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| IUG 2012/08 | An Integrated Process for Delivering IFC Based Data Exchange | buildingSMART International, BLIS Consortium/Richard See buildingSMART international/Jan Karlshoej buildingSMART alliance/ Dianne Davis. | 16/09/2012 | [Released] |

# An Integrated Process for Delivering IFC Based Data Exchange

# Contents

# 1. Foreword by buildingSMART

This document describes the current methodology of producing Information Delivery Manuals (IDM) and Model View Definitions (MVD). It is the purpose an IDM to capture processes and exchange requirements while MVD is aiming at mapping exchange requirements to a data schema, like the Industry Foundation Classes (IFC), and potential constrains to the used data model. The document contains both a methodology for producing both IDM and MVD as they can be seen as an integrated approach of how business cases can be supported or automated through the use of information technology. This current version of the document is an intermediate version of the methodology while the format mvdXML for documenting MVDs and supporting tools are being stabilized. This version of the methodology is mainly published to provide the foundation for a proposed update of the existing ISO 29481-1:2010 Building information modelling - Information delivery manual - Part 1: Methodology and format published by International Standard Organization and creation of an additional part to the standard "Building information modelling - Information delivery manual – Part 3: Model View Definitions". Authors of this document are Richard See, Jan Karlshoej and Dianne Davis.

# 2. Executive summary

For many years, the International Alliance for Interoperability (IAI), now buildingSMART[1], has invested to deliver reliable exchange of Building Information Model (BIM) data between stakeholders in building construction projects. The Industry Foundation Classes (IFC)[2], a comprehensive information model schema for the building industry, was developed as to be an open industry standard for such exchanges. The IFC model is necessarily large and complex, as it includes all common concepts used in building industry projects, from feasibility analysis, through design, construction, and operation of a built facility. Implementing support for all of IFC is therefore beyond the scope of any one application, with the possible exception of model servers[3]. Seen from an end-user point of view, despite significant efforts by the software vendors and buildingSMART it has been difficult to satisfy a reliable and predictable exchange of BIM data.

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[1] History about the transition of IAI to buildingSMART can be found on the bSI website: http://www.buildingsmart.com

[2] A good source for understanding the IFC model is the IFC wiki: http://www.ifcwiki.org/index.php

[3] An example IFC model sever project in BLIS was SABLE: http://www.blis-project/~sable

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**Process** – This document defines an integrated process for designing, implementing, certifying and using standard information exchanges for the global building industry. This process includes 4 distinct phases that begin with requirements definition and end with use of the information exchange in building industry projects.

For buildingSMART and BLIS, the information model schema currently used to coordinate and make various information exchanges in the Industry Foundation Classes (IFC)[4] and the source for coordinated terminology is the International Framework for Dictionaries (IFD)[5].



**Figure 1**: Transformation of needs into operational solutions

**Phase 1: IDM** – an Information Delivery Manual defines an industry process that involves at least two types of software applications, and the information that should be exchanged between those applications. IDMs include four primary deliverables, using standard formats. These are:

- Process Maps which define the industry process,
- Exchange Requirements which define the information to be exchanged,
- Exchange Requirements Models which organize the information into Exchange Concepts that will linked to Concepts in the MVD and enable verification that all requirements have been satisfied,
- Generic BIM Guide which documents guidance to the end user about what objects and data must be included in the BIM to be exchanged. Product specific versions of the BIM Guide will be developed later by vendors of certified software products.

**Phase 2: MVD** – A Model View Definitions document a subset of the IFC Model Specification that is required for the information exchanges defined in one or more related IDMs. As such, it is the 'design' for support of those information exchanges in software products. MVDs include three primary deliverables, each using standard formats. These are:

- MVD Overview/Description which describes the scope of the MVD; especially the IDM that are addressed,
- MVD Diagrams which define the MVD Concepts that will be used in the exchange, as well as the structure and relationships between these Concepts
- Concept Implementation Guidance which defines the IFC entities used to exchange each concept and the Implementer agreements that general reduce the implementation scope that would otherwise be required by the extremely general IFC schema.
- Binding to the IFC schema is documented in mvdXML.

**Phase 3: Software Implementation/Certification** – Once MVDs are documented and posted, support for vendor implementation in their software products is required. This involves technical support for vendors who are implementing support for the IFC data exchange in their products as well as detailed, Concept by Concept testing to confirm whether their implementation is conforms to the MVD specifications. Results of Certification Testing are made public, so that end users can review them and the certification process is open. In most industries, software testing to assess conformance to a standard is outsourced. This is also been the case for both buildingSMART and members of BLIS – who have contracted testing by GTDS and Digital Alchemy, respectively.

