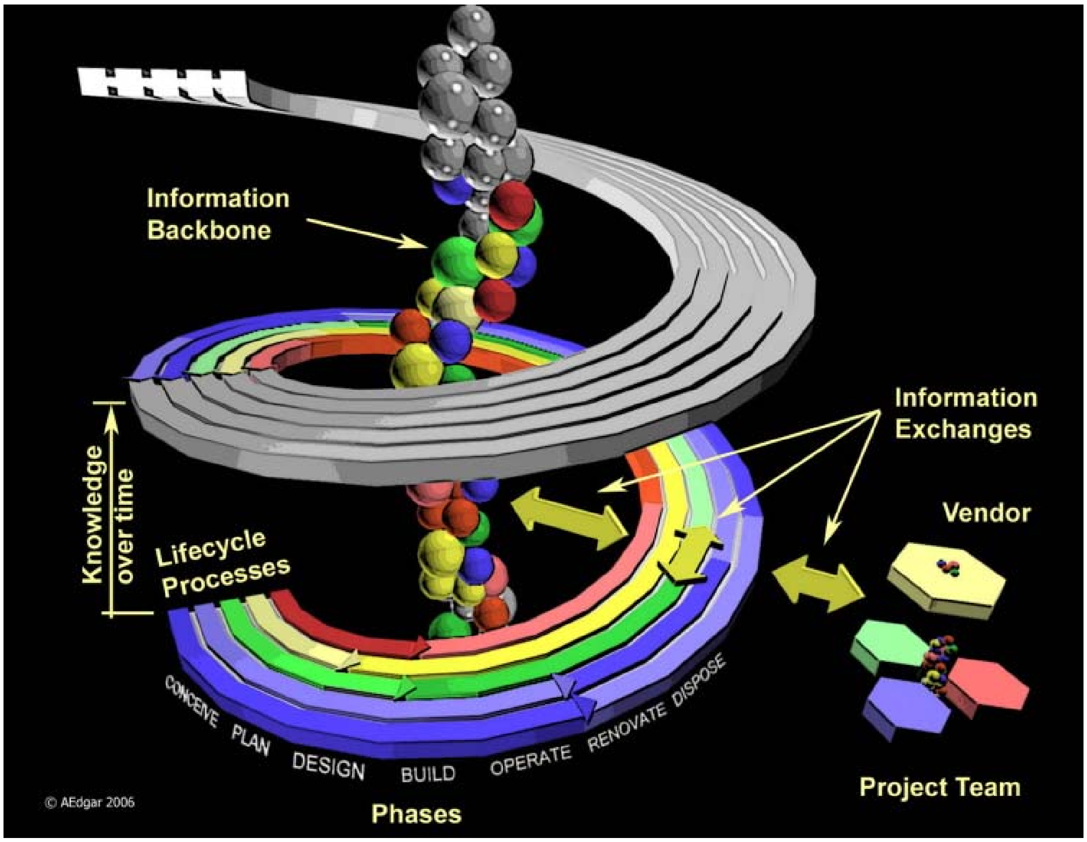


Figure 3.3-1 - Facility Lifecycle BIM Repository (Courtesy Alan Edgar, FacilityGenetics, L.L.C.)

Work to develop repositories of building model components and libraries that contain the intellectual property of owners, designers, manufacturers, and others is currently underway. In the readers' own lifetime they probably have data captured on media or software that can no longer be read. NBIMS provides an open standard upon which to build repositories of information that will provide value 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 from the realm of university research 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:

- EDM, http://www.epmtech.jotne.com/products/index.html
- IFC Model Server, http://www.secom.co.jp/isl/e/theme/ps07/report01/index.html

Chapter 3.4 Information Assurance

Introduction

A Building Information Model (BIM) is a wonderful opportunity to have all the information about a facility in essentially one place. It is an asset 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 advance planning about how best 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 get access, and only to that subset of the 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 care that is commonplace in personnel and banking systems worldwide.

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 facility, some information, e.g. 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 public 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 managers to first responder or incident commanders in an emergency situation.

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.

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 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 on working 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 important to you.

Relevance to the National BIM Standard

In order for everyone who will touch the information in a BIM throughout its life 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 be able to be passed from one control point to the next without danger of compromise. If done appropriately, this will not and cannot limit access to any one vendor in order to protect its sustainability over the facilities lifecycle.

Discussion

The most desirable solution would use open source and 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 Facilities Information Council, charter member the Open Geospatial Consortium (OGC), paves the way. 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). 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):

> *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.

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) is 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.

As we develop our Building Information Models with Information Assurance (IA) in mind, we can also benefit from the experience of federal agencies since 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. If 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.

Best Practice Steps include:

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

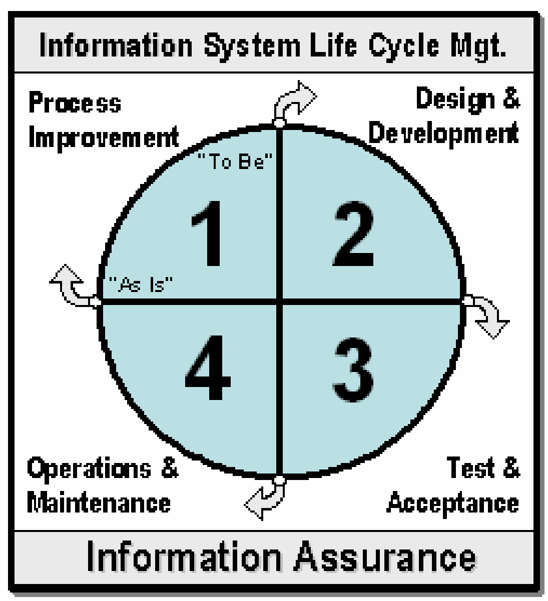


Figure 4.4 - 1 - Information Assurance will be most successful when planned into the management of the entire information system life cycle from the beginning.

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 end 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 & 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 which 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. Additionally, 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 now 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 & 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. data base 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 & 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 is 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 are going on, designed to protect the information. 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 to ensure 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 administrators/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 our charter member, the Open Geospatial Consortium, and the experience of U.S. federal agencies in IA will enable us 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 life 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.*
> http://www.opengeospatial.org/projects/initiatives/ows-4

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 should, therefore, 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 contractors' 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 we are proposing with the National BIM Initiative, 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:

- Establishment of IA procedures in new BIM's,
- Encryption-at-rest measures be initiated,
- Encryption-during-transmission be implemented, and
- Building 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 the information access issue 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 in fact has the most accurate information. This does not necessarily mean that only someone in the ultimate authoritative position can add information, because the information may be the best available information at that point in time; however, the user of that information needs to also 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 actually 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 do they play? This information may be stored with the registration information, however, the person may have different roles and the role they are playing 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 how the system will certify the integrity of the data and the processes. Just as you and appropriate banking officials can access your bank account and other people cannot, or a supervisor can access personnel records of direct reports and 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.
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) the 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's and Lehtinen's "The Useful Minimum."[i][15] Here, a useful minimum for IFC implementations is discussed and the author prescribes technical level approaches for practitioners to maximize collaboration using currently existing BIM software and cultural BIM functionality. Domestically, the Army Corps of Engineers' BIM Roadmap clearly and pragmatically defines their desired minimums on the facility level for required BIM data upon beneficial occupancy by the Corps. However, this proven formula 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, however, is beyond the scope of this chapter and will require further investigation before reaching that level of maturity.

The minimum requirements for a version 1.0 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 paragraphs.

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 really cannot 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 the following characteristics through the associated areas of maturity in the complete CMM, which can be seen in its entirety in chapter 4.2:

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

- ***Data Richness.*** Having some level of expanded data collected so that the model is a worthwhile source of information about a facility.
- ***Lifecycle Views.*** No complete lifecycle project phasing needs to be implemented fully at this point.
- ***ITIL Maturity Assessment.*** The IT Infrastructure Library concepts such as business process change management do not yet need to be considered for a minimum BIM.
- ***Roles or Disciplines.*** The basis for a BIM includes sharing of information between disciplines, so a minimum level of information sharing is required.
- ***Business Process.*** While business process interoperability is a 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 seen yet 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 systems.
- ***Graphical Information*.** Since all drawing 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 identified. 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 the 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 models.

Over time, this minimum level will increase as the rhetorical “bar is raised” and owners expect more from the models being delivered. This requires cultural change on many levels. Not only from practitioners, but also real property operators and sustainers may account for this information in the future. A few early adopters will implement more robust levels of these capabilities and they will be sought out to provide the valuable products they provide and the maturity process will move forward.

These metrics are critical in ensuring that the products 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.

The Interactive BIM Capability Maturity Model		
Area of Interest	***Choose your perceived maturity level***	***Credit***
Data Richness	Expanded Data Set	*1.7*
Life-cycle Views	No Complete Project Phase	*0.8*
ITIL Maturity Assessment	No ITIL Implementation	*0.9*
Roles or Disciplines	Two Roles Partially Supported	*2.7*
Business Process	Few Bus Processes Collect Info	*1.8*
Timeliness/ Response	Most Response Info manually re-collected	*1.8*
Delivery Method	Network Access w/ Basic IA	*2.8*
Graphical Information	NCS 2D Non-Intelligent As Designed	*2.8*
Spatial Capability	Not Spatially Located	*0.9*
Information Accuracy	Initial Ground Truth	*1.9*
Interoperability/ IFC Support	Forced Interoperability	*1.9*
	TOTAL	**20.1**

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

Facility Level Recommended BIM Minimum Data

The USACE BIM Roadmap[16] can be helpful if 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 below could be beneficial for any owner on any new facility. Therefore, the information is included here for industry practitioner ease and wide-spread 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 A/E/C & FM industry. Note: The rest of this portion is an excerpt directly from the USACE Roadmap; however, references to specific industry software platforms have been removed. NBIMS does not prescribe or deter any practitioner from using any specific software platform.

ERDC TR-06-10 – 6.2 Architectural Model Minimum Requirements and Output
Additional minimum requirements are:
Walls. The architectural model(s) should include all walls, both interior and exterior. They should be modeled as they would be built; meaning with enough detail to get quality quantity takeoffs on all construction materials used. They should also be accurate enough that all floor plan and elevation extractions are accurate to the design intent.

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[16] 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

Exterior banding or brickwork, entrance features, and special interior features should be modeled at this stage for communication to the client at review. Each wall shall be to the exact height, length and width so to properly account for space allocation. Fire ratings of walls shall be indicated by using the proper family and part for those wall types. Extractions should re-symbolize properly to identify them.

Doors and Windows. Doors and windows should be modeled to represent the actual size and location on all exterior elevations. They should be the exact door or window that is intended by the Architect in all respects, including size and style. Doors and windows shall be placed using the [vendor supplied] door or window tool and they shall be of a cell type that supports the door and window templates provided by the USACE BIM Dataset CD as well as the data group system for labeling and other BIM functions. They cannot be placed as independent cells. They must be placed within these tools so that the data group system can accurately count and hold data for the doors and windows.

Roof. The roof system must be modeled within the BIM model. The level of detail for the roof system must be adequate to communicate the roof configuration and the method by which the water is removed from structure. Again, this must be modeled as it is built. This does not mean that the entire roof structure must be modeled at this submittal, but it does mean that an adequate place holder representing size, shape and configuration must be modeled. Most quantities can be derived from the surface area and the depth of the roof assembly.

Floors. The floor slab shall be modeled in either the Architectural model or the structural model and then referenced by the architectural models for each floor slab.

Ceilings. All ceilings shall be modeled using either [the vendors] ceiling tool or form modeling to create special ceiling features. All ceilings, including soffits or other special conditions shall be in the model at this submittal.

Spaces. The spaces are a very important element in this submittal. They should be modeled to complete accuracy as to obtain accurate net square footage requirements and to hold data for the room and finish schedules that draw information from them. Room names and numbers should also be finalized within the model for output to schedules for all disciplines.

Furniture. A furniture cell library has been provided in the Corps of Engineers BIM Dataset.

Schedules. Provide door and room finish schedules from the BIM model indicating the materials and finishes used in the design. Also a special item schedule and/or notes shall be provided indicating any special items that will be required for the design. The room finish schedule template is provided within the dataset. Due to the specific nature of the special items schedule, it shall not be required as an output of the BIM, but there are additional templates in development, and these will be required on future projects to support specific output tasks of the design team. These schedules are created with the data group system and any additional schedules created during the design process shall be placed in the same location.

Extractions. The extraction process should be well established at the interim submittal. All but a very few extraction definitions should be complete and submitted within the master models. It is suggested that the design team begin with the extraction definitions provided with the dataset and build from there.

Datagroup. The Datagroup information should be complete at the interim submittal and should not be edited beyond this stage unless large building usage changes have been made. All spreadsheet output should be configured and waiting for any additions or changes made later in the design process.

Dataset. All dataset issues should be resolved at the interim submittal. Any additional families, parts, line styles, special dimension styles, or level not provided in the Corps of

Engineers BIM Dataset CD shall be submitted to the BIM Manager at this and every submittal. (See section “QA/QC and Detection of Changes to the Dataset” for guidance on standard and dataset change requests)

Quality Verification. All quality checks listed in the section “QA/QC and Detection of Changes to the Dataset” shall be completed for all files and disciplines. Output of those checks shall be submitted with the normal submitted materials. In addition, documentation of all unresolved interferences, standards, [Vendor] elements along with an explanation, shall be submitted. A quality check for compliance with the [National] CAD Standard must also be completed on the final file condition prior to submittal and the results of that standard check must be included in the submittal.

Design Analysis. The model must support the design analysis whenever possible and prudent. That decision must be made by comparing the value of the output from the model versus the work added to computer processing, which is affected by the level of de-tail.

Drawings. All drawings that contain information that resides in the model shall be generated from the BIM model in the extraction process. Standard details, index sheet, and other typical drawings need not be included in the BIM model. Civil and electrical drawings are also exempt from the BIM process due to the lack of soft-ware applications supporting these disciplines at this time. Submittals must include the extraction files, sheet files, special patterning, line styles, cells, referenced files or other specific files used to create the drawings as output of the model. All files must be in the proper location within the USACE Workspace delivered on the Corps of Engineers BIM Dataset CD. The District must be able to recreate the BIM process to review the drawings and model. Simple images are not acceptable and are not direct outputs of the BIM.

6.3 Specific Drawings requirements:

Composite Floor Plan. If the main floor plans must be shown in segments to comply with the requirements of the proper scale, pro-vide a smaller scale floor plan from the BIM model showing exterior walls, interior partitions, circulation elements and cross referencing for enlarged floor plans and sections. Show overall dimensions on the floor plan and gross building areas tabulation on the drawing. Tabulated data such as gross square footage shall be considered an output of the model.

Floor Plans. Provide floor plans from the BIM at 1:100 or 1:50 scale. Show gross floor area tabulations if no composite sheet is included. Tabulated data such as gross square footage shall be considered an output of the model.

Building Elevations. Provide building elevations from the BIM model showing grading, openings, principal exterior materials and general profiles of the building (scale shall be the same as the floor plans).

Roof Plan. Provide a roof plan from the BIM model showing the roof configuration and methods by which rain is directed to the building perimeter.

Building and Wall Sections. Provide typical wall sections (1:20 minimum scale) that indicate major elements. Wall sections shall be unbroken where practical and indicate materials and floor-to-floor heights. Building sections shall be an output of the model, but wall sections and details are typical and at such a large scale that they shall not be required as an output of the BIM model.

Reflected Ceiling Plan. Provide a ceiling plan from the BIM model that indicates ceiling material and open ceiling areas. Indicate room numbers, light locations, registers, and all ceiling mounted items, such as exit signs.

Fire Protection/Life Safety Plan. Provide fire protection/life safety drawings from the BIM model that indicate fire suppression information, exit signs, pull stations, exit devices, exit distances, emergency lights, detectors, alarm locations and fire panel locations. Summarize the code information from the design analysis on the drawings.

Next Steps

We are only at the early stages of BIM and, therefore, much needs to be accomplished. We are certainly seeking more than minimums in order to realize the true potential of BIM in the real property industry. 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 and does it meet the minimums identified in this document?
- 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.

References

http://www.nationalcadstandard.org/

Chapter 4.2 Capability Maturity Model

Introduction

The objective of the NBIMS and embedded IDM 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 (A/E/C/O) community. To meet the future needs of a more streamlined A/E/C/O 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[17], but the CMM included here is not targeted at software designers. On the contrary, most of the NBIMS consists of high level doctrine or lessons learned regarding BIM, but the CMM is one of the items targeted at the A/E/C/O industry for immediate use and application on current processes or BIM projects. The vision is that stakeholders will use the CMM like a tool to plot their current location, while looking past their progress to more robust parts of the spectrum as goals for their future operations. Stakeholders will further benefit from using this application through the NBIMS Committee's collection of this longitudinal data and research findings and analysis reported back to the community.

Tabular CMM

There are two versions of the BIM CMM included with the NBIMS. The first is called the "tabular" CMM because it is a static excel workbook consisting of three worksheets with information that lists the information in a true spectrum. The second is the "interactive" CMM and consists of a five-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 this 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 MS Excel.

1. CMM Chart

As seen in the screen capture on the right, the CMM is a matrix with an x axis and a y axis. On the x axis, you can 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

Tabular BIM Capability Maturity Model 5/30/2006

Maturity Level	A Data Richness	B Life-cycle Views	C Roles Or Disciplines	D Business process	E Delivery Method	F Timeliness/ Response	G ITIL Maturity Assessment	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	Separate Processes Not Integrated	Single Point Access No IA	Most Response Info manually re-collected - Slow	No ITIL Implementation	Primarily Text - No Technical Graphics	Not Spatially Located	No Ground Truth	No Interoperability
2	Expanded Data Set	Planning & Design	Only One Role Supported	Few Bus Processes Collect Info	Single Point Access w/ Limited IA	Most Response Info manually re-collected	Initiation	2D Non-Intelligent As Designed	Basic Spatial Location	Initial Ground Truth	Forced Interoperability
3	Enhanced Data Set	Add Construction/ Supply	Two Roles Partially Supported	Some Bus Process Collect Info	Network Access w/ Basic IA	Data Calls Not In BIM But Most Other Data Is	Limited Awareness	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	Most Bus Processes Collect Info	Network Access w/ Full IA	Limited Response Info Available In BIM	Full Awareness	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	All Business Process(BP) Collect Info	Limited Web Enabled Services	Most Response Info Available In BIM	Limited Control	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	Few BP Collect & Maintain Info	Full Web Enabled Services	All Response Info Available In BIM	Full Control	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	Some BP Collect & Maintain Info	Full Web Enabled Services w/IA	All Response Info From BIM & Timely	Limited Integration	3D - Intelligent Graphics	Part of a limited GIS	Limited Comp Areas & Ground Truth	Limited Info Uses IFC's For Interoperability
8	Completely Authoritative Information	Add Financial	Operations & Sustainment Supported	All BP Collect & Maintain Info	Web Enabled Services - Secure	Limited Real Time Access From BIM	Full Integration	3D - Current And Intelligent	Part of a more complete GIS	Full Computed Areas & Ground Truth	Expanded Info Uses IFC's For Interoperability
9	Limited Knowledge Management	Full Facility Life-cycle Collection	All Facility Life-Cycle Roles Supported	Some BP Collect&Maint InReal Time	Netcentric SOA Based CAC Access	Full Real Time Access From BIM	Limited Optimization	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	All BP Collect&Maint In Real Time	Netcentric SOA Role Based CAC	Real Time Access w/ Live Feeds	Full Optimization	nD - Time & Cost	Integrated into GIS w/ Full Info Flow	Computed Ground Truth w/Full Metrics	All Info Uses IFC's For Interoperability

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Figure 4.2-1 - CMM Chart (Diagram courtesy NIBS)

[17] 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.

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 goes without saying that these descriptions will be updated as the community progresses and greater levels of BIM adoption dictate.

2. Descriptions

Capability Maturity Model Category Descriptions

Category	Title	Description
A	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
B	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.
C	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.
D	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. Our 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.
E	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.
F	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.
G	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.
H	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.
I	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.
J	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.
K	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 (Diagram courtesy NIBS)

As the screen capture to the left shows, the "descriptions" tab lists and describes all 11 areas of interest in a tabular format. In the "Description" column, the text is usually 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)[18] 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

[18] 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.

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.

3. Views

	A	B	C	D
1	**Building Information Views**			5/26/2006
2				
3	**Level 1**	**Level 2**	**Level 3**	**Likely Initial Format**
4	Owners View	Financial View	Proforma View	Spreadsheet
5			Mortgage Bankers View	Spreadsheet
6			Cost of Operations View	Spreadsheet
7		Legal Data View	Contract View	Document
8			Litigation View	Document
9			Code Official View	Document
10		Real Property View	Realtor View	Database
11			Appraiser View	Spreadsheet
12			Geospatial View	GIS
13		Planning View	Architectural Program View	Spreadsheet
14			Environmental Impact View	Document
15			Prototyping & Testing View	Graphical
16			CIO View	Graphical
17		Design View	Architecture View	CAD
18			Engineering View	CAD
19			Specification View	Database
20			Cost View	Spreadsheet
21		Construction View	Contractor View	CAD
22			Sub-Contractor View	CAD
23			Fabricator View	CAD
24			Supplier View	Spreadsheet
25			Manufacturer View	Database
26		Protection View	Risk Mitigation View	Document
27			Risk Management View	Database
28			Security Manager View	Graphical
29			Occupational Health View	Database
30			Personnel Safety View	Document
31		First Responder View	Fire Response View	Graphical
32			HAZMAT View	Document
33			Terrorist Response View	Graphical
34		Operations View	Warranty View	Database
35			Energy View	Spreadsheet
36			Network Manager View	Graphical
37		Sustainability View	Maintenance View	Document
38		Occupancy View	Space Manager View	CAD
39		Mission View	Readiness View	Spreadsheet
40			Business Process View	Graphical
41			Process View	Graphical
42			Operational Sustainment View	Document
43			Logistics View	Graphical
44			Weapons Systems View	CAD
45			Housing View	Graphical
46			MWR View	Graphical
47			Personnel View	Graphical
48			Range Management View	Graphical
49			Force Protection View	Graphical
50			BRAC View	Document
51		Demolition View	Green Product View	Document
52				
53				
54	Level 1 view is a high level summary sub-set of level 2 views, little or no retailed information contained			
55	Level 2 views are a summary sub-set of level 3 views and may contain detailed information			
56	Level 3 views contain the detailed information from which the higher levels are derived			
57				© NIBS 2006

Figure 4.2-3 - Views (Diagram courtesy NIBS)

As it has been said many times before, the key to BIM is the “I” portion. However, an overload of information can cause “paralysis by analysis,” and would threaten the primary reason for implementing BIM – to improve the building supply chain through information exchange. If people cannot get to the information they need, it does not achieve its intended purpose. Therefore, a good way to think about a successful BIM is through the lenses of the stakeholders who will work with, or require information from, the BIM process. This tab seeks to address the types of tangible products that different industry cross sections would most likely require from BIMs to improve their operations, but in no way should it be considered hard and fast rules for access to information. It is only intended as a guide or starting point.

Interactive 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.

1. Interactive Maturity Model

The first, and primary, tab of interest 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. First, the areas of interest are listed in the first column, in increasing order of perceived importance. Hovering over each area of interest will elicit a “comment” with the full description of that area of interest. The next column shows the relative percentage out of 100% that each area of interest garners. 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 2007, the minimum score required for the distinction of “Minimum BIM” is 20 points. If the date were 2008, it is 30 points, and if the date were 2009, the minimum is 40 points.

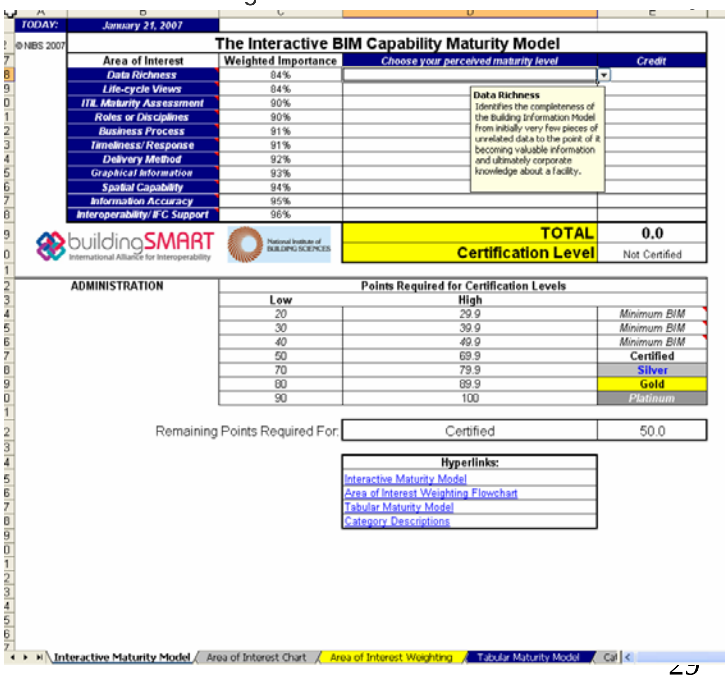

Figure 4.2-4 - Interactive Maturity Model (Courtesy NIBS)

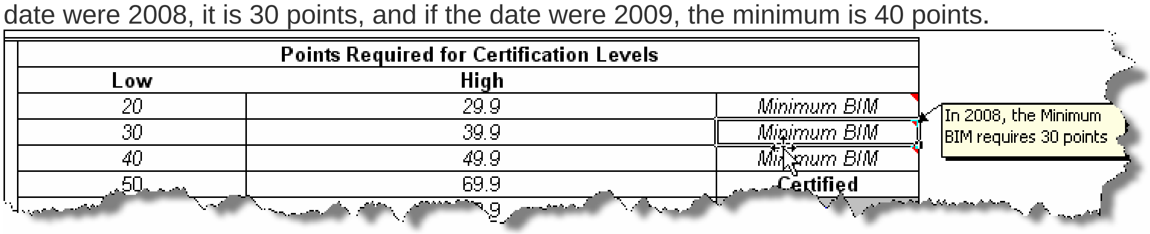

Figure 4.2-5 - Highlighted, Date-Sensitive Minimum BIM levels (Diagram courtesy NIBS)

All certified scores 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.

TODAY: January 21, 2007

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The Interactive BIM Capability Maturity Model

Area of Interest	Weighted Importance	Choose your perceived maturity level	Credit
Data Richness	84%	Data Plus Expanded Information	4.2
Life-cycle Views	84%	Includes Construction/ Supply	3.4
ITIL Maturity Assessment	90%	Limited Awareness	2.7
Roles or Disciplines	90%	Two Roles Partially Supported	2.7
Business Process	91%	Some Bus Process Collect Info	2.7
Timeliness/Response	91%	Limited Response Info Available In BIM	3.6
Delivery Method	92%	Single Point Access w/ Limited IA	1.8
Graphical Information	93%	NCS 2D Non-Intelligent As Designed	2.8
Spatial Capability	94%	Basic Spatial Location	1.9
Information Accuracy	95%	Limited Ground Truth - Int & Ext	4.8
Interoperability/IFC Support	96%	Limited Info Transfers Between COTS	3.8
		TOTAL	**34.4**
		Certification Level	Minimum BIM

buildingSMART International Alliance for Interoperability — National Institute of Building Sciences

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	15.6

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

Figure 4.2-6 – Completed View (note the Certification Level = a "Minimum BIM"
(Diagram courtesy NIBS)

2. Area of Interest Chart

The Area of Interest Chart 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.

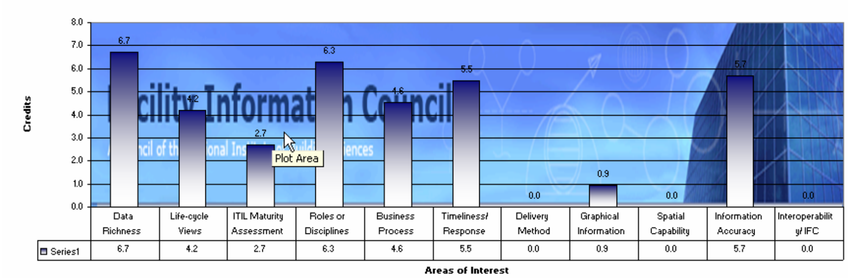


Figure 4.2-7 – Areas of Interest and their Respective Credit Chart (Diagram courtesy NIBS)

3. Area of Interest Weighting

The next tab, 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.

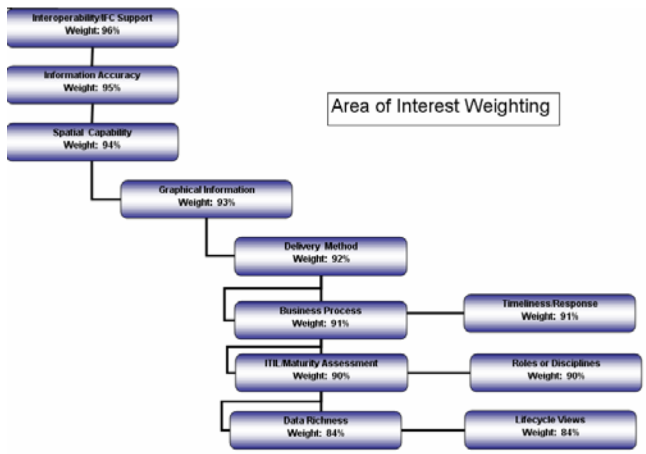


Figure 4.2-8 – Area of Interest Weighting Hierarchy (Diagram courtesy NIBS)

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.

Conclusion

The purpose of the National BIM Standard Committee is to knit 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. 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) will 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 the NBIMS. A diagram of the proposed, added functionality of this notional web interface looks like this:

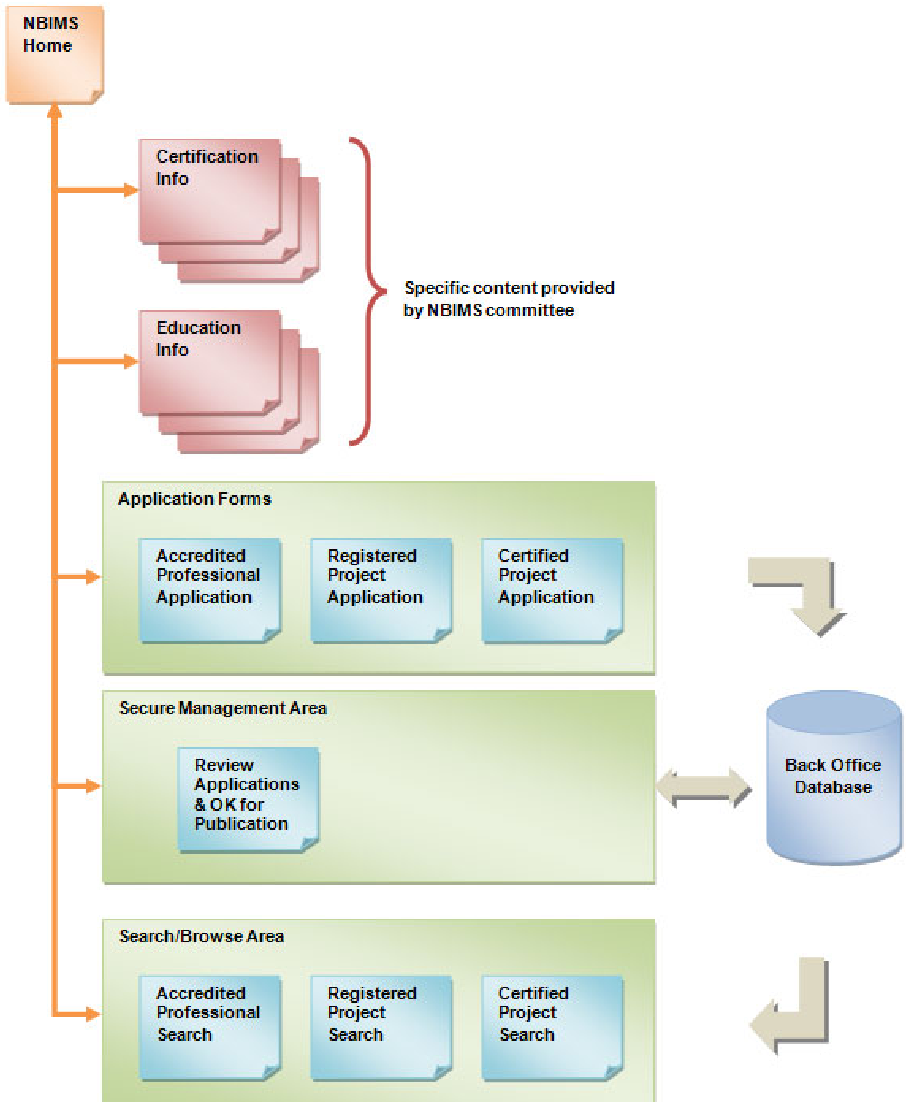


Figure 4.2-9 - Proposed Web-Based Application for Certifying BIMs and Accrediting BIM Professionals[19]

In this way, people would be motivated to learn the information in the 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 A/E/C/O community, which could help them "win jobs" or build respect in their fields. The

[19] Graphic created and provided by Donald F. Sanborn, Unique Solutions, Inc.

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.

The following steps are required to take it 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[20] 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 really only intelligent drawings, visualization tools or production aides. In a more positive light, the current Capability Maturity Model gives the A/E/C/O 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 administrative shape of 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, as well as providing a means and motivation for users to create reliable information that is stored in open and interoperable formats.

The Capability Maturity Model workbook may be downloaded at:
http://www.facilityinformationcouncil.org/bim/pdfs/BIM_CMM_v1.8.xls

[20] See NBIMS Section 4.2-2, pages 1-3.

Chapter 5.1 NBIM Standard Process Orientation

Introduction

Section 5 is dedicated to describing in detail proposals for the processes the NBIMS Committee will employ to produce the NBIM Standard. In order to orient the user, a conceptual diagram is provided. Components of this diagram correspond to chapters that follow in this section. A smaller orientation diagram is also provided within each chapter.

NBIM Standard Components

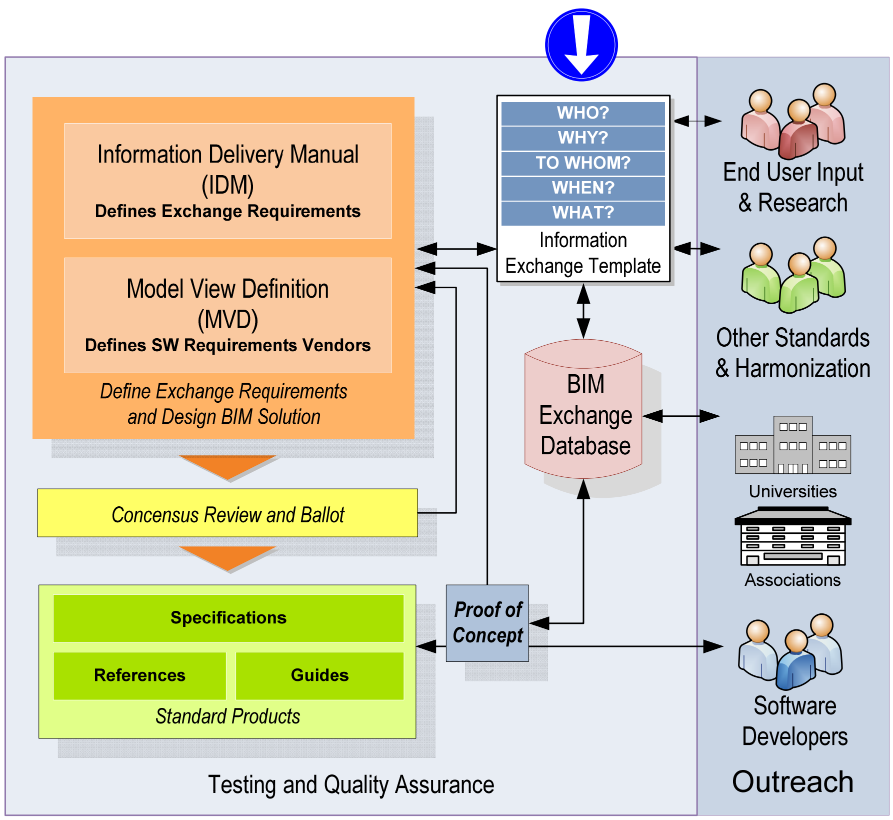


Figure 5.1-1 - NBIM Standard Concept Diagram
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

Best Practices, Consensus, and Verification Testing

Underlying and permeating the entire Standard is a commitment to creating a quality product based on established and emerging industry best practices. As both the processes used to create the NBIM Standard and the products are meant to be open and transparent, NBIMS will employ a consensus process to invite industry-wide understanding and acceptance. In addition, end users and vendors will have the opportunity to participate in testing activities designed to evaluate both elements of the Standard and specific BIMs. Chapter 5.2 presents details related to best practices, consensus and verification testing.

Define and Store Exchange Requirements and Vendor-Facing Solutions

The contents of the boxes labeled "**Information Exchange Template,**" "**BIM Exchange Database,**" and "**Define Exchange Requirements and Define BIM Solution**" together discuss core components of the BIM Standard production process. Chapter 5.3 presents the process for defining exchange requirements; which is an 'end-user facing' activity. This is primarily represented by the graphic element labeled **Information Delivery Manual (IDM).** As a continuation of this discussion, Chapter 5.3.1 discusses the **Information Exchange Template** which can be thought of as a web-based 'front door' for end-users wishing to either search for existing exchange definitions or propose new ones, and Chapter 5.3.2 then discusses the **Information Exchange Database** where the details of exchange definitions are stored.

Chapter 5.4, NBIMS Models and Software Implementation Guidance, then presents the process for preparing exchange definitions to be implemented in software; which is naturally a more 'vendor-facing' phase. This is represented by the graphic element labeled **Model View Definition (MVD).**

Consensus

The '**Consensus Review and Ballot'** graphic relates to one level of review of NBIM Standard concepts and specifications. Chapter 5.2 describes how products will be released for public review, comment, and balloting as a method of ensuring both open and transparent development and appropriate results. The '**Proof of Concept'** graphic refers to planned testing activities. These are described in Chapter 5.2 as well.

Specifications, References and Guides

The NBIMS Committee will publish several types of **Standard Products**; including, for example, specifications of IDM and MVD products, accepted references, and guide documents. The definition of NBIM Standard products is covered in general throughout Section 5.

Outreach

Delivering products and services to the facility lifecycle community is a large part of the mission of the Committee. **Outreach** activities cover a wide range of possibilities and a few of the most prominent are illustrated in the diagram.

Practitioners, researchers and developers will all search and access stored information about exchanges via the Information Exchange Template. Similarly, this template will be used to suggest new or needed improvements to an existing exchange definition. See Chapters 5.3.1 and 5.3.2 for more information.

There are many existing standards, references and practices that the NBIM Standard will adopt and/or harmonize rather than creating from scratch. Chapter 2.2 introduces the NBIMS Committee's approach to working with other organizations and standards. Chapter 5.5 provides an introduction to Reference Standards and then Chapters 5.5.1 and 5.5.2 describe two specific Reference Standards that the NBIM Standard proposes to incorporate. Chapter 5.6 discusses Normative Standards which are specific guidance that must be followed if claiming compliance with the Standard and Chapter 5.7 presents Implementation Standards which are requirements that must be met in the implementation of Standard information exchanges.

The NBIMS Committee has already begun to establish relationships with educational institutions and some have signed the Charter. NBIMS sees education of both practitioners and implementers, which is discussed in Chapter 5.2, as critical to the success of industry transformation. Research and development in all aspects related to the facility lifecycle will both contribute to the definition and implementation of exchanges as well as benefit from the structure and functional capabilities the Standard will provide.

The role of software developers is symbiotic with both the NBIMS Initiative and NBIM Standards. Although NBIMS will not create software, the relationship of NBIMS to software developers permeates the entire initiative and is discussed throughout the document.

Conclusion

For many, the NBIM Standard Concept Diagram will be a very significant image as it represents the high-level relationship and workflows between NBIM Standard production components and relationships between these components and other aspects of the NBIMS Initiative.

Chapter 5.2 Testing

Introduction

Testing is a critical issue for the acceptance of the National BIM Standard and BIM in general as it provides the users a way of reducing risk that something may not function as expected. At the same time it provides standards for which vendors can test and validate their products. This approach not only involves testing the parts that go into a BIM but also the NBIMS itself and the entire BIM process based on the open NBIMS approach. The NBIMS testing strategy takes advantage of the Open Geospatial Consortium Test Bed approach which has already validated their approach on a related aspect of NBIMS – the important CAD-GIS-BIM interoperability thread. The NBIMS testing plan also uses IAI/ISO capabilities planned or in place wherever applicable. Significant effort is still required to put this comprehensive plan in place, but Table 5.2-2 provides a vehicle for seeing all the currently known testing requirements and known or potential coordinators for completing the different areas.

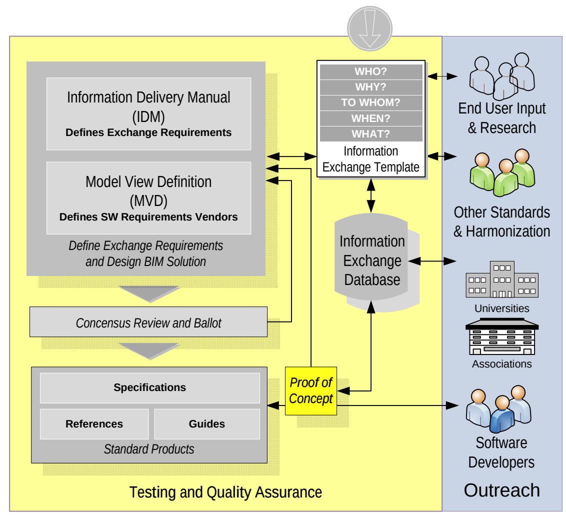


Figure 5.2-1 - NBIM Standard Best Practices, Consensus, and Verivication Testing
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

Background

The objective of the NBIMS and embedded IDM Initiative is to take the next step in technology infusion to transform the building supply chain through open and interoperable information exchange. This will be accomplished by defining and testing an open information exchange standard that can be implemented on projects with the dynamic team membership typical of the broader United States real property industry. In this standard, the group of stakeholders in the BIM discussion is referred to as the Architect/Engineer/Constructor/Operator or Owner (A/E/C/O) community. The exchange standard needs to meet the future needs of a more streamlined A/E/C/O community while building on existing best business practices for more successful assimilation into existing protocols. In order to maximize BIM effectiveness at the tactical or technical level, Information Delivery Manuals (IDM) will be employed due to their capability to: define the processes within the A/E/C/O project lifecycle for which users require information exchange, specify the IFC capabilities required to support these processes, describe the results of process execution, identify the actors sending and receiving information within the process by role, ensure that definitions, specifications and descriptions are provided in a form that is useful and easily understood by the target group, and encourage solution providers to provide guidance on how their software applies and uses IDM principles.[21]

[2] Information regarding IDM comes from the NBIMS Scoping Group Chair, Ms. Dianne Davis, and is discussed in detail in Section 4.1 of this document.

This section primarily describes how testing will be accomplished regarding the NBIMS in concert with the processes defined by the IDM in the Development Phase. Therefore, the testing discussed here matches the terminology in the Development section and will be accomplished in 3 phases: Pilot, Consensus and Operational; and these phases are described below in more detail. However, in addition to the **processes** and **products** testing discussed here, it is also important to note that **people** should be educated, developed and perhaps tested on the information germane for successful NBIMS implementation. This model would be similar to other organizations, like the U.S. Green Building Council and their LEED initiative.