**Phase 4: BIM Validation** – Certified software products do not ensure successful IFC based data exchange in projects. The end user must successful apply guidance documented in the BIM Guide

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[4] http://www.ifcwiki.org/index.php

[5] http://www.ifd-library.org

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for the exchange. BIM Guide is developed as part of the IDM and then (hopefully) made product specific by the software product vendor. BIM Validation enables the end user to verify that a BIM that has been exported from a certified application meets all the requirements defined in the original IDM and MVD for the target exchange. This is very important in industry projects that contractually require IFC based data exchange, because it enables third party verification of correct exchange that can be used by either the provider or receiver (or both). At a technical level, the BIM Validation software methodically checks every object in the BIM against all requirements for that object type. As with Certification Testing, in most industries this type of data file checking is provided as a service provided by endorsed or approved vendors.

Seen from an industry point of view it is important to be aware of that it is only be possible to gain the expected benefits if the solutions are supported by software tools. It is important to identify the which processes that should be support be a digital workflow where data seamless can be sent, received or shared between the relevant parties, since software development is expensive and it can be difficult to get all the relevant software vendors to implement support for handling data according to the specification. It is also important to consider if the existing process should be adjusted or reengineered in order to benefit from a digital support workflow. It should be examined whether all the relevant and necessary organizations are able to implement the potential revised processes and digital supported workflows.

It should be remembers that in most cases there have to be made modifications or additions to the existing software tools or even development new ones in order to achieve digital supported workflows. It is therefore very important that the software developers are committed to implement the proposed solution to avoid a situation where the specifications have been developed but aren't supported by software tools.

It is important to be aware of the solution either is based on the existing data model or extensions have to be developed. Since development, review, test, release, implementation of extensions to the IFC specification is a process that in most cases take several years. Whereas additions of properties to existing data model in most cases can be done immediately.

# 3. Background and Acknowledgements

buildingSMART (then International Alliance for Interoperability) began with a process oriented approach, development activity for several years focused on developing technical data specifications for the Industry Foundation Classes (IFC). Initial implementations and compatibility between those implementations was inconsistent, resulting in end user disappointment.

In 1999, The BLIS Consortium[6] was formed to address this reliability problem. In 2000, BLIS introduced the notion of Model Views -- as well-defined subsets of the IFC model that must be supported by software for specific end user scenarios. BLIS Model Views were defined in terms of reusable Exchange Concepts. Each Concept was defined and a binding to specific entities in the IFC model schema that are used to exchange that concept was documented. This purpose of this Exchange Concept documentation was to unambiguously define the implementation requirements such that implementations by different vendors would be consistent. The value of such documen-

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[6] Information about The BLIS Consortium can be found at: http://www.blis-project.org

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tation was proven in 2002-2003 as members of BLIS developed and certified some 35 applications for consistent support of 4 out of the 6 Model Views defined by BLIS.

In parallel, buildingSMART formed the Implementers Support Group[7] (ISG). ISG also focused on improving compatibility between applications by defining the Coordination View of IFC. As with BLIS, ISG certified several applications for support of the Coordination View over the past decade.

After the early work done by ISG and BLIS, two initiatives began in 2005. One group began the development of IDM, the other group (which grew out of BLIS) begin the development of a more formalized approach to model view definitions. The group developing the IDM focused on documenting industry processes and information exchange requirements. The group developing MVD focused on documenting information exchanges in a manner that could be directly implemented in software and that encouraged reuse of 'information packages' called Concepts. These Concepts eventually became the basis for Certification Testing and BIM Validation.

A large number of people and organizations have contributed to the content of this document, which can best be characterized as an attempt to harmonize and connect different ideas and efforts related to implementing support for the IFC based data exchange in software products, as well as the practical use of such software in building industry projects. Anyone active in this area has contributed in one way or another, especially people involved in buildingSMART and BLIS.

IDM acknowledgements: Jeffrey Wix played a central role in developing the methodology behind Information Delivery Manuals. Several other persons have contributed to the development: Janne Marit Aas-Jakobsen, Kjetil Espedokken, Ole Kristian Kvarsvik, Mark Bew, Lars Christensen, Dianne Davis, Bill East, Eilif Hjelseth, Ole Kristian Kvarsvik, Gang Lee, Thomas Liebich, Celson Lima, Henk Schaap, Richard See, Bjorn Stangeland, Rasso Steinmann and Justin Wong. buildingSMART activities in Norway have funded significant parts of this development.

MVD acknowledgements: Development of the official IFC Model View Definition format was initiated by a proposal from BLIS at ITM Summit #29 in Madrid, February 2005. That proposal and work completed between 2005 and 2008 was led by Jiri Hietanen (author of v1 & v2), and made possible through funding from the Finnish VBE2 project. In the first stage Kari Karstila and Jeff Wix contributed to the harmonization work between the approaches of BLIS, ProIT and IDM. Others who had significant influence include: Janne Marit Aas-Jakobsen, Kjetil Espedokken, Ole Kristian Kvarsvik and Sakari. Valuable feedback was provided by: Vladimir Bazjanac, Chuck Eastman, Kent Reed and Richard See from the BUILDINGSMART Technical Advisory Group. In addition a large number of people actively participated in related meetings, online training sessions and presentations, creating and refining the material which defines MVD. From 2008 to 2011, continuous improvement of MVD tools, templates and coordinating MVD Concepts database was funded and managed by The BLIS Consortium. Published MVD documentation has been continuously hosted on the BLIS website.