In all, the NBIMS vision for BIM testing is based on the assumption that **people** (i.e. the users) are the best source of test data as they will be intimately aware of the lessons learned from testing their own BIMs for interoperability and meeting the collective needs of the other stakeholders with whom they achieve daily successes. However, users and leaders in the A/E/C/O industry will also be well served by other independent testing efforts to leverage best business practices on a larger scale. After proper, macro-level testing of the tenets of the IDM methodology on a national scale, exchange standards developed in the United States can be converted to support taxonomies and normative standards from other parts of the world. However, successful American BIM evolution requires that the overarching development of BIM proceed in a spiral manner, structured by segmenting testing approaches into the three phases below and accomplished iteratively as new ideas and approaches are created, tested, implemented, and improved.

Relevance to Users

This is an important section for those attempting to ensure that their BIM processes and products are sustainable. Once existing business procedures are refined and information exchanges are developed, they must be validated as truly representative of best business practices. In the future, there will need to be a process in place to voluntarily certify a BIM for compliance with this standard, and desirable to have a system in place for accrediting individuals on the tenets of the NBIMS. In any event, it is critical that the standards are followed if various stakeholder data sources are to be truly sustainable. If information is stored in a standard format, then it can be refreshed as new versions of standards emerge. However, this section builds off the standards established in the rest of this document, and codifies the process the NBIMS Testing Team will use to test BIM processes, products, and professionals in concert with the standards promulgated elsewhere in this document.

Relevance to National BIM Standard

Adherence to strict standard is necessary to ensure that machine readable formats can be effectively used. Errors must be identified to the receiving computer and to the user. This is accomplished through extensive testing of the parts as they are developed and then continuous testing as interfaces are exercised. There are many levels of testing and those are identified in this chapter.

Discussion

A comprehensive testing strategy has been developed for taking advantage of international development and testing efforts by IAI and ISO as well as other proven approaches such as those of the Open Geospatial Consortium (OGC) Testbed. It is critical that accepted approaches are implemented throughout the testing process. If accepted open approaches are used where all interested parties have an opportunity to participate and voice their opinions, a solid product will emerge that will be sustainable over the life of the NBIMS. The advantages of this approach can be seen with many products in use today. In fact it is almost expected and second nature that if you buy a device from any manufacturer that it will interface with something already installed (e.g. the example of a hose being able to connect to the water spigot on your house). There are certainly a lot of instances where competing products have caused major problems such as the Beta – VHS tape issue. That was an example of a vendor de-facto standard in a competitive market place. The converse of that is the CD-ROM which is an international standard. Not all standards have lasting impact on the market, and nowhere is that more evident than true in the world of Information Technology (IT), further demonstrating why it is even more important to have standardization and to ensure that our processes follow open standards that can be validated against those standards. If you are following a standards-based approach, there is a much higher chance that an interface from a previous standard is available to allow one

Table 5.2-2 - NBIMS Testing Strategy Matrix

NBIMS Testing Strategy		Business Process Identification Best Practice	Technical Development Pilot Test	Consensus	Technical Validation	Operational Testing
Description		Information exchange and business process workflow modeling	Testing the business processes developed in a controlled market test	Using a formal and recognized process to obtain industry acceptance of the proposed best practice	Taking proven business processes to industry for consensus to become a standard practice	Testing the product with various vendor products to ensure reliability and repeatability on a continuing basis
IFC / IFD	Methodology	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
	Schema Testing	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
	SME Testing	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
	Program Interface Verification	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
IDM	Methodology	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
	Schema Testing	NIBS	NIBS	NIBS	NIBS	NIBS
	Exchange Interface Verification	NIBS	NIBS	NIBS	NIBS	NIBS
	BIM Population	NIBS	NIBS	NIBS	NIBS	NIBS
	Information Delivery	NIBS	NIBS	NIBS	NIBS	NIBS
MVD	Methodology	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO	IAI / ISO
	Views	NIBS	NIBS	NIBS	NIBS	NIBS
	Information Delivery	NIBS	NIBS	NIBS	NIBS	NIBS
Interoperability	Non-IAI information	NIBS	OGC TB	NIBS	OGC TB	OGC TB
Data Standards	Information Sustainability	NA	OGC TB	NA	OGC TB	OGC TB
Tools & Solutions	Product functionality	NA	OGC TB	NA	OGC TB	OGC TB
CAD-GIS-BIM	Thread testing	OGC TB	OGC TB	OGC TB	OGC TB	OGC TB
Education / Training	Common curricula	NIBS	NA	NIBS	NA	NA
User Certification	User preparation	NIBS	NA	NIBS	NA	NA

Return On Investment	Business case	NIBS	NA	NIBS	NA	NA
NBIMS	Version 1 - Part 1	NIBS	NA	NA	NA	NA
	Version 1 - Part 2	NIBS	OGC TB	NIBS	OGC TB	OGC TB
	Ver. 2 & Future versions	NIBS	OGC TB	NIBS	OGC TB	OGC TB
BIM	NBIMS Compliance	NA	OGC TB	NA	OGC TB	OGC TB

Key:	
Capability exists and testing approach in place	
Planned testing area, but either application or plan not ready	
Not planned or not applicable	

to use old information using a new standard. The table above describes the various items to go through the processes described below. In general the approach is to first document the business practice, or process. This is true for business processes described in information exchanges between parties in the capital facilities industry which manifest themselves as IDM as well as this standard itself. We are currently describing our approach and concept and then portions of that will go to consensus. Once we have concurrence that this is an accepted approach then pilot programs will be written to ensure that the accepted business can be programmed and meet the intent of the business process. Then we need to incorporate those best business practices in commercial software. There will be continual updates and those will need to undergo a change management process.

Business Process Identification / Best Practice Phase

The first step of testing is to identify the business processes that are viable to be tested, in other words, creating an approach for successful execution. This is typically accomplished by a group of subject mater experts assembled for the purposes of creating an approach that others will see as generic enough for their usage yet detailed enough to provide all the functionality needed to accomplish their task. We have seen this in the accounting systems that many small businesses use today. Initially there were systems developed in-house or very expensive customizable systems developed for tens of thousands of dollars. Eventually, Intuit QuickBooks was developed and instead of spending tens of thousands of dollars a firm could spend $299.95 for the QuickBooks Pro Premier Edition 2007 which provides far more functionality than the systems of the past. We see similar improvements possible in the area of BIM by all working together on improved business practices.

Consensus Phase

Once an approach has been developed and documented it then goes out for industry consensus. It is important that an established approach be followed to ensure that a wide spectrum of users are heard from and that all the comments and changes have been considered and incorporated of formally rejected as not be required or appropriate. This process does take some time but provides a solid product that can be used by a significant number of users. NBIMS is going through that process currently with several products such as COBIE. It is felt that best business practices have been captured and are included as Appendix B of this document. The next step which will be accomplished in Part 2 of NBIMS will be to take it through the NIBS consensus process. This consensus process was chartered by Congress in NIBS establishing legislation. There are other recognized consensus processes. In the United States many standards efforts go through American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) to reach the International Standards Organization (ISO). The Open Geospatial Organization (OGC) also has a recognized standards process and has created many ISO standards. In the case of NBIMS it is the implementation in the United States of the BIM process and is primarily a standard of standards. However, NBIMS is also working to fill in the missing pieces to a comprehensive BIM concept where either no consensus standard exists or a de-facto standard exists that has not gone through a recognized consensus process. The NBIMS Executive Committee is in the process of setting up a Consensus Task Team specifically for this purpose.

Technical Development / Pilot Phase

During development, leading up to the "pilot phase," software vendors or independent organizations such as the International Alliance for Interoperability (IAI)[22] should accomplish bench tests where they export known data from real projects completed using their software. The data files created will be shared with the NBIMS development team and other vendors for the purpose of testing. As part of this bench test vendors will also document the value proposition associated with the use of the pilot exchange standard compared to previous business processes. Vendors will identify which of the pilot project data elements are supported and to what level the information is provided in external references or in appropriately defined data. After initial errors are noted and corrected, the next step will be to exchange facility information via the most up-to-date Industry Foundation Classes (IFC) version[23]. Note that the Construction Specifications Institute's (CSI's) *OmniClass*[24] standards will be used as the default taxonomy if the stakeholders of a given information exchange do not have a standard taxonomy that is already applicable for that community. After this is accomplished, pilot testing will be accomplished to test the validity of the information exchange in the context of real projects. Results from these case studies will inform updates to the pilot standard that will be documented by the NBIMS Joint Development/Testing Team in a document entitled the Pilot Test Report. During the pilot phase the testing team will request that software vendors document their ability to support each of the data elements in the exchange standard and document their interoperability in line with the Capability Maturity Model (CMM) discussed elsewhere in this standard. Automated file comparison programs will be used whenever possible. Finally, an open flow of communication will be enhanced by national membership and partnerships in and with international organizations such as the International Alliance for Interoperability. Some examples of the concise and valuable data gleaned through their studies can be seen in the Appendixes to the NBIMS.

Technical Validation Phase

The Technical Validation phase is essentially another consensus process for evaluating vendor implementations of standard business practices. During the Technical Validation phase, data format and exchange processes will be standardized through independent software testing according to an algorithm that will later become the Quality Assurance plan for software vendors

[22] See IAI Document, "IFC Exchange Guide between 3D CAD applications, April 2006" from the IAI Forum, Denmark in the Appendixes of the NBIMS for more information
[23] For the most up to date IFCs, go to the following website: http://www.iai-international.org/

[24] At publication, the website for CSI's Omniclass standards could be found here: http://www.csinet.org/s_csi/sec.asp?CID=1369&DID=11262

to later follow and achieve BIM compliance. The data and the processes will be standardized according to future A/E/C/O community need and existing best practices.

Operational Testing Phase

There will be a two-pronged approach to testing in the operational phase: independent research and industry stakeholder testing. The majority of the testing will be accomplished in the operational phase, as more and more is known about BIM and how best to leverage its potential. Although testing under different industry "site" conditions may be more difficult to control than the degree of control possible to achieve in independent research, the primary testing will be accomplished by the stakeholders in the A/E/C/O industry due to their overwhelming amount of knowledge gained from day-to-day, real-world lessons learned. It follows that it is the current stakeholders who will guide future stakeholders to ever-changing best practices. While there are few other reliable approaches that can replicate the reliability and complexity found in real-world industry testing, this "in-situ" approach also has its problems. Comparison and generalization from individual results may be conditional on mitigating the variations between differing test conditions. In some cases, more easily controllable test beds would provide reliable test data. Conversely, in test beds, replicating the complexity of real world conditions would be very difficult. However, it will be important for maintaining generalized lessons learned from the data they produced by both independent and industry testing.

Additionally, it will be crucial for an existence of an easy and open avenue of education and communication for the NBIMS in the operational phase. This flexible communication and education medium will require affiliation with as many organizations and individuals as possible in order to collect all the data that will be necessary to improve processes for future versions of the NBIMS. There will be an entirely multi-media approach to educating, certifying field BIMs, and receiving feedback on the NBIMS for analysis, synthesis, and application to future versions.

Operational compatibility should be maintained on at least a rolling 5-year basis.

Conclusion

The purpose of the National BIM Standard Committee is to knit 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. A BIM should access all pertinent graphic and non-graphic information about a facility as an integrated resource. A primary goal is to eliminate re-gathering or reformatting of facility information; which is wasteful. The NBIMS seeks to improve business functions so that collection, use and maintenance of facility information are parts of doing business by authoritative sources and not separate or wasteful, redundant activities. Therefore, testing must be accomplished to ensure all these requirements are being met, and hopefully, surpassed. The goal of the testing team is to facilitate the evaluation of projects in the pilot, consensus, and operational phases. This will be accomplished by processes outlined above.

Overall, NBIMS testing will best be accomplished by knowledgeable individuals in the BIM field on a daily basis. However, where opportunities exist for leveraging economies of scale for wide scale testing, the NBIMS Testing Team will require significant resources to take on this requirement. As both a summary and look-ahead with regard to testing, the NBIMS Testing Team commits itself to the following ideas:

1. Technical or "tactical" level testing

   a. Standards-based testing – For examples of IFC-standards driven testing, like EPM EXPRESS Data Manager (Licensed) or the IfcObjCounter (Freeware)[25]
   b. Interoperability testing – Using the OGC approach, the testing team can focus on only using things that are already out there and seeing what happens when data is shuttled "round trip" between interfaces by assembling various systems/applications together, posing a problem and seeing if the participants can execute the exchanges required, as well as seeing where opportunities exist within currently available software platforms for development.
   c. Requirements-driven testing – These will be complete as requested/funded for future development.

2. 'Labeling'
   a. Compatible – Applications are 'compatible' with NBIMS standards. Look at methods and results but doesn't require exhaustive hands-on testing in test-bed situations. Quicker, less expensive.
   b. Compliant – Uses tools identified in item 4b above to do full and independent review.
3. Oversight and Quality Assurance of NBIMS process
   a. NBIMS is evolving a new process and just like a factory, NBIMS needs for that process to be well defined, efficient, reliable, and producing a high quality product.
   b. The results of NBIMS development will be matured cyclically and the selection of candidates for maturing, cycles of review, maintaining consistency while evolving will all require QA controls.

Next Steps

This is the inaugural version of the creation of the NBIMS and parallel inception of the NBIMS Testing Team. More than providing current test data, per se, it creates a framework and a process for comprehensive testing. However, data is being added to the "body of knowledge" every day and much work remains to be done in order to mature it to a fully up and running process with tangible products. The following steps are required to take it to the next level:

- Current partnerships must be nurtured with existing testing organizations like the IAI, NIST, OGC, OSCRE, CSI, USACE, GSA, Coast Guard, and the myriad of other organizations that could be listed here to publicize existing testbeds that provide people with the right information.
- Additionally, new partnerships must be formed on technical levels for day-to-day operations and more tangible benefits for the BIM technicians who so desperately need checklists or manuals on "what to do next." These may be more difficult because of traditional divides between job descriptions or geographical separation across oceans. It is the goal of the NBIMS committee to serve as the central nervous system that will turn these divides into metaphorical "synapses," bridging the gap with the electronic, rather than electric, transmission of important and urgent information.
- The administrative shape of 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, as well as providing a

[25] For more information on these two applications, see EPM EXPRESS Data Manager (Licensed): http://www.epmtech.jotne.com/products/ or IfcObjCounter (Freeware): http://www.iai.fzk.de/english/projekte/VR-Systems/html/Download/Softwa

means and motivation for users to create reliable information that is stored in open and interoperable formats.

Chapter 5.3 NBIMS Requirements Definition

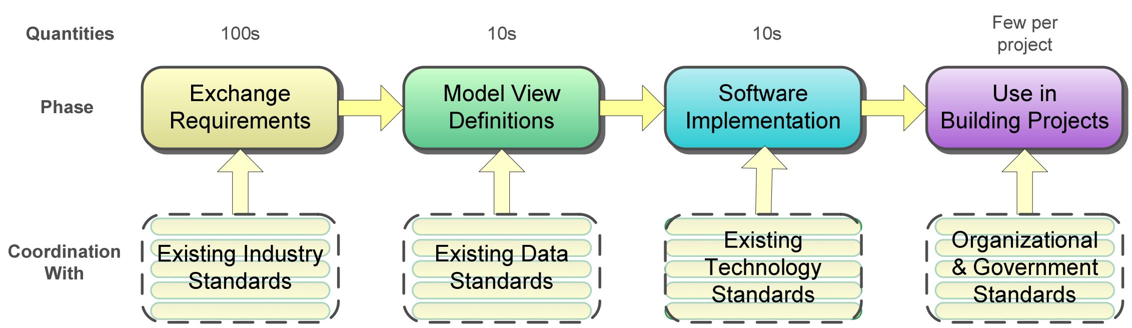
Introduction

Requirements in the NBIMS standard will be driven by BIM based updates to standard processes in the building industry and the information exchanged between project participants in these processes. The NBIMS Scoping and Requirements Definition teams will work with industry to identify and document these requirements using the Information Delivery Manual (IDM) process and toolset developed by the international IAI and buildingSMART alliances. These requirements will then drive design of a BIM subset (called a View) that includes all of the required information. The NBIMS Models and Implementation Guidance team will develop this BIM View and associated specifications using the Model View Definition (MVD) process and toolset developed by BLIS Consortium and IAI. These specifications will enable software companies to build support for the View and associated building industry processes in their products. When these products are released, building industry professionals will be able to migrate to the target BIM based process updates and realize the competitive advantage that BIM based projects promise.

End User Processes and Requirements

The primary driver for defining requirements for the National BIM Standard is industry standard processes and associated information exchange requirements. The NBIMS Scoping and Requirements Definition teams will facilitate identification and documentation of these processes and information exchange requirements. These requirements will then be used as the basis for defining the NBIMS standard models and implementation specifications. These specifications will provide software companies guidance for implementing support for the standard in their products which, in turn, enable end users in the building industry to use the standard in practice.

This process, from requirements definition through use of commercial software can be summarized in a high level flow diagram as follows:



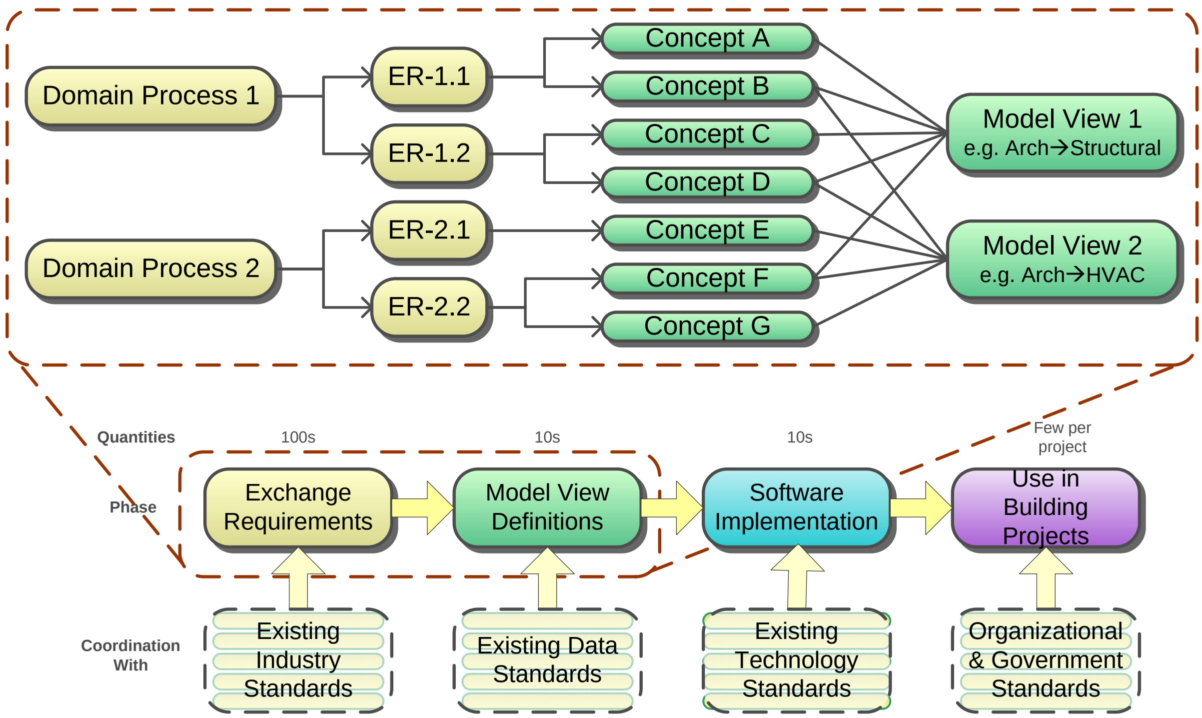
Note that at each stage of this development process, coordination with existing standards is planned. It is also interesting to note the quantities of each deliverable that are anticipated. Ultimately, there will be hundreds of Exchange Requirements. These will be grouped into 10s of Model View (or BIM) definitions to be exchanged between target applications types or professional domains, for a particular purpose (please see the next chapter).

The Norwegian chapter of the IAI and buildingSmart initiatives has developed a process and toolset for defining requirements for “contracted data exchange.” This was an important development as the resulting documents are much more specific about what data will be exchanged between which stakeholders in a project at specified milestones in the project. It is the intent of the Norwegian building industry to reference such requirements definitions in building project contracts.

The NBIMS committees have decided to use an adapted form of the IDM processes, tools, and formats to define requirements for the NBIMS standard, in part because they are in use in multiple other countries (which will make international collaboration easier), and in part because it is a good toolset for this purpose. Background information on IDM and the NBIMS adaptation is described in the next section.

It is important to understand the fit and flow between requirements definition (defined using IDM) and BIM solutions design (defined as Model Views in the chapter 5.4).

As described above, many exchange requirements will be addressed in a single Model View – as shown in the following expansion of the development flow diagram introduced above.



NBIMS Information Delivery Manuals (IDM)

A good deal of background information about IDM can be found on the IDM web site[26].

Identification and prioritization of industry standard processes to be documented using IDM will be driven by the NBIMS consensus process.

NBIMS IDM Development Process

The NBIMS teams will use most of what is defined in the standard IDM process, tools, and formats, but will also enhance the IDM toolset with a few tools being developed now. These are:

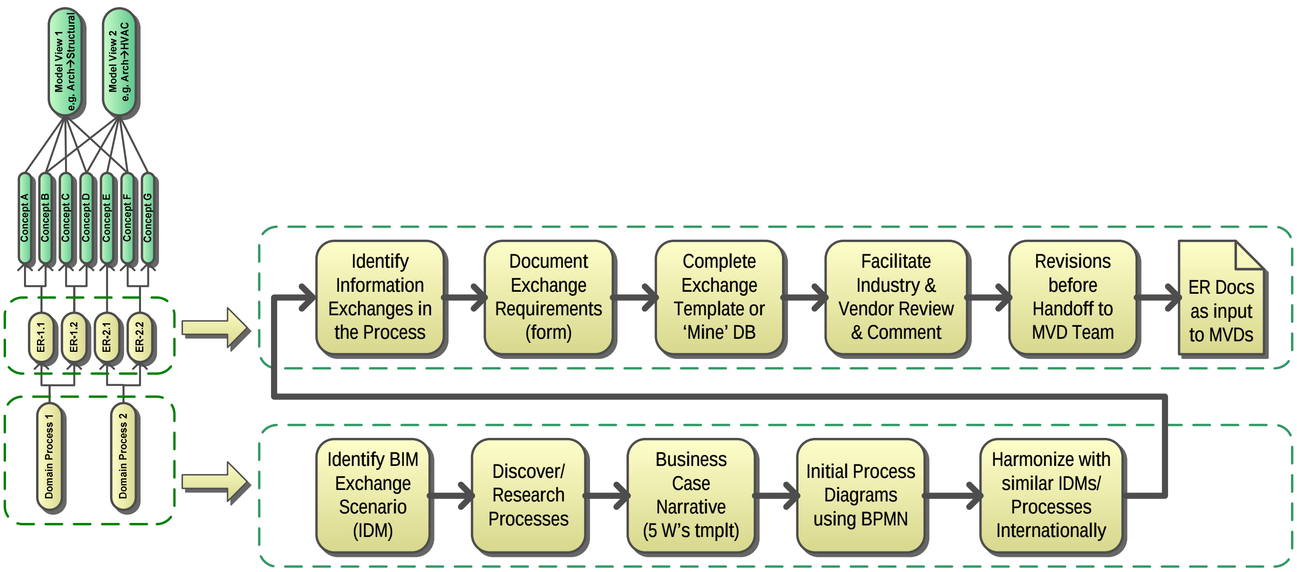
- The Business Case Narrative Template

[26] http://idm.buildingsmart.no/confluence/display/IDM

- The Exchange Template
- The Exchange Database

All of these are described in sections 5.3.1 and 5.3.2.

NBIMS IDM will be developed using the following process (expanded from the IDM-MVD diagram above):



Identify BIM Exchange Scenario – Scoping and Requirements Definition teams to work with industry organizations to identify and prioritize BIM exchange scenarios for development into IDM.

Discover/Research Processes – Industry collaboration to ensure identification of a process that truly meets the industry needs.

Business Case Narrative – complete the standard document defining the Who, What, Where, When, etc., as defined in chapter 5.3.1.

Initial Process Diagrams using BPMN – develop an initial process map (multiple inter-related process diagrams) that completely describe the scenario and all information exchanges.

Harmonize with International IDM/Processes – international collaboration activity to ensure maximum alignment of processes being standardized for the US industry, with those being defined in other geographies. After all, the building industry is global!

Identify Information Exchanges – identify all the points in the process map at which one project stakeholder passes information to another.

Document Exchange Requirements – use IDM standard templates to define detailed data requirements for each information exchange in the target process.

Complete Exchange Template or 'Mine' Exchange DB – use the NBIMS Exchange Template or mine the Exchange database to find an existing exchange that will meet the information exchange requirements defined in the previous step.

Facilitate Industry and Vendor Review & Comment – Scoping and Requirements Definition will ensure a broad industry review to validate the IDM definition before it is submitted for inclusion in a Model View.

Revisions before Handoff to MVD Team – final adjustments to the Exchange Requirements definitions being passed to the MVD development team.

Requirements Defined as Exchange Requirements (ERs)

The Exchange Requirements definitions serve as the requirements definition for the Model View Definition team. As described in chapter 5.4, this team will develop a BIM model View to satisfy these requirements.

International Coordination

As described in the fifth step in the development process above, the NBIMS teams will coordinate IDM development with other similar development in several other countries. This will maximize the alignment of BIMS being used through the global building industry. The Norwegian IDM team is developing an online repository for international IDM definitions to support this coordination.

Version 1 IDM

As 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 IDM included in this part of the v1 standard. IDM will be developed for part 2, which will define the v1 standard.

Next Steps

Next steps for development of NBIMS Requirements for the version 1 standard include:

- Identification of IDM to be included (some candidates are included in the Appendices to this document)
- Development of v1 IDM as defined above
- Validation through industry review and comment (both end user organizations and software vendors)

Chapter 5.3.1 NBIMS Information Exchange Template

Introduction

The NBIMS Initiative seeks the broadest participation in its development activities.

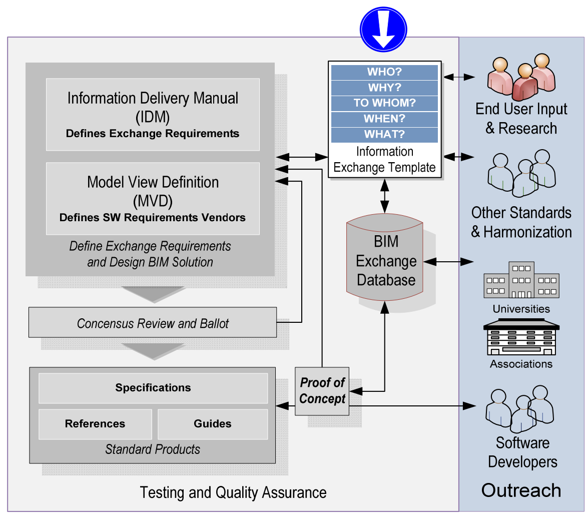


Figure 5.3.1-1 - NBIMS Initiative - Information Exchange Template
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

Internet based tools such as the Information Exchange Template will be used whenever possible to connect with industry professionals and include their knowledge in the effort while helping the industry use standards in their BIM implementation. This will help create the broadest consensus on the National Building Information Modeling Standard (NBIMS). Second, the use of an Information Exchange Template will begin to address the longstanding and fundamental issues of information standardization, use, and sharing within the construction industry process which has been identified as costing society $15.8 Billion due to a lack of information interoperability.

Teams may use the NBIMS Information Exchange Template free of charge on the NBIMS website. Its use provides a standardized way of requesting BIM centric information for projects and internal BIM implementation. The template will be available in the 2nd Quarter of 2007 and will have a print-out and commenting capability for users. The data captured through template use will better inform the NBIMS technical committees, industry stakeholders and software solution providers of BIM information requirements for implementation within the Capital Facilities Industry.

Background

The industry is constantly asked to share better information with an ever expanding set of stakeholders. Understanding what information is needed when, why, and in what form to best serve the current and lifecycle needs of the project or activity are mandatory if we are to gain the productivity increases seen in other industries.

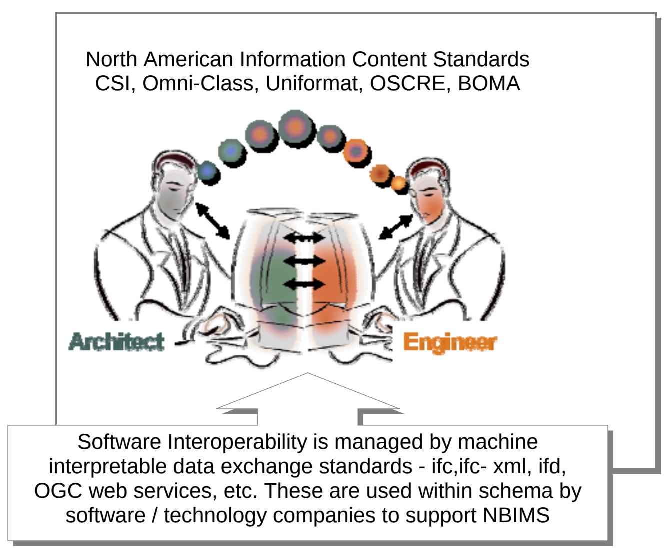


Figure 5.3.1-2 - The Basis of Information Exchange
(Courtesy of AEC Infosystems)

The NIST report estimated a $15.8 Billion yearly cost to society due to poor information interoperability within the construction industry. This report highlighted fundamental issues in the current industry's IT and information sharing processes.

As the construction industry matured through twenty years of CAD and IT use there was an increasing focus on the application format as a “quick fix” to information sharing and collaboration rather than the development of data interoperability and content normalization to manage the growing issue of integrated team collaboration within an enterprise IT environment for project execution. Even with the mandating of single solutions, teams continued to have information fragmentation.

Using the same software application does not guarantee seamless sharing of information. If the content is not normalized there will be problems exchanging information. Costly mapping, data re-creation and other non-value added tasks waste resources time and introduce errors into the process impacting productivity. Time is spent on these activities and costly Requests for Information clarifications rather than adding expertise and value to the project solution.

The NBIMS scoping group identified these root inefficiencies, reviewed the AIA discussion on Request for Information needs and the legal issues arising from current outcomes. The Information Exchange Template and Standards Harmonization activities of the NBIMS Initiative are outcomes of this study. These activities will benefit the industry today and significantly accelerate the Information Delivery Manual process (IDM) which is the basis of information exchange and model view development of the NBIMS. In countries where this methodology has begun, higher productivity and an accelerated use of BIM can already be seen.

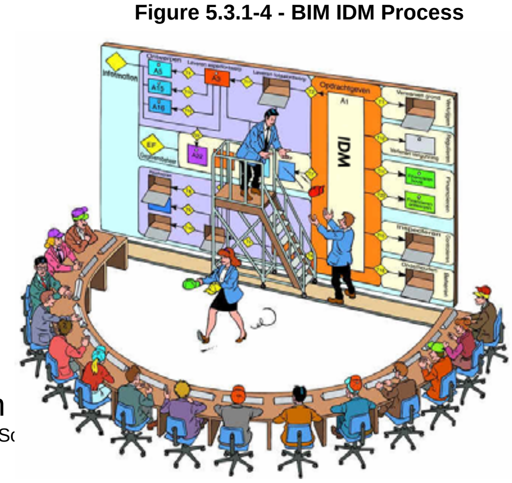
The NBIMS Initiative seeks to remedy current information fragmentation issues exacerbated when proprietary formats are the focus of data sharing vs. the implementation of interoperable data based upon well understood workflows, open standards and content requirements.

Relevance to the User

Figure 5.3.1-3 - Current Paper Centric Process

In today’s project execution and management environment one measure of an activity’s success is the participant’s ability to share information and exchange knowledge. The sharing of information and knowledge requires communication. Reading this page requires the use of communication standards set by the English language. Information shared through language and the human interpretation of lines, arcs, circles and text in CAD have formed the functional paper-centric basis of our current information exchange process.

Figure 5.3.1-4 - BIM IDM Process



From a business case view information exchanges have sometimes been considered intellectual property, which is counter-productive to owner and industry collaboration. While the content of an information exchange (the design or cost of a window) may be considered intellectual property or proprietary to a company the schema and mechanism for sharing this information between team members should be open and well understood so that time is not wasted on re-defining information sharing with each new activity, project and teaming.

The Building Information Model as process, product and IT enabler of a collaborative workflow environment is changing what, when, why, how information is shared by teams and between software applications.

Mapping to different team's CAD standards has already consumed a vast amount of industry resources. BIM with its basis of information sharing and knowledge capture will indeed be costly if it is done company by company with internally developed standards. In order to reduce the immediate and long term cost of BIM implementation the NBIMS Initiative is developing this web-enabled information exchange template supporting more standardized communication among industry teams using BIM.

When used this information exchange template can form the basis of a referenced standards based request for BIM information that can be useful as a basis of project communication reducing the cost of sharing BIM information and reducing the risk of miscommunication.

Relevance to the National BIM Standard

The Information Exchange Template is the NBIMS user interface for broad industry participation in the NBIMS Information Delivery Manual Process (IDM). IDM is the international process to standardize and make ready for software development the business case and the Who, To-Whom, What, When, Why, and How information can be shared by interoperable software packages to support information use and re-use in the facility lifecycle. This is the foundation of true interoperability supporting an enterprise and collaborative use of information in the industry.

The template standardizes what we know we can standardize today and gains feedback from the industry on current best practices. It provides a combination of building data aligned to intelligent digital object representations of building elements which will be made machine interpretable through IFC exchanges.

Consensus on the information exchanges and workflows within a transparent BIM process will unleash the collaborative capability of industry professionals to design and manage a better built environment with a better informed decision process and more cost effective and risk adjusted methods of project delivery.

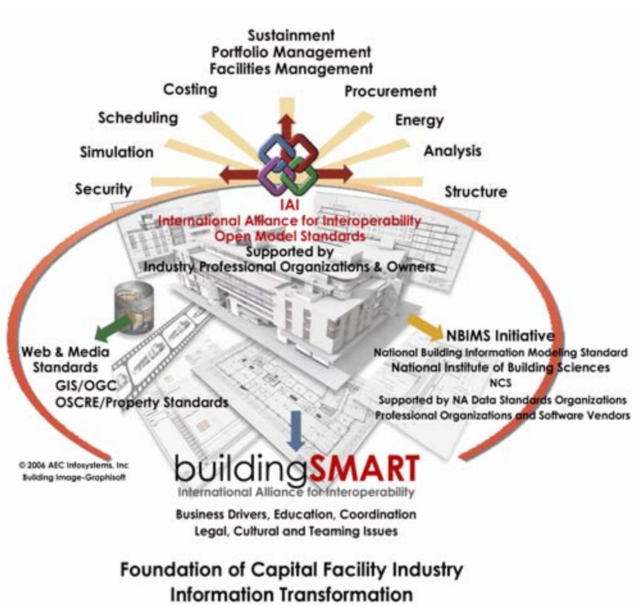


Figure 5.3.1-5 - buildingSMART construct (Drawing courtesy of AEC Infosystems and Graphisoft)

The North American Information Exchange Template

The purpose of an Exchange Template:

1. Provide a template that can be used by teams today to develop a transparent and repeatable BIM based Request for Information (RFI) that has value in supporting current BIM implementation. The template would be accessible via the NBIMS website

and be a printable product for use by all. Make any template easy to understand and use and of equal value to the technical teams.

2. Align needed North American data standards to BIM (IFC) elements and support current “best practices” of data aggregation for specific BIM elements. For the US and North America these would include CSI (*OmniClass* and *UniFormat*) NIBS, National CAD Standard (graphics and layering that is applicable to BIM) OSCRE (Real Estate) ASTM, etc. Ex. *OmmiClass* classifications for “roles,” building systems, and project phases.

3. Identify the authoritative data standards groups used within the template to facilitate data awareness and normalization across all parties. Identify the conflicts and gaps in North American information Standards that might inhibit IDM and BIM development.

    a. Where harmonization is necessary for better BIM use, NBIMS along with other industry organizations and stakeholders will support this activity. Ex. Harmonization of space standards and naming conventions between ANSI, BOMA, IFMA and the various “flavors” of these standards used by specific organizations.

4. Create the template as a database that can be mined for consensus and data sets informing the technical committees of industry data needs in a faster and more cost effective manner.

5. The NBIMS IDM and Model View teams will use these user defined exchanges as raw information to develop consensus driven IFC schemas for software development and certification. This consensus will be driven by NIBS, the signers of the NBIMS Charter, buildingSMART and including IAI, AIA, AGC, CSI, OSCRE, FIATECH, CURT, and numerous government agencies

The *Scoping Activity of IDM* represented by the North American Exchange Template is the activity that is most useful to the user or project delivery team. It identifies the information sets needed to support Building Information Modeling (BIM) within an Integrated Practice/Project delivery method.

The *IDM* is the background work by the professional communities of practice, i.e., architects, planners, engineers, contractors, facility managers, etc., that forms the basis of a more formal *Contracted Exchange* which can be written into a project delivery and requirements document.

Figure 5.3.1-6 - BIM Collaboration
(Drawing courtesy of Onuma Design)

This information is useful in three ways; (1) It forms a basis of information understanding and sharing within the team needed to support effective and efficient project execution and delivery in a BIM based process for an AECO (architecture, engineering, construction, operations facilities) project. (2) It forms the basis of a more formal Contracted Exchange which can be used within a project delivery method document. (3) It identifies and outlines the datasets needed by software developers to support these processes within applications that are IFC compliant. This allows the software developer to automate the workflows used within a project further streamlining project delivery and management of the built environment.

The Information Template - Who, Why, When, to Whom, and, eventually, How

Though still under development items from the template are presented here to explain how data and methodology are connected in the template. There are two steps to using the exchange template.

Step 1 is to create a narrative about your information need. A business case will always have a minimum of two parties and will have a project benefit and a time frame implied. Once you have your exchange narrative (business case) you are ready to use the template to define the information needed to support your exchange.

Figure 5.3.1-7 - Example of Business Case (Courtesy of AEC Infosystems)

Example of a Business Case Narrative: WHO - of WHOM, WHY, WHEN and WHAT

Background- Jenny (WHO) works as an Energy Analyst for a consulting company. Her services are offered to companies needing energy performance analysis (WHY) of their buildings, both new and existing. One large part of her normal job involves creating a Building Information Model (BIM) suitable for an energy analysis. One day she gets a slightly different request from a company. They request that she use *their model* when doing the important energy analysis. In addition they want one analysis to be performed during design phase, and several others throughout the whole project.

Jenny is concerned about trusting the other companies model as her previous experiences with using other peoples models has shown that the information isn't developed in a way that works for her task. Often she gets models that lack important information and industry standards she'll need to produce reliable results.

However this company has a suggestion. They introduce her to the concept of an Exchange Standard for a *Contracted Data Interchange*. This means that a contract, in addition to the normal clauses can also contain a detailed description of the information the company will be responsible for providing in their BIM as well as a detailed description of the results Jenny is expected to deliver back to the company for each project phase.

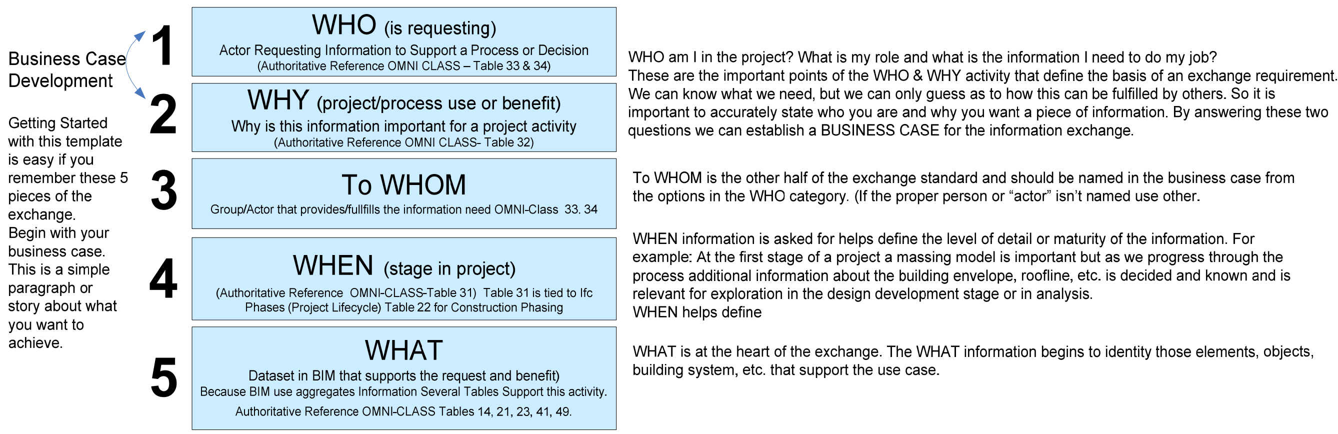
Jenny will use an "Exchange Template" to quickly check off the information she needs to do her analysis. The exchange template will help manage the structure and detail level of the information so that everyone knows what is expected and what the process will be.

As a professional, Jenny knows the information and level of detail she needs for her first energy calculation. She will request information from the architect (of WHOM we want information) working on the model and provide, through the template, a clear definition of the information (WHAT) she needs. She is relieved that she will not have to write out so much of the data standards information as this is already in the exchange template.

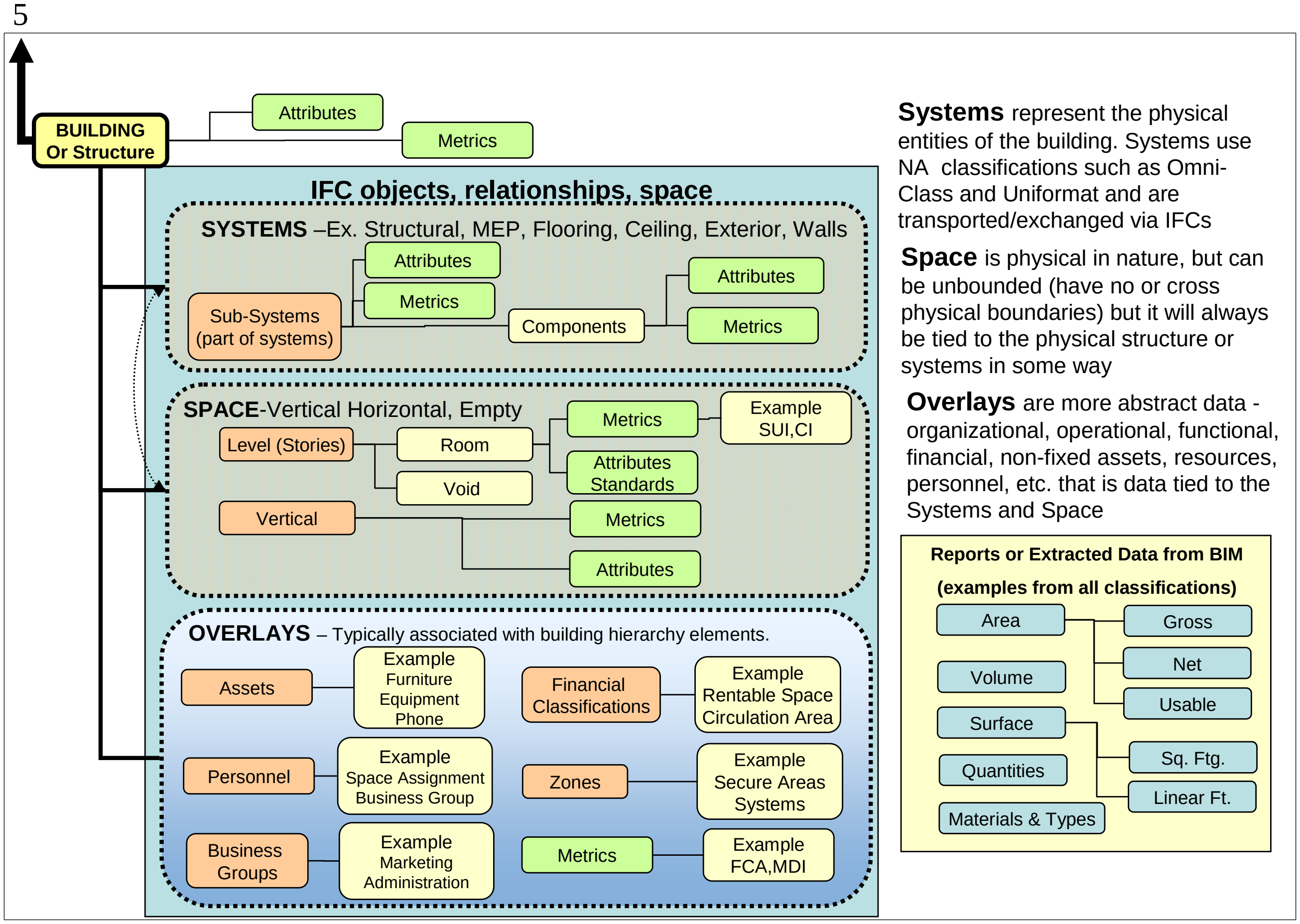
Example of a Business Case Supported by the Information Exchange Template

An understood business case or reason for the information is combined with the print-out from the template and supplies the team information that is useful in communicating BIM based project information. This information needs to align with industry data standards such as CSI, *UniFormat*, *OmniClass*, *MasterFormat*, and International Building Codes. The template group is aligning this information within the template.