# 4. An Integrated Process

This work integrates the development process and deliverables for IDM and MVD. It also identifies certification testing and end user BIM Validation based on requirements defined in IDMs and MVDs as necessary activities to insure industry use.

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[7] Information about ISG can be found at: http://buildingsmart-tech.org/implementation

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The IDM process is now an ISO standard[8]designed for use by industry workgroups, but the process currently defined in the ISO documents is somewhat different than what is defined here – as the process and deliverables have been harmonized with those in use for MVD in order to arrive at an integrated process.

In this integrated process, industry workgroups define scope, workflows and requirements for Information Exchanges.   Additionally, workgroup instructions have been produced in 2010-2011.[9] This documentation includes templates for IDM narratives, workflow diagrams, and exchange requirements.  The US documentation identifies reference standards, which add more structure to the narrative and scope documentation for IDMs.  Additionally, tools for IDM automation are being developed.

There is a harmonization around the terms *Exchange Concepts*, *Functional Parts*, and *Exchange Objects*. In the future **Exchange Concepts** will be the preferred term, which is defined in the section for IDM Deliverables.

## 4.1. Process Overview

The integrated process defined in the remainder of this document is largely based on agreements forged in meetings between August and October 2007.  The process was first presented to the buildingSMART International Technical Management (ITM) committee during the November 2007 meetings in Brisbane, Australia.

An integrated IDM/MVD process has four phases and involves several participants.
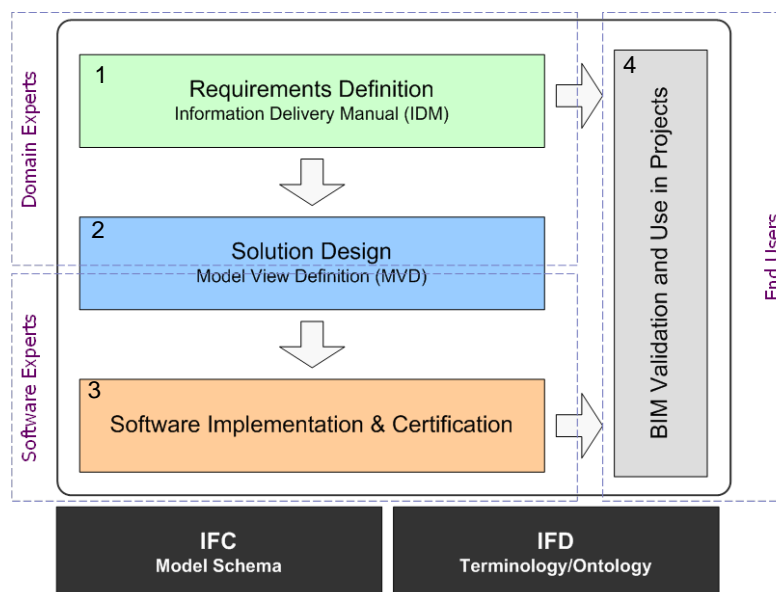


Figure 1 – Four Phase Integrated Process

The following sub-sections will provide an overview of the participants, templates, tools and deliverables for each of these phases.  More detail is provided in the sections later in the document – one each for each of these phases.

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[8] ISO 29481-1:2010 specifies a methodology and format for the development of an information delivery manual (IDM).

[9] IDM Workgroup Instructions BSa 2011

### 4.1.1. Requirements Definition – IDM – An industry led activity

The IDM process begins when AEC industry domain experts form a working group to develop an IDM for a specific process that would benefit from an IFC based information exchange. There are four deliverables in an IDM. The first task is to develop a consensus document or business use case for the target industry process. This use case identifies the process participants, points at which information content and format must be exchanged, and for what purpose. Next Process Maps are created using standard Business Process Modeling Notation[10] (BPMN) templates. This notation also supports the nesting of sub-processes.
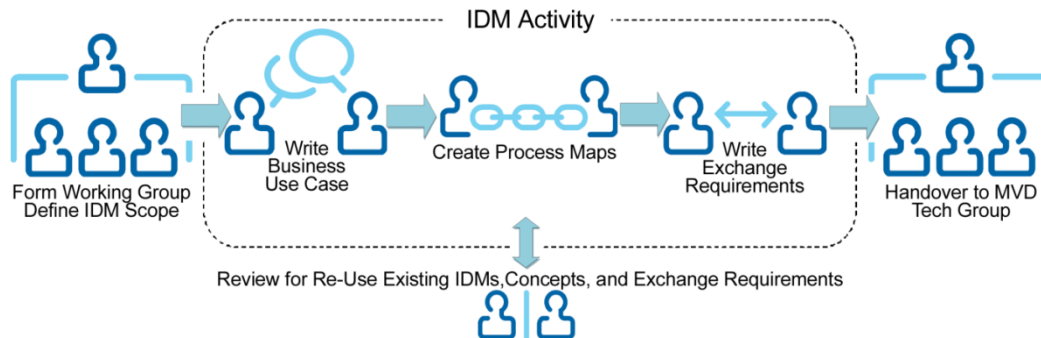