Figure 5.3.1-8 - Relationship of Who, Why, Whom, When, and What
(Courtesy of AEC Infosystems)



BIM Hierarchy Supported by the Information Exchange Template



The Information hierarchy of a BIM model is identified in the taxonomies used by the NBIMS. Referenced data standards are used at each level of detail.

Example of "WHAT" data at a building level

This can be used for preliminary planning, massing data assignment, and aggregation of Building Code data for planning. The numbering and naming convention is given so that uniform data can be created as part of the information request. The numbering can be helpful in BIM to transfer information similar to *UniFormat* for costing.

Where information does not meet the needs of the user, empty boxes can be filled in.

Form use and feed back will be monitored and changes will be made to make the form better as suggestions are given.

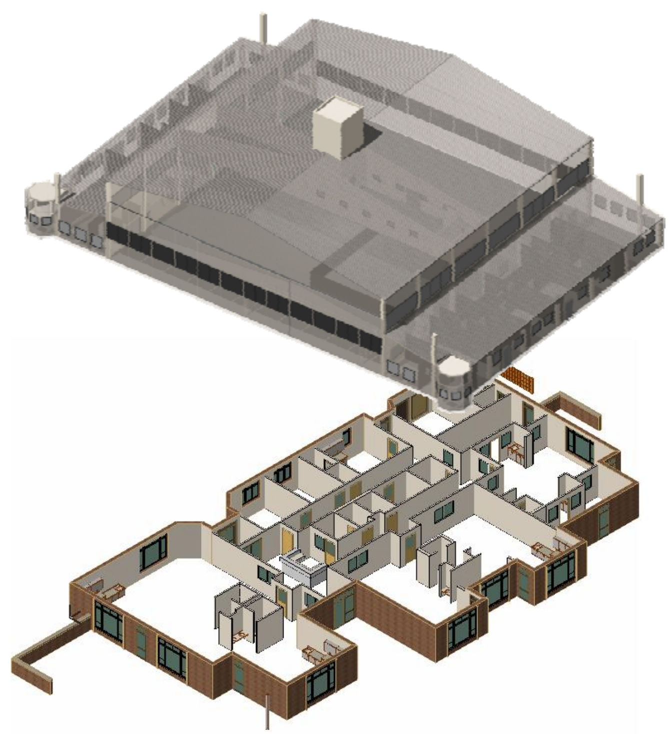
Taxonomies Used in NBIMS Classification

Example of Omni-Class Building Classification Information Commercial Facility 11-17 00 00			
Offices 11-17 11 00		***Mixed-Commercial Facilities 11-17 27 00***	
Headquarter Office 11-17 11 11		Commercial Malls 11-17 27 11	
Regional Adm Office 11-17 11 14		Shopping Centers 11-17 27 14	

Figure 5.3.1-8 - Classification Example
(Courtesy of CSI *OmniClass* Data)

Example of "WHAT" data at an entity/element level

As more is known about the facility more detail is required in the exchanges. More data standards are needed to define the entities in ways that are useful to the BIM process. Wall standards are currently in harmonization as the traditional "Wall type A, B, etc. is not appropriate long term for BIM.



BIM software should have normalized data points for objects and entities supporting data integration.

New Data Types

As an information aggregator, BIM can be used for other types of data in the lifecycle not traditionally considered part of BIM but always a part of a facility lifecycle. These can be reviewed in the lower box in the hierarchies of the BIM taxonomy.

Next Steps

There is clearly a lot of work that still needs to be accomplished in applying the templates to develop the information exchanges but it offers several advantages to current processes. Upon review this methodology is to be incorporated at an international level for other country's IDM efforts.

We will open this effort up to all parties involved to develop IDM in parallel and provide the environment to allow for developing a consensus on the IDM developed using this approach. In that way we will achieve best practices in the shortest amount of time.

Items needing standardization

Standards that the template is based upon are currently under review, and CSI has already begun their *UniFormat* standardization activity with GSA, Navy, and ASTM to better support BIM data integration. Other harmonization activities will continue in parallel with template development. The template itself needs to go through the consensus process.

References and Links

NIST Report
CSI, *OmniClass*

Chapter 5.3.2 Information Exchange Database

Introduction

There are two web-enabled products to be issued supporting the NBIMS. These are the Information Exchange Template and the IDM Exchange Database. The Information Exchange is a mechanism to develop the Request for BIM information between parties. The Exchange Database is the web enabled repository of Information Exchanges and best practice Workflows for BIM Collaboration. It will be available to all interested parties. This information exchange database will maintain the following specific functions:

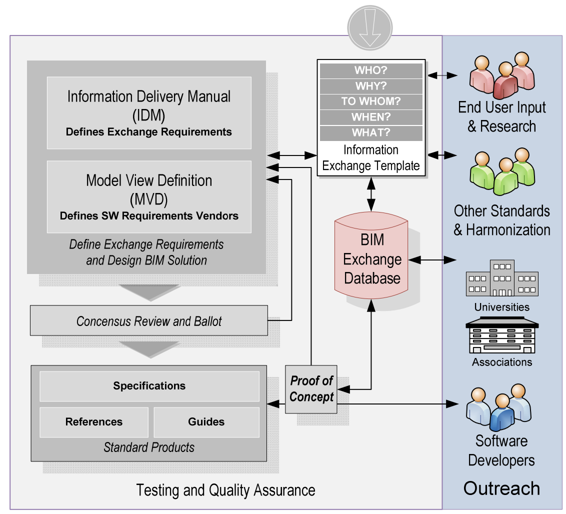


Figure 5.3.2-1 - NBIM Initiative BIM Exchange Database
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

- Retrieval capability of existing information exchanges
- Identification of data standards relevant to BIM implementation
- Identification of information exchanges needed by phase or party
  - Definitions of specific exchange requirements
  - Descriptions of individual functional exchange parts
- Coordination with international exchange standards through the IDM website link
- Updates on data standards and harmonization efforts or needs
- Identification of compatible and compliant vendors
- Current consensus status

Background

Design, construction, analysis and assessment information is costly to create and maintain at any time during the building lifecycle. This information once created has a greater value beyond its immediate project use. This information is needed to manage the assets the information describes. Over the building lifecycle the information about an asset may become more important to the organization than the asset itself.

If this information is not used as part of an organization's workflow or if it must be recreated because of a lack of interoperability then the information is open to error or decay. Once this happens the cycle of information recreation begins again. It is the systemic problem of our current process and a continuous waste of resources.

It is estimated that the US spent billions on the implementation of CAD. Our return on this investment (ROI) is documented in the NIST report showing a $15.8 Billion loss of productivity due to poor data management and a lack of interoperability. Our implementation of BIM, which is much more info-centric, must be done in a different way if we do not want an even higher loss.

NBIMS first activity is to define the workflows and datasets required for BIM implementation. It shall be open and interoperable information for use during a building lifecycle. Workflows are open information sharing activities to manage work in a collaborative environment. These workflows should not be mistaken for intellectual property as a lack of transparency in workflows and data exchanges is counter-productive to a collaborative environment.

The data that is exchanged in a workflow may be proprietary data-such as the cost of an item, but how that information is shared is open, well understood and can be implemented by software applications supporting model views for IFC-costing.

Relevance to the User

Today companies and organizations are exploring BIM use and spending many person-years to define what BIM implementation means to their organization. BIM use in a solitary company does have value but it is in the sharing and re-use of the information that the larger benefits arise both to the professional service provider and the owner.

Ultimately BIM implementation is a “team” activity. Alone, there is a greater possibility of missing data needs and limiting data sharing to a few partner companies. But working together with multiple organizations and more companies there is a reduction of risk, greater efficiencies in the creation of information and more time spent on developing knowledge for data rather than continuous decisions about data.

The information exchange database will allow users to search for standards related to their work segment(s), professional needs and project activities. As members of the Architect, Engineer, Constructor, Operator, Owner communities and related stakeholders identify the types of information exchanges in which they are interested the gap between the information exchange standards currently in the NBIMS and those that need to be developed.

Analysis of these gaps can be used in one of two ways. Those constituents with a pressing need will be able to meet each other and self-organize to begin a new exchange project. A key capability of the information exchange database will be to allow these users opt-in to such efforts.

A second approach to addressing the technical gaps in the NBIMS will be to use the gap analysis to allocate future NBIMS activities of teams already in place.

This provides both a “bottom-up” and “top-down” capability to the NBIMS activity.

Relevance to the National BIM Standard

The issue of industry re-engineering is and many have thought impossible to impact at this level, however the use of web-enabled technologies, databases, the NIBS consensus process and the NBIMS activities aligned to international activities is the right opportunity to define the building lifecycle process in a more cost effective, risk reduced way, guaranteed to be open and available for all.

Another function of the information exchange database will be to capture the context and general content of information exchange standards that are currently under development, in pilot testing, published for consensus, or published as operational standards. As noted in a previous section all projects will be classified according to the stakeholder, the phase of project and other indices.

Finally, for implementers of information exchange standards, the Functional Parts (FP) definition will provide the specific IFC implementation needed for the standard. It is expected that the specific parts of individual ER and their associated FP form a set of building blocks of which additional future information exchange standards could be created. As long as software firms are consistent in their implementation of FP, new exchange standards could be built using previously created FP.

It is expected that a technical specialist acting as a librarian will be available to support the consistent creation and application of ER and FP in the database. Through this database users with specific needs will be able to draw on already implemented standards to produce new data exchanges. The ultimate goal of the NBIMS information exchange database is to facilitate the re-use of ER and FP.

The final portion of the database will allow software vendors to indicate their compatibility or compliance with the related ER. Following the Pilot test phase of an NBIMS standard software firms may self-certify that they meet the requirement of the standard. This self-certification will be referred to in the information exchange database as “compatible” software. “Compliant” software will be software that is tested against an NBIMS standard that has progressed to the operational phase. The body responsible for reporting compliant software has not yet been identified, however, the National Institute of Standards and Technology is a likely organization to organize and or provide independent software certification testing.

Although the information contained in the United States NBIMS, described above, will be hosted through the National institute of Building Sciences (NIBS), the content of the exchange requirements and functional parts will be coordinated with the international database of IDM information. In early 2007 the Norwegian chapter of the International Alliance for Interoperability will be publishing the Norwegian exchange requirement definitions. Since the business processes that drive exchange requirements, and their functional parts, are created based on the business processes required with given national governments, it would be expected that the information shared across countries may not be completely compatible.

Discussion

Many persons would have the industry conclude that this effort is best put in the hands of a single software provider, but in a McGraw-Hill survey in 2006 of industry professionals determined that the software companies could not create the process for the industry. We can also look at our current ROI of CAD implementation and see that format does not solve the issue of content.

Today many people, organizations and groups are working together to create a process workflow with the appropriate data standards to create a structure for collaboration. This is NBIMS, BuildingSMART and IAI. With these groups are all the interested organizations.

Next Steps

Currently NBIMS is working with CSI, IAI, and other groups to define the exchange template. Part of this work highlighted the need for harmonization of standards. This work is moving forward and will be updated through the website.

The websites will be available and have a place for comment.

Items Needing Standardization

Our information classifications of *OmniClass* Tables, *UniFormat*, and IFC Entities definitions, workflows as they apply to the meaning of BIM elements is an important activity that has not been done to date in the U.S. At the same time we need to align what this information means to specifiers, contractors, designers, and owners.

References and Links

The NIST report on the cost to society ($15.8 Billion yearly) due to the lack of information interoperability within the construction industry highlighted more fundamental issues in the industry's IT processes.

Chapter 5.4 NBIMS Models and Software Implementation Guidance

Introduction

The Models and Implementation Guidance Committee will integrate Exchange Requirements (ER) coming from many IDM processes to the most logical Model Views that will be supported by software applications. Globally, there will be hundreds (or even thousands) of ER mapped into tens of Model Views. This will be done at both generic (solution technology independent) and implementation specific levels, using tools and processes aligned with international projects creating similar standards for other countries. Implementation specific guidance will specify structure and format for data to be exchanged using a specific version of the IFC standard. The resulting generic and implementation specific documentation will be published as Model View Definitions (MVD), as defined by the Finnish Virtual Building Environment[27] (VBE) project, the Building Lifecycle Interoperability Consortium[28] (BLIS), and the International Alliance for Interoperability[29] (IAI).

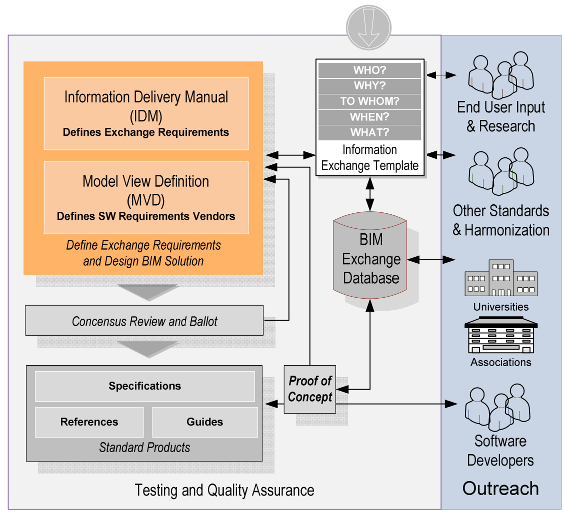


Figure 5.4-1 - NBIM Standard Model and Implementation Guidance
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

The committee will work with software vendors and the Testing committee to plan and facilitate pilot implementations, 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, final updates will be made to the MVD documents for inclusion in the next NBIMS release.

Integrating Exchange Requirements to Create Model Views

As is explained in other chapters, NBIMS makes use of an in some ways attempts to harmonize the use of several existing standards, including information exchange models. Key among these is the IFC data model. It 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 deal with the entire breadth of information in a building information model.

To address this conundrum, BLIS developed the concept of IFC Model Views in 2000. Model Views serve the same purpose as relational database views. They define 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.' In 2001 through 2004, BLIS and the Finnish ProIT[30] project took the idea of model views through implementation in over 60 BIM products and many pilot projects. In 2005,

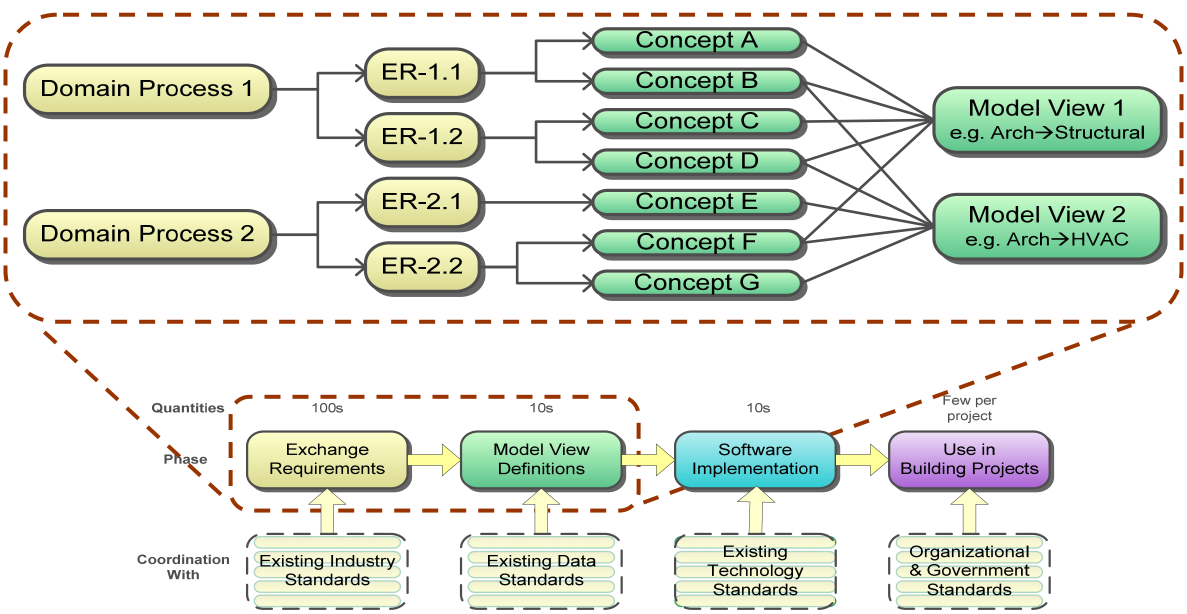
[27] http://cic.vtt.fi/projects/vbe-net/
[28] http://www.blis-project.org
[29] http://www.iai-international.org
[30] http://virtual.vtt.fi/proit

the Finnish VBE2 project and BLIS refined the tools and process for defining Model Views under the name Model View Definition (MVD).

MVD 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 resulting, integrated process and toolset 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 committees are using these tools and process. 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. Where 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 in software.

It is important to understand the many-to-one relationship between IDM exchange requirements and Model Views. Where 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 follows:



Alignment of Model Views to application types is driven by pragmatism. One of the important considerations 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.

NBIMS Model View Definitions (MVD)

As indicated above, NBIMS will be adapting processes and tools developed by the BLIS consortium, buildingSMART, and IAI in order to maintain maximum compatibility with similar developments globally.

This section describes NBIMS use of the Model View Definition tools and documentation formats.

MVD Concepts

Concepts are the building blocks for MVD. These correlate 1:1 to the notion of Functional Parts in the extended IDM process. The purpose of concepts is to allow clear definition and reuse of fundamental ideas or data elements and to support reuse of software code that implements or represents those ideas in software applications. Examples include a wall in an 'Architectural Design to Quantity Takeoff' view or a beam in an 'Architectural Design to Structural Design' view.

MVD Documentation

Complete documentation for the IAI standard Model View Definition Format is available from the IAI[31]. This section provides a brief guide to facilitate reading and understanding NBIMS MVD documents.

MVD documentation is divided into two levels: IFC release independent (generic) and release specific (for implementation). The release specific level is also referred to as the 'View Binding' (to a specific release of IFC). Each of these levels includes both verbal (semantic) and diagrammatic (relationship) definitions. The established convention is that the generic level documents and diagram templates use shades of blue and the release specific documents and diagram templates use shades of orange.

The relationship of these documents is perhaps best described by the following diagram from the original MVD Formats document.

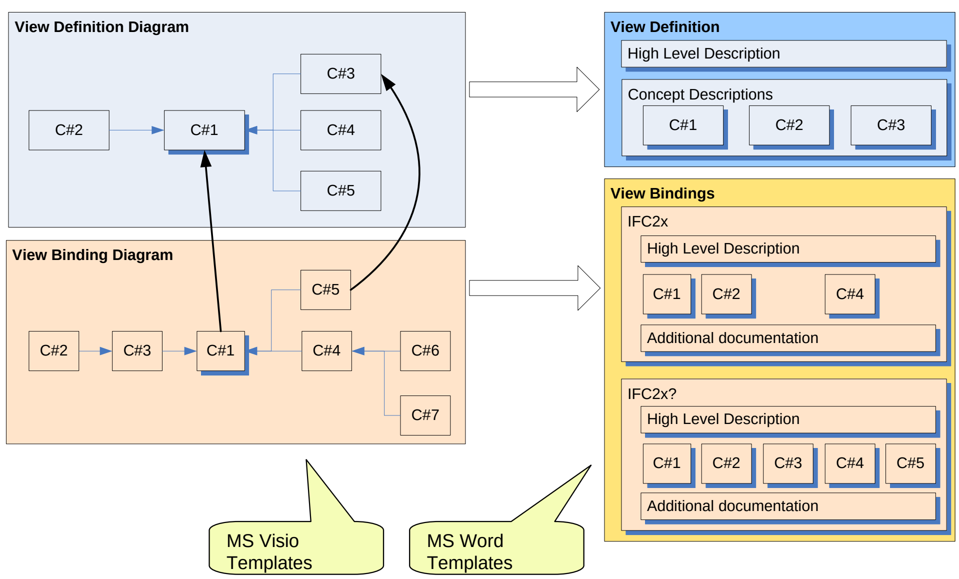
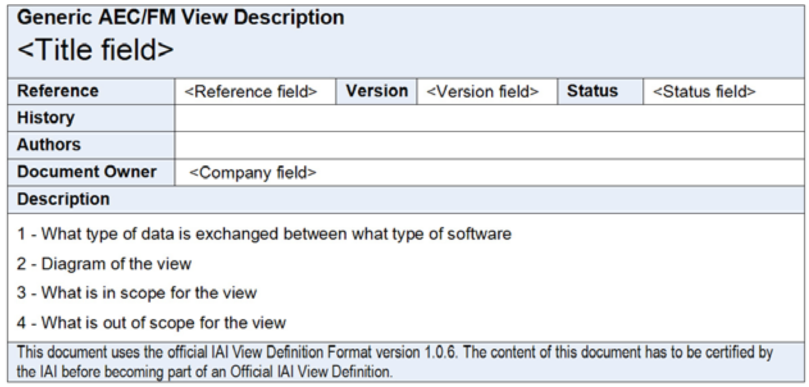


Figure 5.4-5 - MVD Documents Overview – Hietanen, 2006

[31]http://www.iai-international.org/software/mvd.shtml

Generic View Definition

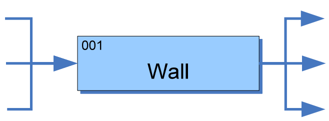


Generic AEC/FM View Description					
<Title field>					
Reference	<Reference field>	Version	<Version field>	Status	<Status field>
History					
Authors					
Document Owner	<Company field>				
Description					
1 - What type of data is exchanged between what type of software					
2 - Diagram of the view					
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.					

High Level View Description

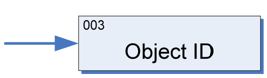
This description, created using the MS Word template shown, provides a quick overview of the concepts or ideas to be exchanged using the view. It should not go into details, but be focused and clear. Generally, the high level description should fit on a single page.

Generic Concept Diagrams – These diagrams are created using an MS Visio template. 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 follows:



Variable Concept – These 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.

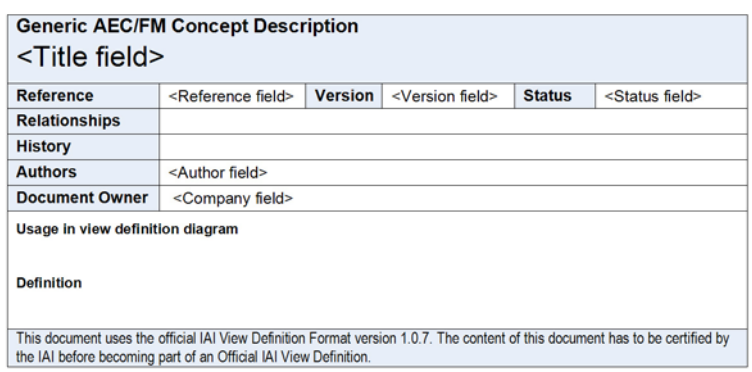
Group Concept – These concepts provide structure for the scenarios by grouping together static concepts and/or other group concepts. The content of the same group concept can be different in different scenarios. Examples: wall geometry, door properties



Static Concept – These concepts remain the same in all scenarios in which they are used. They can be re-used without modification because they don’t contain any options. Examples: Object ID, bounding box geometry

Generic Concept Definitions

This definition, created using the MS Word template shown, provides a verbal description of the idea or concept independent of any specific data exchange schema or format.



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.					

Examples from the GSA's Concept Design View

High Level View Definition

Generic AEC/FM BIM View Specification

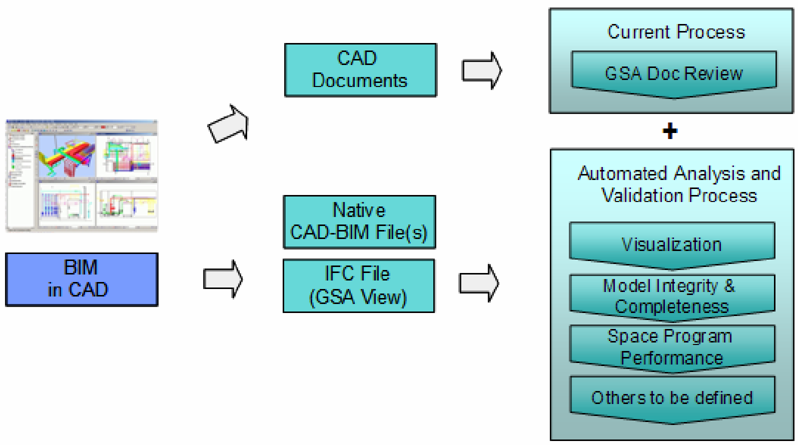
GSA Concept Design View (2006)

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.

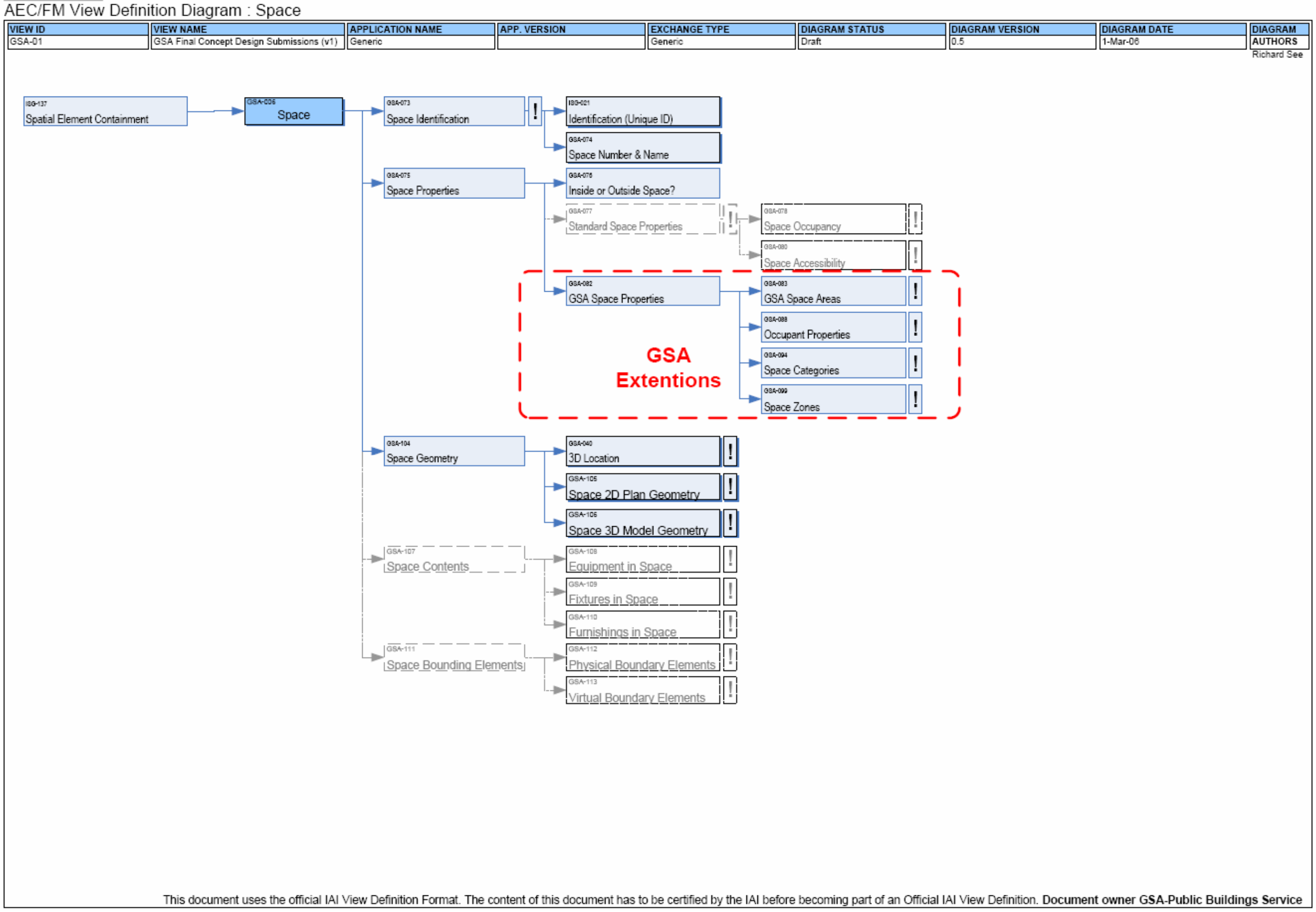
It is anticipated that future versions of this IFC Model View will expand both information and object requirements to support other analyses such as: early design based cost assessment, early design based energy performance simulation, and LEEDs simulation. GSA would prefer to work with other organizations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

1 Generic Concept Diagram for Space

AEC/FM View Definition Diagram : Space



2

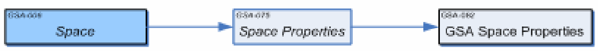
Generic Concept Definition for GSA Space Properties

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.

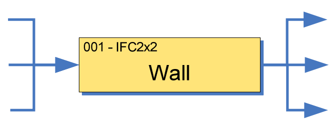
IFC Version Specific View Definition

High Level View Description

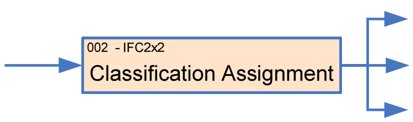
This description, created using the MS Word template shown, documents high level decisions made in the binding to a release of IFC. It should not go into details, but be focused and clear. Generally, the high level description should fit on a single page.

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.					

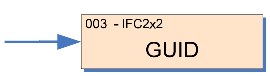
Release Specific Concept Diagrams – As with Generic Concept diagrams, these diagrams are created using an MS Visio template that supports import and export of the underlying XML schema. Each diagram defines a unique Variable Concept and the static and adapter concepts that are related to it. These types of concepts are diagrammed as follows:



Variable Concept – These 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 – These 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 – These concepts remain the same in all scenarios in which they are used. They can be re-used without modification because they don't contain any options. Examples: GUID, bounding box geometry

Release Specific Concept Description

This definition, created using the MS Word template shown, provides requirements for implementing support for the concept in software with conformance to the IFC release specifications. This includes and 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.					

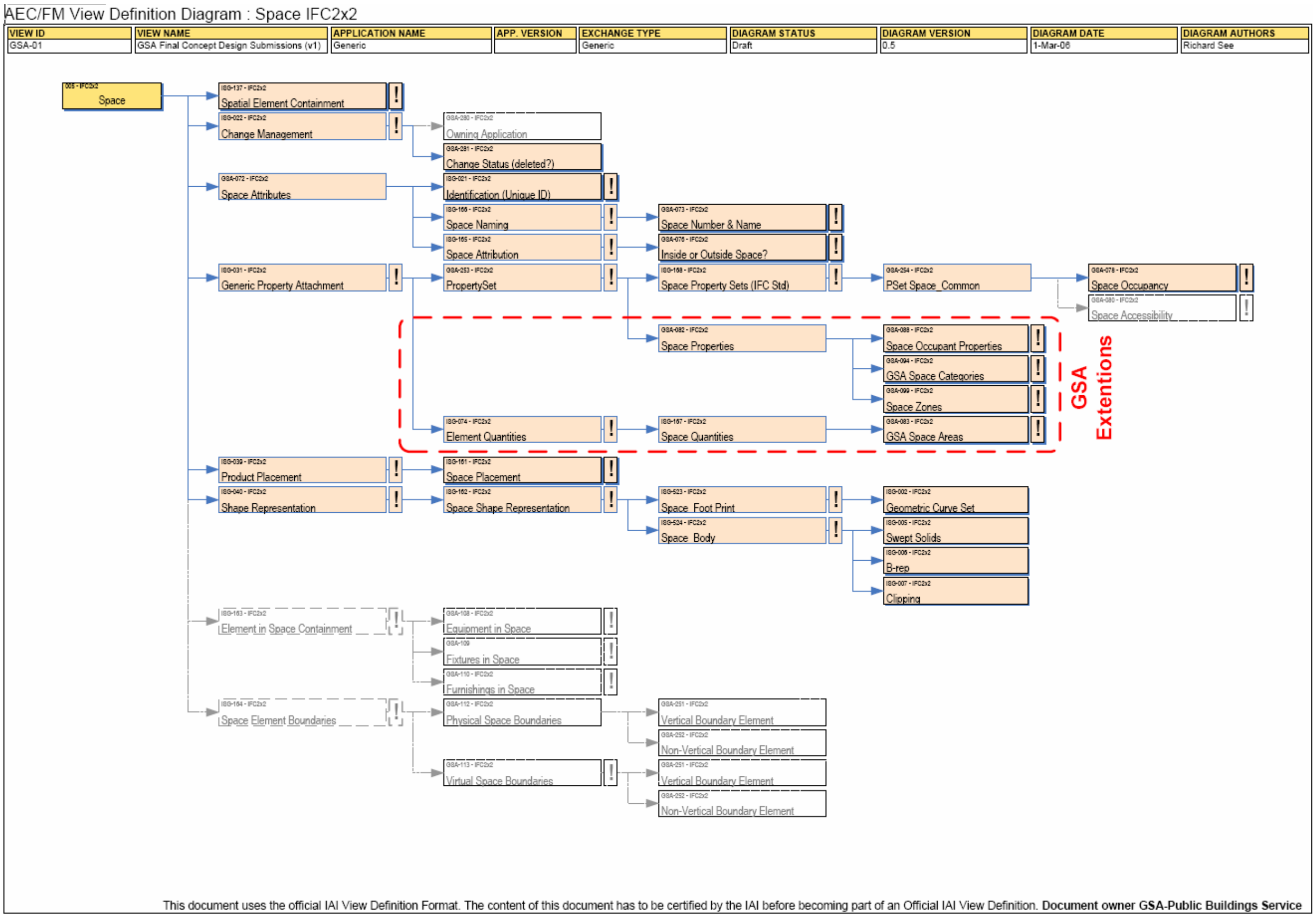
Examples from the GSA's Concept Design View

IFC 2x2 High Level View Definition

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.					

IFC 2x2 Concept Diagram for Space

AEC/FM View Definition Diagram : Space IFC2x2



1 IFC 2x2 Concept Definition for GSA Space Areas

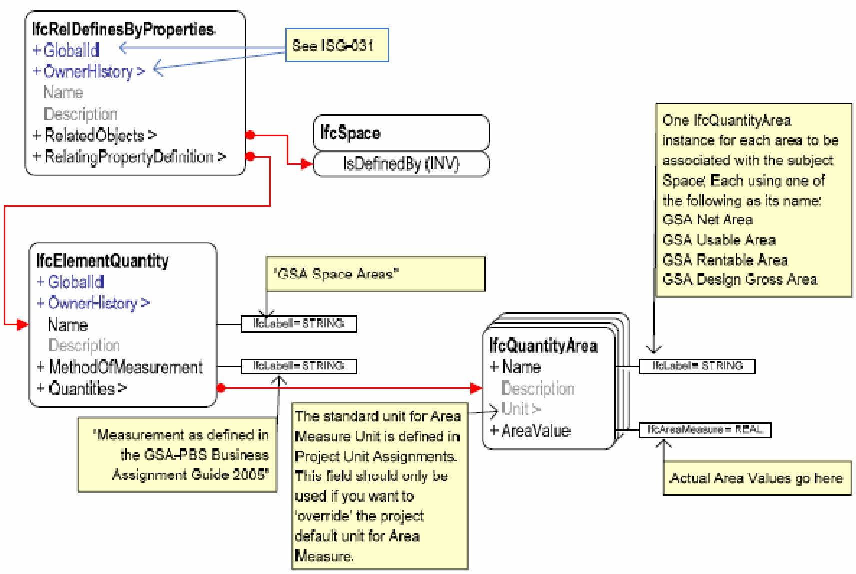
IFC Release Specific Static Concept Description (IFC2x2)

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).

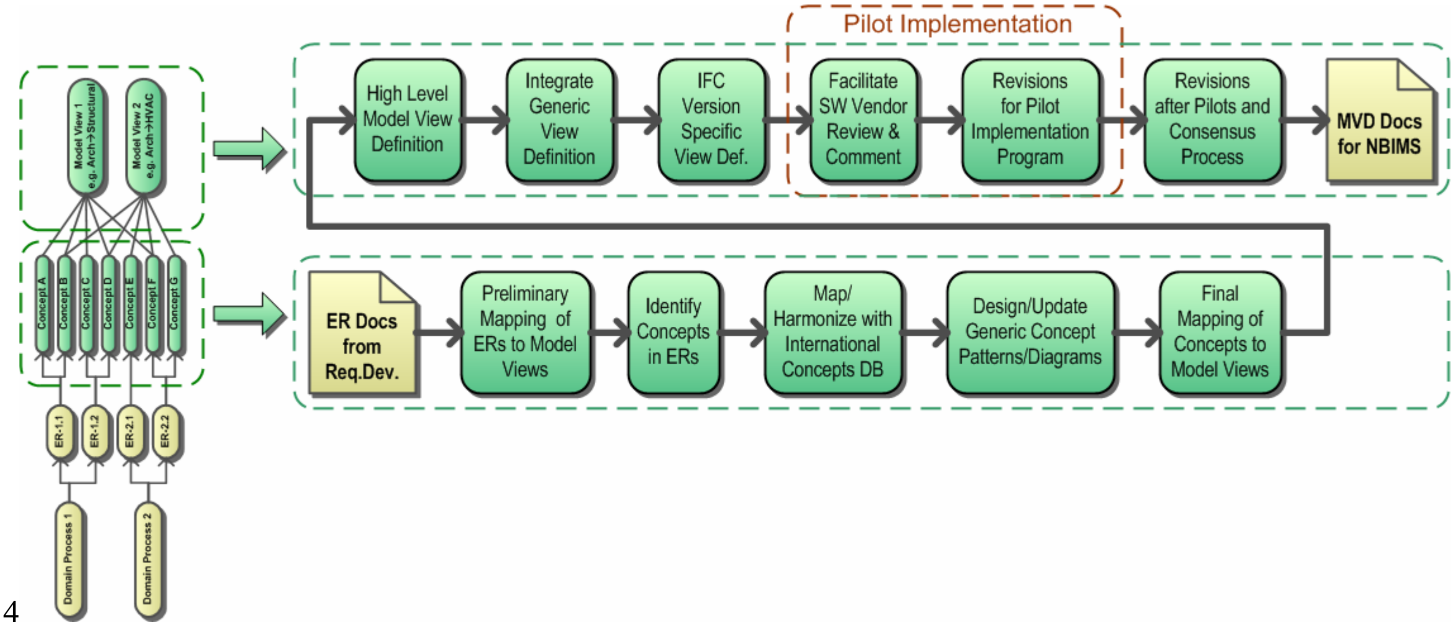
According to the IAI Implementers' agreement, building floors (IfcBuildingStorey) do not include geometry. To aid in visualizing such building floors, GSA has adopted the convention of including a 'Full Floor' Space object for each floor. This space extends horizontally to the outside face of building 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.

2 Implementation requirements and options can be summarized as follows:

MVD Development Process

NBIMS MVD will be developed using the following process:



Preliminary Mapping of ERs to Model Views – Model Views will be aligned to roles in building project teams (e.g. architect or structural engineer) and/or software applications (e.g. architectural BIM authoring or structural BIM authoring apps). These Views will effectively aggregate information exchange requirements 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 ERs – 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 DB – The next step is to harmonize the identified Concepts with those already supported by existing Model Views. Where like Concepts already exist, the mapping may be 1:1, where they are similar, the existing Concept may be expanded, or a new Concepts added to the cross view database of Concepts. An online database and 'Model View Coordination' toolset is being developed and should be available in time for use in NBIMS version 1 development. If a Concept does not already 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.

Design/Update Generic Concept Patterns/Diagrams – Where new Concepts are identified, their generic data representation patterns will be defined next, using the Generic Concept Diagram and Generic Concept Definition templates described above. Similarly, where existing Concepts are to be modified or extended, these definition documents will be updated. A toolset is being developed to facilitate diagram development in Microsoft Visio and definition development in Microsoft Word.

Final Mapping of Concepts to Model Views – After all Concepts representations are complete, the final assignment/grouping into Model Views will be confirmed before moving on to complete the formal Model View definitions.

High Level Model View Definition – 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 next be integrated to form the generic MVD.

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

Facilitate SW Vendor Review & Comment – It is important to involve potential software implementers in the definition of MVD. Therefore our process includes a review and comment period to collect vendor input. Experience has taught us 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 – Even in cases where an MVD is accepted for inclusion in NBIMS, we expect acceptance to come with a list of minor changes or improvements. The final step in MVD development will be to incorporate the agreed 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.

International Coordination

The International Alliance for Interoperability and BLIS Project are coordinating development of MVD internationally. A web site and web based toolset will be launched by the time NBIMS version 1 development begins. NBIMS MVD will be coordinated with other international projects developing MVD through this site and toolset.

Version 1 MVD

As 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 MVD included in this document. MVD will be developed in future releases of the actual standards document.

Next Steps

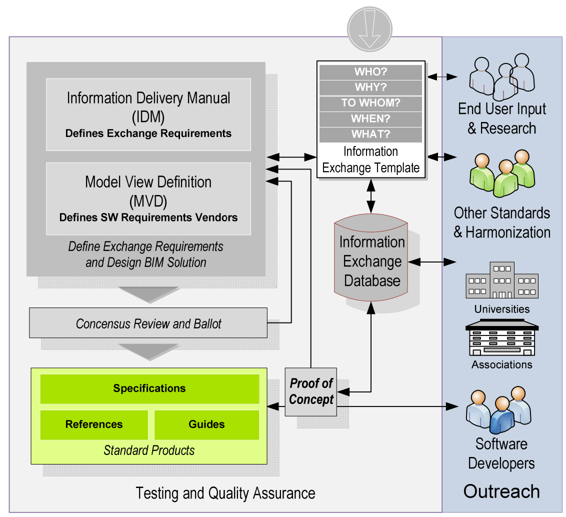
Next steps for the Models and Implementation Guidance committee in developing a version 1 standard include:

- 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, ER, and MVD (together with Requirements Development and Testing)
- Plan and manage the consensus process (together with Executive Committee)
- Generate and publish v1.0 NBIMS documents (together with all committees)

Chapter 5.5 Reference Standards

Introduction



Reference standards provide the backbone upon which the seamless exchange of project information may occur. The reference standards selected by the NBIMS are international standards that have reached a critical mass in terms of capability to share the contents of complex design and construction projects.

Background

Consider the ubiquitous nature of word processing software. Without a reference standard that provides a computer-operating system and software-independent definition of the letter "a" no one would use a word processor. Reference standards in NBIMS provide the underlying computer-independent definitions of those entities, properties, relationships, and categorizations critical to express the rich language of the building industry.

Relevance for Users

While general awareness of the purpose and history of the NBIMS reference standards is helpful to understand the rationale for selection of these standards as the bases for NBIMS, practitioners within the design and construction industries do not need a deep knowledge of these reference standards. As with use of the word processor, users do not need to know the difference between an ASCII carriage return and a line feed in order to start a new line of text. Through the NBIMS development process, domain experts' input is captured during the Information Delivery Manual (IDM) process then translated into reference standards by the Development and/or Implementation Teams.