**Figure 2 Identifying processes that should be supported by IFC based data exchange**

Exchange Requirements document the data to be included in each information exchange identified in the process map. These are normally documented in tabular or spread sheet applications[11]. Finally, a series of entity relationship diagrams[11] – called an Exchange Requirements Model (ERM) are developed for each high level object in the information exchange (e.g. Project, Site, Building, Building Story, Space, Wall, Door, Window, etc.). The building blocks of ERM diagrams are Exchange Concepts, each of which defines the information to be exchanged, the data type, minimums, maximums, defaults, etc. Existing Exchange Concepts are tracked in a coordinating database[12] so that they can be reused across many IDMs and linked to MVD concepts that define a solution for exchanging the data in software. Through this link, we are able to verify if an IDM fully satisfies the information exchange requirements of the ERM.

### 4.1.2. Solution Design – MVD

A Model View Definition (MVD) document the subset of the IFC Model Specification that is required for the information exchanges defined in one or more related IDMs. The MVD is the 'for software providers to support industry defined IDMs in software products.

MVDs include three primary deliverables, each using standard formats. These are:

- MVD Overview/Description which describes the scope of the MVD
- MVD Diagrams which define the MVD Concepts that will be used in the exchange, as well as the structure and relationships between these Concepts,
- Concept Implementation Guidance specifications which define the IFC entities used to exchange each concept and the Implementer agreements that generally reduce the implementation scope that would otherwise be required by the IFC schema.

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[10] Information about BPMN can be found at: http://www.bpmn.org/ Are we going to use the document from Jeff Wix on this- with updates?

[11] See examples of ER tables and ERM diagrams at: http://blis-project.org/IDM-MVD

[12] Current coordinating DB for Exchange Concepts is at: http://blis-project.org/IDM-MVD

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To date, MVDs have been defined primarily for implementation of information exchanges using IFC. The process and formats defined in this document covers the same scope. However, it is important to understand that MVDs can be used to define information exchange using any information model schema. This means that adopting organizations are free to experiment and prototype with other models, in addition to IFC.

In defining Model Views the goal is to find a useful balance between the wishes of the end user and the possibilities of software developers, and documenting the outcome clearly. The IFC Model View Definition Format is used for documenting this outcome.

The format must be well defined and unambiguous, but the format is only one part of what is needed. All of the following have been considered and addressed.

- **Format**: The type of data that needs to be captured and how that data is structured

- **Content**: The data that is needed in a specific case. For example the IFC Schema is content that is captured using the EXPRESS format and an IFC Model View Definition is content that is captured using the IFC Model View Definition format.

- **Process**: The roles and responsibilities of different involved parties, for example how a model view definition is endorsed, published, and how certification is organized.

- **Tools**: The tools used for creating content, e.g. defining concepts and concept diagrams, and managing the process of creating content. Tools are highly important, but the format itself must be independent from any specific tools.

Although the format is, in theory, independent from the other parts it must in practice support all of them. It is also clear that the format is not the full answer, but having a commonly agreed format is the starting point. Without a common format it is very difficult to reuse content and tools, or to define a clear process. You will learn about the templates for deliverables in the detailed section that follow.

### 4.1.3. Software Implementation and Certification

Even after requirements have been defined in the form of an IDM, and an implementable solution has been defined in the form of an MVD, the solution cannot be used in projects until it is supported by at least two software applications – the sender and receiver of the exchange. Support for vendors looking to implement support in their software products is important. Both ISG and BLIS have done a reasonable job of this in the past, but it can be improved, especially in the form of better documentation of implementation requirements, and in the form of tools that can be used by vendors during their development (see detailed section).

However, implementation support is not sufficient to ensure to end users that they will have a reliable exchange of BIM information in their projects. To ensure such reliable data exchange, third party testing and certification of software products is required.

Software certification testing for export requires that the vendor create certain test cases (BIMs) which include all data configurations required in the exchange. The Certification Test software then load the test case files and checks each object instance against the requirements defined in the IDM/MVD. Conformance reports are generated by the testing software, reporting the success/failure of the exporting application in a manner that can be published for end users to review. Software certification testing for import is more complex because it requires evaluation of how the importing application has interpreted and uses data in the exchange. At this time, import testing cannot be fully automated in the ways that export testing can, so the judgement of a testing expert is required.

To date, Certification Testing for IDMs/MVDs has been based on a combination of the following: MVD Diagrams XML, Concept level Implementation Guidance documents, and Business Rules from the ERM. This has involved human translation of these requirements into testing software. Earlier this year, a group in the German Speaking chapter of buildingSMART proposed an approach that would capture all of this information into a single XML file such that human interpretation of the requirements would be significantly reduced. The schema for this XML data is called mvdXML. This should reduce any differences in testing that might have resulted from alternative implementations based on the current approach, but most likely will not be implemented in testing software until 2012.

This type of testing is very detailed and specialized. In virtually all other industries, such testing is done under contract or by appointment of companies/organizations that specialize in this type of testing. Both buildingSMART and BLIS are well advised to contract or appoint have historically contracted third party testing services that they believe will provide the necessary level of quality and reliability. Examples of third part certification testing that have resulted in certified applications used in building industry projects. buildingSMART has endorsed the Institut for Applied Building Informatics[13] (iabi) at the University of Applied Sciences Munich campus to provide third party certification testing for the Coordination View of IFC (both versions 1 & 2). Similarly, several national property management organizations, including the General Services Administration (GSA) in the USA, Statsbygg in Norway, and Senate Properties in Finland have endorsed Digital Alchemy[14] (a BLIS member company) to provide third party certification testing for 6 MVDs. These include: the Concept Design BIM 2010, the Design to Spatial Program Validation view, the Design to Energy Analysis View, the Design to Quantity Take-Off for Cost Estimating view, the Design to Circulation/Security Analysis view, and the Nordic Owners Energy Analysis View (see the BLIS IDM/MVD website[15] for details on each of these).

### 4.1.4. BIM Validation and Use in Projects

Certification Testing is necessary for reliable data exchange, but not completely sufficient. This is because the software used to create the BIM to be exchanged is not the only determinant of the information in that exchange. The end user is just as important (if not more) in forming the data to be exchanged. If that end user does not follow instruction provided in the BIM Guide for the exchange (see overview of IDM above), then the exchange may not meet all requirements defined in the IDM. Therefore, even when certified applications are used, testing should be done for each individual BIM exchange in projects. This is called BIM Validation. This testing validates that the exporting application has met all software requirements, that the end user has used that software correctly, and that the user has met all end user requirements, including business rules, in creating the BIM to be exchanged.

As with Certification Testing for IDMs/MVDs, current testing is based on a combination of: MVD Diagrams XML, Concept level Implementation Guidance documents, and Business Rules from the ERM. The phase 3 version of mvdXML, once it is complete, should improve consistency across multiple implementations of BIM Validation testing.

BIM Validation in projects will become increasingly important as project agreements begin to require the use of BIM exchange between project participants. In these cases, both sender and re-

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[13] See – http://portal.bau.hm.edu/IABI

[14] See – http://digitalalchemypro.com/html/services/services.html

[15] Details for 28 MVDs can be reviewed at: http://www.blis-project.org/IDM-MVD/

ceiver will want to have third party validation that the contracted data exchange has been delivered.

As with software certification testing, BIM Validation is highly specialized. Both buildingSMART and BLIS are well advised to contract or endorse third party providers of such services.

## 4.2. Coordination of IDM/MVD Projects

As shown in figure 2, there are multiple stakeholders involved in a project from IDM definition through to BIM Validation. If projects are not coordinated, it is very possible that multiple solutions are developed for the same industry processes. Additionally, without coordination it is inevitable that the processes/exchanges that are defined will overlap, when they should be linking and complimentary. Both buildingSMART and BLIS have made attempts at coordination in the development of IDMs and MVDs. This paper defines a process through which various organizations (beginning with buildingSMART International and BLIS) can coordinate, but are still encouraged to innovate.

### 4.2.1. IDM/MVD Coordination in BuildingSMART

To date, there has been activity at two levels of buildingSMART. buildingSMART International has long sponsored the development of the Coordination (Model) View, and has endorsed the iabi to perform certification testing for reasonable fees. Additionally, the buildingSMART alliance (in North America) has been active in the development of IDMs/MVDs by member organizations. Notable examples include the US GSA, the Precast Concrete Institute, and the US Army Corps of Engineers. These IFC based information exchanges will be published for use in industry through the US National BIM Standard (NBIMS) after suitable early implementations have been tested and verified.

So buildingSMART is active in promoting IDM/MVD standards at both the international and national (regional) levels. Member organizations at both these levels are encouraged to ensure coordination of their IDM/MVD projects with the appropriate level of buildingSMART. This is done not to control these projects, but to enable coordination, consistency, and maximum benefit to the building industry.

Contact points for such coordination include:

- IDMs -- International IDM Coordinator or National/Region IDM Coordinator
- MVDs – International MVD Coordinator or National/Regional MVD Coordinator
- Software Implementation – ISG Coordinator or National/Region Implementation Coordinator

Contact information for each of these roles can be found at the various buildingSMART websites.

### 4.2.2. IDM/MVD Coordination in The BLIS Consortium

IDM/MVD Coordination in The BLIS Consortium is done mainly through the BLIS IDM/MVD website[16], and through a series of tools that have been developed to make such coordination a natural part of the process.