Relevance for National BIM Standard

For software developers, BIM managers, and technical consultants the listing of reference standards provides a starting point to understand the framework within which NBIMS operates. Given the complexity of our industry the reference standards that need to be applied are, by necessity, complex. For highly qualified technical staff unfamiliar with the reference standards used in the NBIMS there is a steep, but beneficial, learning curve. This document serves as a rudimentary introduction to the standards upon which NBIMS relies.

Discussion

Since the 1980s many people, companies, and standards organizations, nationally and internationally, have been trying to define a computable representation of the built environment. When beginning this work, organizations develop data elements and classification schemes that allow data to be selected and sorted within specific market segments.

It is the goal of NBIMS to act as a catalyst to bring together these standards. In some cases harmonization of standards is possible. In other cases cross-referencing standards is most efficient. Through NBIMS, the stakeholders responsible for different market segments have a forum to conduct such discussions.

In order to accomplish cross referencing of existing standards for specific constituent segments, exchange requirements, and best practice across all disciplines and project phases, NBIMS relies on a common platform of international standards to describe the built environment. The following international standards are used as the basis for NBIMS.

- "2005 Industry Foundation Classes Release 2x, Platform Specification (IFC2x Platform)" [ISO 2005] provides a standard model, written in the EXPRESS [ISO 1994] notation, for lifecycle project information sharing. The specific release cycle that is used as the reference standard for the NBIMS is IFC 2x3 [Liebich 2006].

- "Building Construction – Organization of Information about Construction Works – Part 2: Framework for Classification of Information" is the standard upon which the *OmniClass*™ Construction Classification System (OCCS) of fifteen data tables comprising all facets of the organizations, processes, and results of construction projects [CSI 2006] is built.

- "Building Construction – Organization of Information about Construction Works – Part 3: Framework for Object-Oriented Information" [ISO 2007] provides a language-independent dictionary framework needed to harmonize international taxonomic and building model applications. This framework is called the International Framework for Dictionaries (IFD).

The role of the IFC2x3 within NBIMS is to provide a common framework for the description of all physical and conceptual components of the built environment during an entire lifecycle. IFC2x3 is widely recognized as the only sufficiently robust platform upon which to base building information exchanges.

The role of *OmniClass*™ within NBIMS is to provide a framework to compare similar information from different projects. Through the use of the standard *OmniClass* taxonomies, information from different points of view may be harmonized to a common framework.

The role of the IFD within NBIMS is to provide a cross reference among frameworks when multiple frameworks are required. Many owners and associated stakeholders have their own individual taxonomies that will not be replaced by the adoption of *OmniClass* as an NBIMS reference standard. To coordinate and translate between disparate taxonomic information the IFD can be used as a translator.

In addition to open technical standards that support the interoperable exchange of data about the engineered environment, there is another International Standards Organization (ISO) document that will be required by NBIMS to guide the development of technical exchange standards. This standard is ISO/AWI PAS 29481-1, "Building Information Models – Information Delivery Manual – Part 1: Methodology and Format," November 2006. Use of the standard Information Delivery Manual process will increase the ability of NBIMS development efforts to be shared internationally and supported by service provider communities.

Only international standards shall be considered for adoption by the NBIMS as reference standards. Additional standards may be added to future NBIMS reference standards if these standards are unanimously agreed upon by the executive committee of the NBIMS.

While international standards are the backbone of the NBIMS reference standards, additional standards, called normative standards, may be applied in the context of specific information exchanges. Normative standards are commonly used U.S. industry standards for specific domains. These standards are typically promoted by specific sets of industry stakeholders, around specific technologies, or by manufacturer's associations. During the process of creating an information exchange standard, participating stakeholders will determine the applicability and specific usage of normative standards.

The objective of the NBIMS is to provide open standards for the good of the entire capital facility industry. Any reference standard or normative standard used as part of the NIBMS will be available for use and distributed free of charge, except for those charges associated with the costs of reproduction of the standards. Under no circumstances shall proprietary standards, either international or national, be included or referenced within NBIMS.

Next Steps

Development of the IFC and IFD reference standards are open international activities. Stakeholder effort to support NBIMS directly supports the automated exchange of information between the U.S. and international communities. Through NBIMS, U.S. requirements and translation of those requirements into other national design, construction, and operations communities is accomplished. The harmonization of U.S. NBIMS with the international IFC and IFD will increase the ability of U.S. firms to compete internationally.

References and links

[Liebich 2006] Liebich, Thomas, Adachi, Yoshinobu, Forester, James, Hyvarinen, Juha, Karstila, Kari, Wix, Jeffrey (2006) "Industry Foundation Classes, IFC2x Edition 3," International Alliance for Interoperability, http://www.iai-international.org/Model/R2x3_final/index.htm

[ISO 1994] International Standards Organization (1994) "Industrial Automation Systems and Integration – Product Data Representation and Exchange – Part 11: Description Methods: The EXPRESS language reference manual," ISO 10303-11:1994, http://www.iso.org/iso/en/CatalogueDetailPage.Catalogue Detail?CSNUMBER=18348

[ISO 2001] International Standards Organization (2001) "Building construction – Organization of information about construction works – Part 2: Framework for classification of information," ISO 12006-2:2001, http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=35333

[ISO 2005] International Standards Organization (2005) "Industry Foundation Classes, Release 2x, Platform Specification (IFC2x Platform)," ISO/PAS 16739:2005, http://iso.nocrew.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=38056&scopelist=PROGRAMME

[ISO 2007] International Standards Organization (2007) "Building construction – Organization of information about construction works – Part 3: Framework for object-oriented information," ISO/FDIS 12006-3, http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=38706&scopelist=PROGRAMME

[CSI 2006] Construction Specification Institute (2006) “*OmniClass*™ Construction Classification System,” http://www.omniclass.ca/

Chapter 5.5.1 IAI Industry Foundation Classes (IFC)

Introduction

IFC define the virtual representations of industry objects used in capital facilities, their attributes, and their relationships and inheritances. Properly implemented, they are the mechanism which makes BIM interoperable with the over 300 software applications that currently support them world wide. They 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

The International Alliance for Interoperability (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 critical element to 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 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 life of a facility.

The IFC data model consists of definitions, rules and protocols that uniquely define data sets which describe capital facilities throughout their lifecycle. 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 individual software application's internal data structure. Software applications that have IFC interfaces are able to exchange and share 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 life-cycle 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 in a way consistent with BIM and 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 the exact vocabulary to use in the description of the data content of these data "buckets" to avoid possible misunderstandings. NBIMS is relying in this task on OmniClass object classification (see Chapter 5.4.2 for information on OmniClass).

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. Since the IFC data model covers the entire facilities lifecycle, no single software application needs to or can implement the entire data model. Implementation of IFC is thus 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 Chapter 3.3 for information on 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. Thus, by definition, an open standards based BIM is an IFC-based BIM.

Next Steps

The IAI is currently certifying only the implementation of the coordination view of IFC. Additional views are under development; many more are needed. NBIMS should actively support the development of model views that represent capital facilities industry processes throughout facilities lifecycle.

Not having seen much market demand in the past, many capital facilities industry software developers in the United States have resisted developing and supplying IFC interfaces to their software. Some are fearful that interoperability based on an open standard will cost them part of their current market share, others see too much financial risk in making their software interoperable. 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 competitive disadvantage in the long run. Therefore pressure must be exerted to ensure that the implementation of the only open and extensible data model becomes more wide spread and accelerated in the United States.

Items Needing Standardization

Data exchange and sharing facilitates the use of software in industry processes throughout facilities lifecycle. Data set requirements and formats needed for effective data exchange and sharing in processes of the United States capital facilities industry should become part of NBIMS. IFC provide the necessary data definitions, rules and protocols for inclusion in NBIMS. As the IFC data model is continuously expanded, new versions of the data model will be published in the future. New expansions of the model support additional industry processes by defining objects and attributes used in these processes. NBIMS should continue to be updated with such newly developed specifications.

References and Links

General, publicly available documentation of the IFC data model is available at the international IAI web site http://www.iai-international.org/Model/IFC(ifcXML)Specs.html. Software developers interested in developing IFC interfaces to their software should contact the Coordinator of the IAI international Implementation Support Group (ISG) at rasso.steinmann@steinmann-consult.de.

Chapter 5.5.2 *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 BIM. 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 BIM. *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 in the following way:

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	ISO Table 4.1 Construction entities (by

Entities by Form	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 e.g. 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 September 29, 2000 inaugural meeting.

- *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 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. 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 life cycle. 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*.

[*Contents of 5.4.2 adapted from the Introduction to OmniClass Release 3/28/2006, copyright CSI*]

Items needing Standardization

- The fifteen *OmniClass* tables need to be accepted as industry standards.

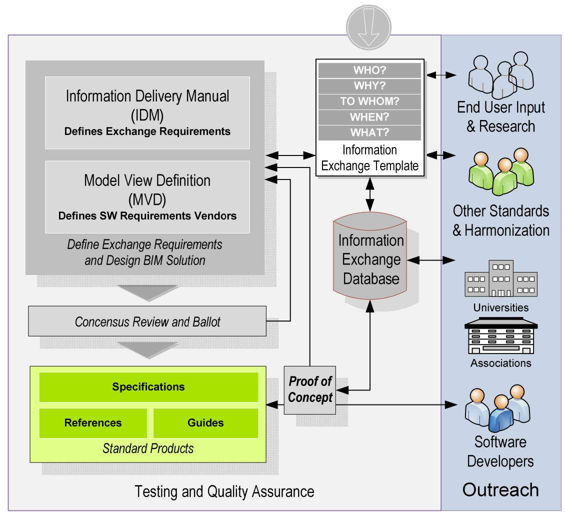
- Tables 11, 12, 13, 14, 22, 31, 32, 33, 34, and 41 are ready to be submitted to the consensus process in 2007.
- Table 21 is undergoing harmonization and will be ready for consensus in 2008.
- Table 23, 35, 36, and 49 will be ready at a future date.

References and Links

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

Chapter 5.6 Normative Standards

Introduction



Practitioners, stakeholders, and service providers to the lifecycle building industry have, since the beginning of time, been creating individual standards to support specific compatibilities of physical space. From standard brick sizes, to screw tread count, to railroad gauge, to power supply systems, our human engineered environments demand the creation of standards to reduce cost and provide interoperability. The current state of the building industry is that purpose-built multiple information standards exist, compete, and conflict. One view of the history of technology could be from the point of view of a "natural" evolution of multiple proprietary standards into a single common platform. The resolution of these multiple standards, based on historical precedent, is typically the trumping of a single individual commercial standard.

Such a discussion is not simply of historical interest. To consider the impact of our industry's current lack of interoperability through analogy, readers are encouraged to consider the following thought experiment. Determine the impact on your life if each home and neighborhood in your town were able to choose its own configuration of electrical grid. Consider the number of adapters and variation in appliances needed in such a world.

The objective of NBIMS is to allow the plethora of standards needed for specific purposes to exist as "normative" standards. These normative standards are linked through NBIMS IFC models (and well defined extensions of these models) to allow interoperation of currently un-harmonized standards.

Background

NBIMS provides an opportunity for a more egalitarian approach to the resolution of normative standards. This approach has, in the past, bristled those attempting to "corner the market." The ultimate result of harmonizing individual standards to NBIMS is that implementing a common interoperable format will allow vendors to focus on providing better products for their customers: products that provide the functionality needed without requiring local adaptation or vertical integration.

Through NBIMS, existing standards may be mapped into NBIMS and thus provide direct and clear interoperability. Unless the industry consolidates to one set of vertically integrated applications, as has implicitly occurred in the realm of computer operating systems, the only way to ensure the long-term survival of existing standards is to map them into a common platform. NBIMS provides that platform and open, non-competitive environment, through which a common "grid" for our building information may be shared.

Relevance for Users

Users of NBIMS will need to work with the standards bodies in their own domains to help these standards organizations understand that the move to harmonize normative standards supports the long-term use of multiple, appropriate normative standards. Unless standards organizations are able to harmonize their requirements, these standards will be subsumed by those presumably less capable general purpose standards that are selected for implementation by those vendors who have "cornered" their perspective markets.

Relevance for the National BIM Standard

For software developers and BIM digerati, the participation by normative standards bodies in the NBIMS process is an approach to be welcomed. Through this approach users may continue to interact with the systems that support such standards without vendors and BIM managers being required to write custom data exchanges across all needed, relevant standards.

Discussion

NBIMS specifies the detailed definition of information to be exchanged at a given step within the context of a given type of work. To ensure that information is consistently represented and maintained in open-standards framework, key information is captured based on the IFC and IFD reference specification. Not all information, however, will need to be kept or exchanged directly in the reference standards. In many cases, the full set of information used by those responsible for the detailed engineering of a specific building system or the manufacture of a given product will not need to be included in a more general information exchange or model repository.

Within a very specific domain there are likely to be existing standards that define a full set of information that is needed within that community. Generally, such information will be of limited value to those outside the specific community. Standards used by these communities may be required in the NBIMS as part of a given information exchange. Such domain-specific requirements, if required by NBIMS, are referred to as "normative standards."

An example of a normative standard in the area of structural engineering is the "CIS/2" standard. This structural standard provides a full definition of structural steel including bolts, washers, and nuts. While the specification of this information is of critical concern to the structural engineer, steel fabricator, and erector, the specifics of the steel connections (other than the overall dimensions of the connections) are not typically needed by the mechanical engineer, painting subcontractor, or interior designer.

It is not the intention of NBIMS to replace or re-define widely used, domain-specific standards. These normative standards will be adopted to the extent that they are used within the specific domain community. The goal of NBIMS, however, is to provide a "translator" between the core set of open-standard information that provide the project lifecycle BIM and the domain-specific standard.

One approach to specifying the use of normative standards is to map the NBIMS reference standard to the normative standard. This approach will not provide an effective translator, since during a given project not all information is exchanged at each information exchange point. As a result, NBIMS takes a different approach to the inclusion of normative standards.

During the process of NBIMS requirements definition, specific information exchange requirements are identified. These exchanges occur between or among several project stakeholders at specific points in the process that is the subject of the standard. If normative standards are used to develop the information to be exchanged, then the normative standard will be referenced in the NBIMS. Rather than look at the entire IFC model and normative standard, only those aspects that reflect the exchange requirement will be mapped. Through this process a limited and well defined set of information needed in the NBIMS open standard can be defined.

In the case of the complete structural steel design, for example, the extruded shape definitions for beams and columns and information about the connection details from the CIS/2 model are likely to be provided back to the architect. Information from the CIS/2 model regarding bolt patterns will not be specified in the NBIMS exchange standard, although the information exists with the CIS/2 model. A link to the full CIS/2 model file in its native format is, however, likely to be included with the exchange to ensure that the structural engineering and fabrication information may be captured if needed later in the project lifecycle.

Another example how normative standard are applied within NBIMS is found in the Construction Operations Building Information Exchange (COBIE) standard. The purpose of COBIE is to eliminate the paper boxes provided by construction contractors to facility owners when projects are closed-out. The exchange requirements for COBIE include information related to operations, maintenance, and asset management. In the area of asset management there are two major normative standards used to define area measurement calculation methods. The COBIE standard allows the project stakeholders to define the method to be used for area calculations based on specific project and customer requirements and reference that method within the COBIE information exchange. By exchanging the name of the normative standard it would be possible to translate between standards applied by different project stakeholders.

In some cases groups with conflicting normative standards may find NBIMS a useful forum for the identification of differences and development of consensus toward unified standards. Any parties interested in working together through NBIMS are welcomed to contact NBIMS executive committee.

Another classification of standards related to normative standards is “reference standards.” These standards while being applicable to a given set of project stakeholders may not be fully implemented by the entire industry. An example of such reference standards are asset category codes used by facility owners. If identified during the NBIMS requirements definition phase, these reference standards may be identified in the NBIMS. The use of these standards is by agreement or contractual requirement governing exchanges on specific projects.

Next Steps

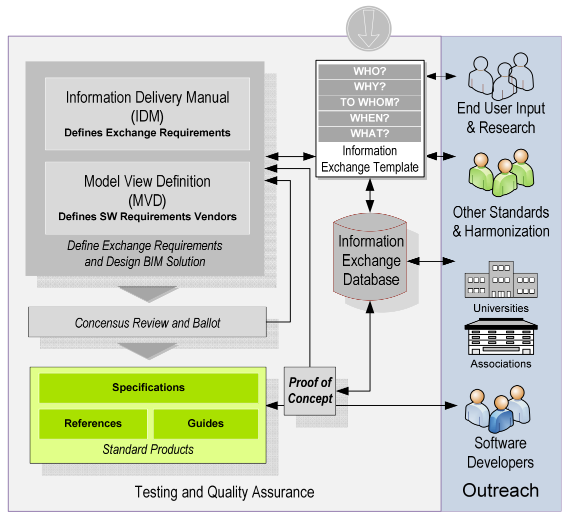
Readers of this document who represent widely used domain standards (i.e. normative standards) are welcome to undertake NBIMS projects to help define those information exchanges needed for their specific communities. Readers of this document who utilize local standards are asked to participate in relevant NBIMS projects to identify the extent to which requirements defined by their standards may be represented in the NBIMS open-standards framework.

References and links

The References section contains a list of many existing normative standards. Those involved in the efforts identified in the References section have joined with NBIMS to begin the work of appropriately harmonizing their standards.

Chapter 5.7 Implementation Standards

Introduction



Detailed technical standards are required to unambiguously define the requirements of specific information exchanges. Users of the exchange standards will do so with various types of software. These software systems will embed the requirements of the standards within their designs, hiding the complexity of the underlying standard or standards that are implemented by the system. Implementation standards are created by the teams who will use NBIMS to assist software developers to create either individual or “bundled” sets of exchange requirements defined by detailed Industry Foundation Classes (IFC) and International Framework for Dictionaries (IFD) specifications.

Background

Over the past decade the International Alliance for Interoperability (IAI) has developed implementation standards called “model views.” These model views define multiple subsets of the IFC model that could be packaged together to provide a coherent, critical mass of building data. The approach taken by IAI, until recently, was to define the entities and properties needed in a model view without a detailed specification of the constraints on these entities and properties required to ensure consistent use. As a result, current IAI implementation model views have not only proven inadequate to support software interoperability, they have been demonstrated not even to allow correct import/export within the same software system.

During the last three years, IAI international members have been working toward harmonizing the Information Delivery Manual (IDM) process to define unambiguous technical exchange standards with the requirements of vendors to provide exchanges that contain data that would support multiple exchange standards (i.e. model views). While this harmonization effort is ongoing throughout the international community, key ideas of this effort can be adopted by NBIMS. This section provides an overview of the implementation standards to be created as part of NBIMS.

Individual exchange import/export tools and model views are expected to comprise, at least initially, a large proportion of the types of implementation standards. These types of exchanges represent “batch-processing” of BIM data. More discrete types of exchanges are likely to become increasingly common in the future. For example, plugging software into a shared project repository may be an option for teams with controlled infrastructure and high speed internet connections. The use of web services promises to provide packet- or transaction-based information exchanges. Such packet-based exchanges can serve to simulate the shared project repository across networks with limited internet connectivity.

NBIMS will not be prescriptive of the type of implementation standards that are needed. However, the public and private sectors may use NBIMS as the platform, where need combines with innovation and ingenuity, to create future interoperable implementation of NBIMS.

Relevance to Users

Critical to NBIMS are implementation standards through which the exchange standards are translated into useful software tools for end users. The general reader may be aware that the standard upon which word processing software is written is called ASCII. The value of implementation standards is that users need not understand ASCII codes to know how to use word processors or exchange information between word processing software.

Relevance to National BIM Standard

NBIMS can assist software vendors by providing a forum where vendors can meet to develop, publish, and test such implementation standards, while IAI International resolves methodological issues related to the automated translation of the IDM to model views. The production of model views remains an open issue that is just beginning to be discussed. Interested parties are welcomed and encouraged to participate in our open, but finite, deliberations.

Discussion

NBIMS open standards are defined based on references to the IFC and IFD. Normative standards may prescribe some of the information to be exchanged in the IFC based reference. To accomplish exchanges, implementation standards will also need to be developed.

One way to view the relationship between implementation, reference, and normative standards is provided in the following figure.[32] IDM allows subject matter experts to translate their specific exchange requirements, based on standard business processes, into specific IFC model entities. The detailed specification of the IFC entities, relationships, and constraints required to prescribe specific exchange requirements is the ultimate goal of the IDM process.

Functional Parts are reused across NBIMS specifications. For example, the specification used to define information about the people who created data in a given exchange will be the same across all NBIMS. This specification is based on the IfcOwnerHistory entity. The representation for spaces within a facility will also be shared across many of the standards, based on the IfcSpace entity. Rather than have a separate Functional Part definition of actors and spaces, NBIMS Functional Part specifications will re-use previously developed “atomic” specifications.

Detailed specifications and testing against those specifications will ensure that NBIMS provides truly open, interoperable information exchange standards.

The specification of a combined set of information exchange standards is referred to as a “reference implementation standard.” The format for this standard, still based upon the Functional Parts, is defined by the technology required to support the information exchange. In many cases, sets of combined implementation standards information will be exchanged between software systems. A current approach to the creation of software implementations from combined sets of Functional Part definitions is identified by the “Model View Definitions” layer of Figure 5.7-1. Since model views are created directly from the detailed requirements specified in the Functional Parts, it will be possible for vendors and others to rigorously test software interoperability. Model views developed will reflect the diversity of vendors supporting different segments of the facility lifecycle.

[32] Adapted from Hietanen, Jiri (2006) “IFC Model View Definition Format,” International Alliance for Interoperability.