Contact points for such coordination include:

- IDMs – BLIS IDM Coordinator
- MVDs – BLIS MVD Coordinator
- Software Implementation – Project Certification Testing organization or BLIS MVD Coordinator

Contact information for each of these roles can be found at the BLIS IDM/MVD website.

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[16] The BLIS Consortium coordinating IDM/MVD website is: http://www.blis-project.org/IDM-MVD/

### 4.2.3. IDM/MVD Coordination in Other Organizations

Any industry consortium or association can facilitate the development if IDMs and MVDs in order to enable IFC based BIM data exchange for its member companies. Examples that have already been active in this arena include:

- US GSA, Statsbygg (Norway), Senate Properties (Finland)
- American Institute of Steel Construction (AISC)
- Pankow Foundation
- Precast Concrete Institute (PCI)
- US Army Corps of Engineers/NASA

Ministry of Land, Transport, and Maritime Affairs (MLTM), South Korea Coordination of IDM/MVD development in these projects has been done through both buildingSMART and BLIS.

## 4.3. Organizational Endorsement

### 4.3.1. Endorsement of IDMs/MVDs

It should be clear that IDMs and MVDs can be developed for many different levels of standardization across the global AECOO industries, including:

- International – including buildingSMART, BLIS, or other international industry associations
- National – including buildingSMART or other national industry associations
- Multinational – including regional industry associations or groups
- Cluster– including large companies or groups of companies doing business together

Use of the process defined in this document should be encouraged at all of these levels. Those that are most used will naturally tend to float to the top – through industry use and growing software support.

Additionally, organizations at any of these levels may choose to publish their IDMs/MVDs on their organizational websites, or may choose to use site already developed by buildingSMART or BLIS. Any of these options is fine. The collective goal should be to increase the use of IFC based BIM data exchange in building industry projects.

### 4.3.2. Endorsement of Certification and BIM Validation Testing

As stated elsewhere, it is highly unlikely (and possibly ill-advised) that any of these organizations try to develop Certification and BIM Validation testing themselves. It is much more practical for them to provide unambiguous definitions for what must be tested to companies that specialize in such certification testing. The recently proposed MVD-XML is an example of how such testing requirements could be provided to such testing agencies.

Both buildingSMART and BLIS should seek out such testing agencies and work to develop an eco-system of end users, software vendors, and member organizations that will encourage the testing agency to develop the certification testing speculatively. Funding of such development is cost prohibitive for both buildingSMART and BLIS. The two examples cited above (GTDS for Coordination View and Digital Alchemy Testing Service for several other IDMs/MVDs) prove that this is possible. This approach is, of course, also available to organizations at the other levels of standardization listed above. In fact, endorsement at these various levels is a path to developing the eco-system that will be necessary to support such speculative development.

# 5. Developing an IDM
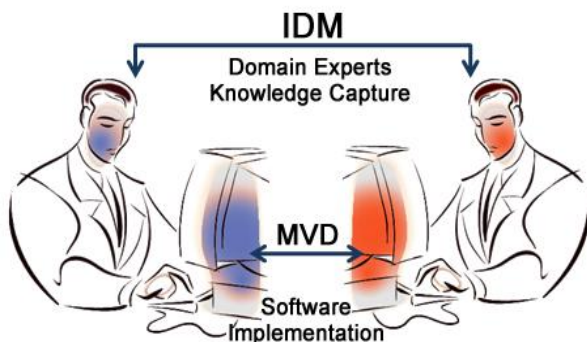


The Information Delivery Manual (IDM) process provides a universal, repeatable, and verifiable methodology for creating information exchanges by industry professionals. This level of standardization helps BuildingSMART Chapters, and interested industry workgroups develop useful explanations of process needs with an appropriate level of data and format specificity suitable for handover to a Model View Definition (MVD) software implementation group. Additional advantages of the IDM process include the re-use of IDM content across workgroups and consistent content for streamlined MVD creation by software vendors implementing many exchanges overtime. Finally the guidance in an IDM supports industry best practices.

It is the goal of the IDM methodology that industry professionals, with as little supervision as possible, capture their knowledge and needs utilizing the templates and instruction provided in the IDM process. BuildingSMART Chapters may provide additional regional information that may be necessary or advantageous through a localized workgroup supplement document. [17] Chapters should have an IDM Coordinator to provide guidance when necessary. Additional IDM expertise and technical resources should be available as needed. [18]e.g. to judge if the required information are specified in the preferred schema or not. In the case of the buildingSMART data model IFC it should be recognized that if the needed information not already are included in the specification it can be a time consuming process before the required information are a part of an official IFC release.

It is not from a technical or use case point of view necessary to have business managers or change agents involved in the team, but it is important to remember to have somebody to be responsible bringing the idea of a digital supported workflow into practice since implementation in most circumstances not are straight forward process.
IDM activities are typically organizational and regional at their inception; however mechanisms and requirements are in place to advance an IDM to an international level in buildingSMART.
http://iug.buildingsmart.com/idms/approval-of-idms

## 5.1. Required and Recommended Experience for IDM Workgroup Participants

**Domain Experts**
The main purpose of an IDM development is to identify and document the exchange process, workflow, data sharing, data format and content requirements for an industry activity to be imple-

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[17] The US has created such a document in 2010 supporting OmniClass and other NA standards use in IDM creation.

[18] A list of IDM persons capable of leading IDM development

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mented in software.  Therefore, involvement and commitment by experts in the specific exchange domain/s is required to generate the appropriate industry perspective and knowledge.

### Additional Expertise

If an existing workflow is generally non-digital in the industry, then an IDM team may wish to include persons aware of the benefits and technological capabilities for a digitally supported workflow.  This may be an industry professional, one of the domain experts using an automated process, or software providers, however, an IDM is not vendor specific.

### Workgroup Leadership

It is advisable that a domain expert be workgroup leader. The leadership may be shared across domain experts and with technical expert support.  Requirements of workgroup leadership include:

- following the IDM methodology to produce the necessary products for IDM submission
- insure products are thoroughly reviewed for process, content, format, and completeness
- Determine whether extensions to the IFC model are needed to meet the IDM data requirements
- Submit to approval process for official (starting at regional or national) recognition of the IDM

# 6. IDM Deliverables

There are several documents that define an IDM.  These include:

- Business Case
- Process Map
- Exchange Requirements (tables)
- Exchange Requirement Model
    - Description
    - Diagrams
    - Exchange Concept Definitions

Each of these is described and examples given in the following sections.



Figure 3- IDM Deliverables

## 6.1. Working Group Scope Process

Having defined an area of need, the working group determines the project or lifecycle process to be satisfied. The process should be manageable given the working group timeframe and resources. This process scope provides a context for the IDM Business Use Case narrative.

The IDM scope should identify if any software tools already support the process. If IFC interoperability is needed then the working group should determine if the IFC model supports the exchange requirements or extensions are needed.

### 6.1.1. Use Case Discovery

The working group shall determine if the IDM covers an existing process to be enabled/modified by the exchange, or if it is a new process because of technology advances, interoperability needs, analysis capabilities, or information management.

### 6.1.2. Review IDMs, Concepts and Model Views

IDMs, concepts, and model views exist for re-use by working groups. The working group shall determine if an IDM, MVD, or concepts already exists for a process. This is coordinated with the IDM chair and review of the IDM website.

### 6.1.3. Use Case Narrative

The business use case is a plain language narrative description of the industry process, as subject of the IDM.  A use case can be a single exchange of information between two parties (share architecture model with engineer), an iterative activity across time with increasing detail (space validation), or one contributing to the greater network of information developed during a project or the building lifecycle (estimating). The use case provides the scope, context, rationale, level of detail (LoD), and projected outcome for use. The working group scope defines the boundaries for the business use case.

### 6.1.4. Writing the Business Use Case Narrative

The essentials of the use case narrative are the problem statement, which identifies an industry need, a general description of the workflow, the participants, and the information content and flow necessary to achieve the desired outcome.  A first draft on the narrative allows for multiple views or needs of the various parties in the process.  This draft may be expanded or reduced depending on the final IDM scope. The workflow explains in general terms *when* and *how* the interaction between parties (*who*) achieves the desired outcome.  It provides an overview of what software services (ca-

pabilities) and information requirements needed. All IDM activities are in search of "best practices" for processes.

Use of industry terminology to structure language in Use Case – When possible, it is advisable for industry terms to be standardized within the IDM, specifically the IFC Phases, Participant Names and Disciplines, Activity or Service Name. Terms can be found in regional classifications (Omni-Class in North America) and the IFD Library. These terms will be used in all the deliverables.

### 6.1.5. Process Map

A process map is a visual representation of the logical and sequential flow of activities and information exchanges described in the IDM Use Case. The purpose of a process map is to gain an in-depth understanding of the relationships between the activities (processes) to achieve the outcome, the actors involved, and the information required, consumed and produced. The *QuickGuide toBPMN at http://iug.buildingsmart.com/idms/methods-and-guides* provides working groups with an overview of process mapping for IDM creation typically using a Visio template provided or other BPMN tools.

A process map:

1. has a desired outcome (Ex. Quantity Take-Off)
2. has specific inputs (typically from other exchange requirements and from other data sources)
3. has specific outputs (typically to other exchange requirements)
4. uses/requires resources
5. has a number of activities that are performed in some order or sequence
6. may affect more than one organizational unit
7. creates value of some kind for the customer

For the IDM, the process map:

- Sets the boundary for the extent of the information contained within the process
- Establishes in detail the activities within the process and their logical sequence
- Identifies the exchange requirements that support the activities within the process
- Enables reference processes to be determined.