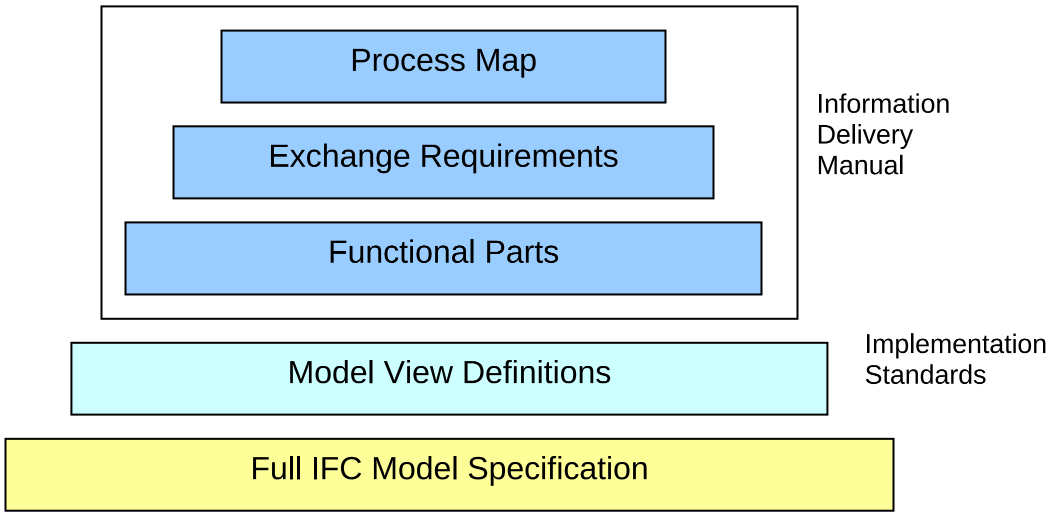


Figure 5.7-1 - Implementation Standard Hierarchy

While the current approach to implementation standards is model views, it is likely that innovative software engineers will be more effective in defining information standards than those domain subject matter experts who help define the requirements for the standards themselves. Those modelers creating the Functional Parts would also do best to provide consistent specifications of functional parts, with all required constraints, rather than to focus on support for software.

NBIMS does not plan to create a centralized repository of implementation standards for machine-to-machine interfaces. Such a repository would not take advantage of the potential for innovation within software service providers. An example of the innovation recently discussed by NBIMS members was the rapid adoption of web-services. In these services small packet-based exchanges will be used to exchange only a limited portion of what might be contained in a fully specified model view.

When NBIMS require human interaction or during the development of Pilot NBIMS projects, implementation standards using common software platforms are likely to be created. These Pilot standards will typically reflect individual NBIMS exchange requirements and functional parts. NBIMS that require human interaction to capture data will be required to look like the forms and web-pages with which users are familiar.

Ultimately, NBIMS implementations must become transparent to the user. The process should be similar to the evolution in the ability to exchange word processing documents. At one time file formats were incompatible between software and operating systems. Now, these file formats are readily available and supported by all word processors, so that users no longer concern themselves with the details of the placement of the bold, underline, and italics within the file as long as the information exchanged results in exactly the same bold, underline, and italics in the target platform. Once the work of NBIMS has reached a critical mass, the discussion of IFC, IFD, and IDM will become something of interest only to academics and digerati in our industry.

Next Steps

As IAI International formalizes its methodology for the harmonization of the IDM (bottom-up) and Model View (top-down) approaches, NBIMS will continue to serve as a forum for discussion of U.S. implementation.

NBIMS encourages software vendors to participate in the discussion of the methodology to provide an open framework for 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.

References and links

The conceptual framework for the integration of IDM and Model Views is being accomplished by the Finnish Chapter of the IAI. The latest publication on this topic may be found at:

- Hietanen, Jiri (2006) "IFC Model View Definition Format," International Alliance for Interoperability.

The relationship between software implementers' view definitions and user-driven requirements analysis in IDM may be found in the following ISO standard:

- ISO/AWI PAS 29481-1, "Building Information Models – Information Delivery Manual – Part 1: Methodology and Format," November 2006.

While the compilation of multiple exchange standards into model views is important for general software support, the provision of information exchanges to support individual contractually required information exchanges will also support implementation standards for specific exchanges. These specific exchanges will enable users to create BIM data without the overhead associated with larger software platforms. An example of such an implementation standard is the COBIE spreadsheet provided in Appendix B.

Acknowledgements

The following subject matter expert authors listed alphabetically contributed to the development of the National BIM Standard Version 1– Part 1: Overview, Principles, and Methodologies. While many were authors of individual chapters, each contributed to the overall final version. Originally I had planned on identifying the chapters that each had contributed to, but in the end it was truly a team effort and almost impossible to keep track of as we explored concepts, combined chapters, and moved content around to make a more readable and integrated product.

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:

Howard W. Ashcraft, Jr.
Senior Partner, Hanson, Bridgett, Marcus, Vlahos and Rudy
hashcraft@hansonbridgett.com (415)777-3200

Mr. Ashcraft is a senior partner in the San Francisco law firm of Hanson, Bridgett, Marcus, Vlahos and Rudy. A graduate of Stanford University and the University of California School of Law (Boalt Hall), Mr. Ashcraft represents designers, owners and contractors in project formation, professional practice and construction disputes with a focus on public infrastructure and complex private projects. In addition, he is the firm's technology partner. He is a member of the California Council AIA Integrated Project Delivery Taskforce and is active with other professional associations regarding Building Information Modeling and related topics. Mr. Ashcraft is also a Fellow of the American College of Construction Lawyers.

Vladimir Bazjanac, PhD
Staff Scientist, Building Technologies Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, University of California.
v_bazjanac@lbl.gov (510) 486-4092

Longest standing North American technical representative in the International Alliance for Interoperability (IAI), involved with the IAI since its beginning in 1994. Leader of IAI Technical Advisory Group, Member of the IAI International Management Committee and the IAI Software Implementation Support Group. Former long-time faculty member in the Department of Architecture, University of California at Berkeley. Won national architectural design, industry and scientific awards. Published over 100 articles, papers and reports related to the AECO industry on design theory, simulation, information technology, and software interoperability. Lectured at major universities and professional societies in both Americas, Europe, Australia and Asia.

Mark Butler
HDR Systems Integration Manager
Professional Associate
r.mark.butler@hdrinc.com (402) 392-8782

Mr. Butler has been involved in the capital facilities industry since the mid 1970s, with background in both production and technology. As Systems Integration Manager for HDR, his role is to successfully leverage technology to support HDR's business goals. Mr. Butler has been involved with the important work of NIBS since 2000 when HDR chose to adopt the US National CAD Standard. Mr. Butler currently serves on the Steering Committee and chairs the BIM Task Team for the NCS, is a Charter signer and is active in the Scoping and Development Task Teams of the NBIMS.

Tina Cary, PhD

Cary and Associates
tcary@caryandassociates.com 303-774-8415
Tina Cary is President and founder of marketing firm Cary and Associates. As a consultant and keynote speaker she has worked with senior executives in all sectors of the geotechnology industry from Fortune 100 companies to universities, federal agencies and non-profits. Past president and a Fellow of ASPRS, she earned a Ph.D. in Geography from Columbia University in New York. An internationally-noted speaker who has made presentations in more than a dozen countries on four continents, Dr. Cary has been described as "one of the most articulate people in the industry."

Greg Ceton, CSI

Construction Specifications Institute
GCeton@csinet.org (703) 683-6422
Greg Ceton provides technical advice on classification to the *OmniClass*™ Development Committee on behalf of the Construction Specifications Institute, and works to support development of many of CSI's technical initiatives. His past work included extensive experience in classification, library administration, and technical services with a diverse array of library collections. Mr. Ceton received his training from the University of Maryland, where he was awarded a Master's of Library Science. Prior to that, he also received a Juris Doctor degree in 1990 from the University of Florida College of Law, where he is a member of the state Bar Association.

David R. Conover

International Code Council
DConover@iccsafe.org (888) 422-7233
David Conover holds the position of Senior Advisor with the International Code Council. He holds graduate and undergraduate degrees in Mechanical Engineering from the Catholic University of America and has been involved with the development, assessment, adoption and implementation of building construction regulations and new building technology for 30 years. Prior to joining ICC he served as the CEO of the National Evaluation Service (NES) and held positions with Battelle, the National Conference of States on Building Codes and Standards, and the American Gas Association. During his time as an undergraduate he also swam for CUA.

Dianne E. Davis

BIM Process Director, AEC Infosystems
Chair, Scoping Task Team, National BIM Standard
d.davis@aecinfosystems.com (410) 435-3600
With a multi-disciplinary background and experience in design, architecture, and construction management, Dianne E. Davis has worked since 1980 on the issues of industry integration and information management. In 1989 AEC Infosystems was founded by multi-disciplinary partners

beginning some of the first projects now referred to as "BIM". AEC is currently a consultant to the US Coast Guard, GSA/DHS on BIM related activities, and supports over 300 architecture, design, construction and engineering firms on BIM implementation. Ms. Davis is member of the McGraw-Hill Interoperability Council, a participant on the international IAI Interoperability Council. Ms. Davis is a past nominee for the A/E/C SYSTEMS' Ed Forrest Award for service to the construction industry.

Gerald Davis, CFM, AIA

President/CEO, International Centre for Facilities
fs-gd@icf-cebe.com (613) 727-1788

Gerald is also Chairman, TEAG The Environmental Analysis Group. He is the current Chair, ASTM Subcommittee E06.25 on Whole Buildings and Facilities, current USA voting delegate to ISO Technical Committee 59 on Building Construction; and convenor of ISO 59 / SC 14 / WG10 on Functional requirements-Serviceability of facilities. He was technical lead for the IAI PAMPeR project to define property sets for functionality-serviceability in IFC-release 2x3. Davis is a Certified Facility Manager (CFM, from IFMA). He is the recipient of the ASTM George Stern Award of Excellence, 2004, *IFMA Chairman's Citation*, 1998, and Environmental Design Research (EDRA) *Life time Career Award*, 1997. Davis is *IFMA Fellow*, 1999, and *ASTM Fellow*, 1995.

Louis J. Dennis, Esq.

Of Counsel, Zetlin & De Chiara LLP
ldennis@ZDLAW.com (213) 996-8333

Louis J. Dennis is Of Counsel in the Los Angeles, California office of Zetlin & De Chiara LLP, a national construction law firm based in New York. He has a B.A. in Developmental Psychology from the University of California, Santa Barbara and received his J. D., magna cum laude, from the University of Santa Clara School of Law. Mr. Dennis' practice focuses on construction, including litigation, mediation and arbitration of construction matters involving public and private works as well as the review and drafting of construction contracts. Mr. Dennis represents public entities, private owners, design professionals and contractors in construction disputes and provides advice to clients throughout the development, contracting and construction processes.

E. William East PE, PhD

Research Civil Engineer, Engineer Research and Development Center
Chair, NBIMS Development Task Team
bill.east@us.army.mil (217) 373-6710

Bill East is Research Civil Engineer at the Engineer Research and Development Center, Champaign, IL. Bill's work provides methods and tools supporting the public agency side of facility life-cycle business processes. Bill leads the Government To Business Process committee of NIBS and is the inaugural chair of the NBIMS Development Team. Bill is also Chair, Constructability Committee, American Society of Civil Engineers.

Alan Edgar, Assoc. AIA

President, FacilityGenetics, L.L.C.
Chair, NBIMS Communication Task Team
aredgar@facilitygenetics.com (765) 215-8251

Alan Edgar, Assoc. AIA, is President of FacilityGenetics, L.L.C. a facility information management consulting company, headquartered in Yorktown, Indiana. Mr. Edgar received Bachelor of Architecture and Master of Architecture degrees from Kansas State University in 1978 and 1983 and has 24 years experience in the fields of architecture, OAEC processes, facilities management and facilities information management technology. He has served as project architect, director of architectural information systems, a senior project manager and senior consultant to private, institutional and government clients and is a senior research associate with the Building Futures Institute at Ball State University, Muncie, IN. Alan is currently Chairman of the NBIMS Communications Task Team.

Fallon, Kristine

K Fallon Associates
kfallon@kfa-inc.com (312) 641-9339

Kristine Fallon has been a pioneer in applying information technology to design and construction since the 1970's. She spent the first 15 years of her career in large AEC firms. In 1993 she founded Kristine Fallon Associates, Inc. to consult on the use of information technology in the design and construction industry. The company is currently involved with major deployments of web-based project management technology as well as BIM consulting and services. Fallon has been co-project leader of the multi-year NIST research initiative on capital facilities information handover, a member of the College of Fellows of the AIA and 2007 Chair of the AIA's national Technology in Architectural Practice (TAP) Advisory Group. A recognized author and speaker, Fallon is also an adjunct professor in Northwestern University's Master of Project Management Program for which she has created curriculum in Computer-Integrated Project Delivery.

William Fitzgibbon

Independent Consultant
William.fitzgibbon@comcast.net (703) 586-0121

A former Navy Assistant Chief Information Officer (CIO) for Information Assurance (IA) and driving force behind a Navy IA Program Management information system, he is now an IA consultant for the Office of the Secretary of Defense.

Andy Fuhrman

Chief Executive Officer, Open Standards Consortium for Real Estate (OSCRE)
andy.fuhrman@oscre.org (831) 458-3346

Andy Fuhrman has served since June 2004 as Chief Executive Officer for the OSCRE, and is responsible for the organizations strategic, operational and tactical level success. Andy's background includes over 20 years of commercial construction experience followed by 14 years providing consulting and related services in business process improvement and technology systems implementations for Construction, Corporate Real Estate and Facilities Management operations. As a technology consultant and certified building inspector with the International Conference of Building Officials (ICBO), Andy was a key contributor in Silicon Valley's Smart Permitting initiative. Andy also is an Executive Board member for both the National Building Information Model Standard (NBIMS) and the Virtual Builders Roundtable.

Francois Grobler, PhD

Research Civil Engineer
Engineer Research and Development Center
f-grobler@cecer.army.mil (217) 373-6723

Dr. Francois Grobler is a Principal Investigator on numerous projects with the Engineering Processes Branch of the Facilities Division, ERDC-CERL in Champaign IL. Dr. Grobler has graduate degrees in Civil Engineering from the University of Illinois at Urbana-Champaign, and has over thirty years experience in the construction industry. He held industry jobs in professional civil engineering and project management and served as a tenure-track faculty member in Construction Engineering and Management at Penn State University. He serves as Technical Coordinator of the North American Chapter of the International Alliance for Interoperability (IAI), and is currently the Vice-chair of the IAI International Technical Management.

Stephen R. Hagan, FAIA

U.S. General Services Administration, Public Buildings Service
Stephen.hagan@gsa.gov (202) 302-4659

Stephen Hagan is recognized as an industry expert and technology evangelist, focusing on the real estate, construction industries and the federal public sector market place. Stephen has been program and project management lead for the PBS Project Information Portal (PIP) and a member of the GSA 3D / 4D Building Information Model (BIM) team. He was the 2006 Chair of the AIA Technology In Architectural Practice (TAP) and is on the Executive Committee of the National BIM Standard Committee. Stephen currently directs the Project Knowledge Center within the Property Development Division. He is a graduate of Yale College and the Yale School of Architecture.

David M. Hammond, RLA, APA

Headquarters, United States Coast Guard
David.M.Hammond@uscg.mil (202) 267-1980

David M. Hammond is the Chief of the Shore Facility Capital Asset Management Division, Office of Civil Engineering, United States Coast Guard. In addition to reengineering program-wide planning, design, portfolio, and asset management business processes, he has also pioneered the use of Building Information Modeling (BIM) and leading edge integrated and interoperable assessment tools to develop performance based capital asset management and balance score card performance measures related to program and Coast Guard-wide strategic outcomes. Mr. Hammond is the recipient of the Commandant's Superior Achievement Award, and the Oren Metal from the Society of American Military Engineers. He earned a Bachelor of Science degree from Cornell University, and a Master of Science degree from Syracuse University.

Louis Hecht, Jr.

Open Geospatial Consortium
lhecht@opengeospatial.org (301) 365-5907

Louis Hecht Jr. is with the Open Geospatial Consortium. He has worked in the field of geospatial information since 1985. Currently he is responsible for Business Development with emphasis on emerging issues of convergence between geospatial information and other technical and business disciplines.

Damian Hill

Associated General Contractors
hilld@agc.org (703) 837-5365

Damian is the Senior Director of the Associated General Contractors of America's (AGC) Building Division. Mr. Hill has been with AGC for more than 18 years. He started in AGC's Highway Division in 1988. He has also been the Director of Quality Programs, Associate Director of Public Affairs, and Newsletter Editor. Among other duties at AGC, Damian is responsible for producing and developing products and services for building contractors. Damian is a graduate of Marquette University in Milwaukee, Wisconsin, and is an active member of the Marquette University Alumni Association. He also has been active in the Public Relations Society of America and several other national organizations.

David A. Jordani, FAIA
President, Jordani Consulting Group
Vice Chair, Facility Information Council and NBIMS Project Committee
Chair, Business Process Integration Task Team
djordani@jordani.com (612) 333-9222
David is president of a Minneapolis based independent consulting practice that provides information technology (IT) services to facility management, building design, and construction industry professionals. Mr. Jordani has more than twenty-five years of experience developing systems for the facility management, design and construction markets. He is also the Chair of the National CAD Standard Project Committee. Mr. Jordani is a frequent speaker and author on topics related to use of computers in the facilities management, design and construction industry. His consulting groups clients include General Motors, Abbott Laboratories, American Express, Disney, IBM, AT&T, 3M, John Wiley & Sons, Inc., the University of Minnesota, and Harvard University.

Calvin Kam, PhD
General Services Administration
calvin.kam@gsa.gov (202) 208-0447
Dr. Calvin Kam is the National 3D / 4D BIM Team Program Manager with the Office of the Chief Architect, Public Buildings Service of the United States General Services Administration. Dr. Kam is also currently appointed as a Consulting Assistant Professor with the School of Engineering in Stanford University. Dr. Kam represents GSA at the Executive Committee of the National BIM Standard, Board of Direction of the International Alliance of Interoperability, Federal Government's GeoSpatial Line of Business, and leading collaboration efforts with the National Institute of Standards and Technology, Harvard University, Stanford University, Georgia Tech, and the international OAEC community.

Charles Matta, FAIA
Director, Federal Buildings and Modernizations, GSA Office of the Chief Architect
charles.matta@gsa.gov (202) 219.2355
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 a M Arch degree and is licensed in VA and DC. He is former President of AIA NOVA and a Fellow with the AIA.

Susan Nachtigall
Army Corps of Engineers, Engineer Research and Development Center
susan.nachtigall@us.army.mil (217) 373-4579
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.

Richard H. F. Jackson, PhD

Director, FIATECH
Chair, NBIMS Fundraising Task Team
rjackson@fiatech.org (512) 232-9600

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.

Kimon G. Onuma, AIA

ko@onuma.com (626) 793-7400

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.

Mark Palmer

National Institute of Standards and Technology
mark.palmer@nist.gov (301) 975-5858

Mark Palmer leads the Computer Integrated Building Processes Group at the Building and Fire Research Laboratory of the National Institute of Standards and Technology. Mr. Palmer is active in national and international standards development activities and numerous industry organizations. This includes leading collaborative projects on interoperability to support the life cycle of constructed facilities and the supply chains for these facilities. He is a vice chair for UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business). Prior to joining NIST, Mr. Palmer spent 14 years in the engineering and construction of commercial, industrial and residential facilities. He earned his Bachelor of Architecture degree at the University of Oregon and his Master of Science degree at the Massachusetts Institute of Technology.

Richard See

Managing Director of Digital Alchemy
Chair, NBIMS Model View & Implementation Task Team
RichSee@digitalalchemypro.com (206) 779-6308

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

Dennis R. Shelden, PhD

Chief Technology Officer, Gehry Technologies
dennis.shelden@gehrytechnologies.com (310) 482-3033

Dennis is a founder of Gehry Technologies, a building industry technology company formed in 2001 by the research and development team of Frank Gehry Partners. Prior to joining Gehry Partners, he performed structural engineering, energy systems and technology development work at firms including Ove Arup & Partners, Consultants' Computation Bureau and Cyra Systems. Dr. Shelden lectures and conducts research in building industry process advancement and in design computation and cognition, and has been a visiting faculty member at the Southern California Institute of Architecture and MIT. He holds a Bachelor of Science in Architectural Design, a Master of Science in Civil and Environmental Engineering, and a Ph. D. in Computation and Architectural Design from MIT.

Dana K. "Deke" Smith, RA

DKS Information Consulting, LLC
Chair, Facility Information Council & NBIMS Project Committee
deke@dksic.net (703) 481-9573

Deke Smith is the founder and current chair of the National Institute of Building Sciences (NIBS) Facility Information Council. 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.

Patrick C. Suermann, PE

Major, United States Air Force
Chair, Testing Team National BIM Standard Version 1.0
suermann@ufl.edu (719) 964-6289

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.

Françoise Szigeti

President, The Environmental Analysis Group (TEAG)
fs-gd@icf-cebe.com (613) 727-1788

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.

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1 # Glossary

Abbreviation	Term	Discussion
	Authoritative Standard	A data standard considered the authority for that type of data. It is usually managed by an association that has as its charter sustaining that data. Authoritative data is data required in the BIM process and must have a point of reference for data fidelity and validity in a BIM product. *UniFormat*™and OmniClass™ are examples of authoritative standards proposed for NBIM Standard data.
	buildingSMART	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—the new buildingSMART Alliance operates within the independent nonprofit National Institute of Building Sciences (NIBS)
BLIS	Building Lifecycle Interoperable Software	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/
BPMN	Business Process Modeling Notation	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.
CIS/2	CIMsteel Integration Standards Release 2: Second Edition	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/
CSI	Construction Specifications Institute	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
	Harmonization	Comparison and normalization of two or more similar standards including issues such as scope, specifications, guidance or implementation.
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
	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
IFD	Industry Foundation Dictionary	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/
LEED	Leadership in Energy and Environmental Design.	An initiative of the U.S. Green Buildings Council. See also: www.usgbc.org/leed
	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 .
OAEC or A/E/C/O	Owner/Architect/Engineer/Contractor/	Common term used to describe as a group the principal actors/stakeholders during building design and construction projects.

Abbreviation	Term	Discussion
	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.
	taxonomy	A collection of controlled vocabulary terms organized into a hierarchical structure
	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
	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

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