The actual information that is within the process boundary is determined by the contents of the exchange requirements that support the activities within the process.
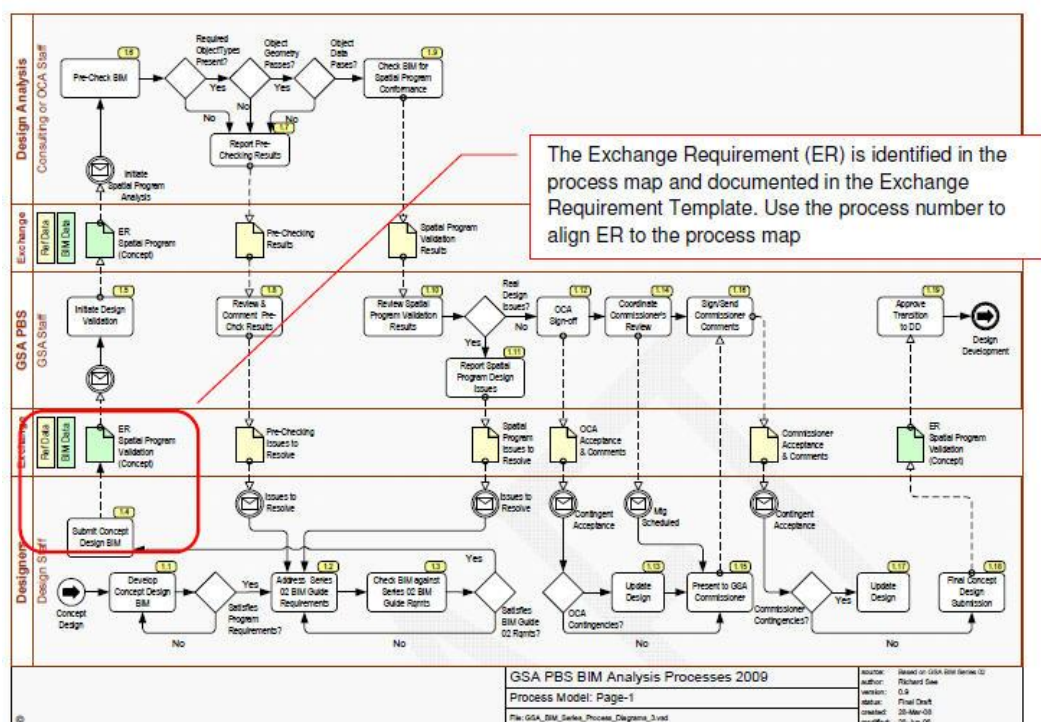


Figure 4 - Courtesy Digital Alchemy/GSA

| Page no. | Document title |
|---|---|
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### 6.1.6. Use of Reference Processes

IDM and MVD work has produced re-usable content. A reference process is an identifiable basic unit of a process map (or an activity) that can be considered to have a universally consistent definition both in terms of its meaning and its attributes/properties.
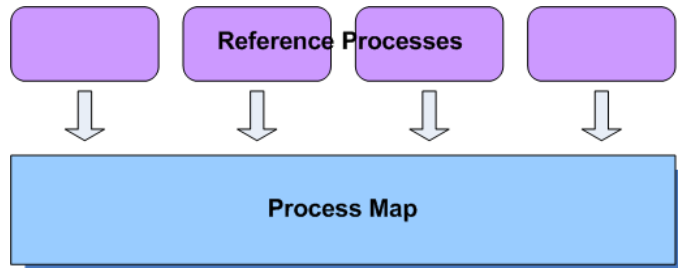


Figure 5- Reference Process Re-Use

A reference process exists as a process type. A reference process may have many process occurrences within a building construction project.

The purpose of capturing a reference process is to support the progressive definition of a reference process library from which future industry standard and locally specific (including project specific) process maps can be developed. In the case of project specific process maps, it is considered that a set of reference processes can form a process ontology that can be used, with the addition of planning durations or schedule times, in the creation of a project plan and/or schedule
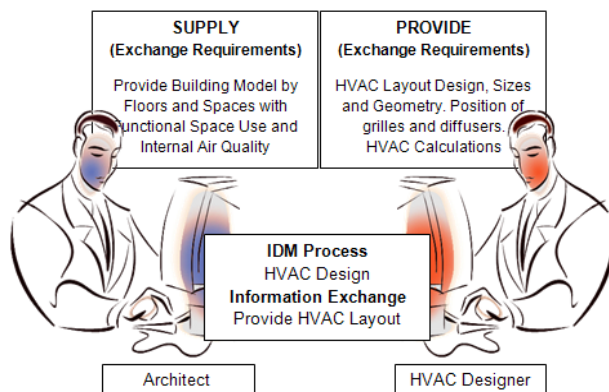
### 6.1.7. Exchange Requirements



Figure 6 - Example Exchange Requirement

An exchange requirement documents the information needs between two or more parties to be exchanged in support of a particular business requirement at a particular stage of a project. An exchange requirement represents the connection between process and data. It applies the relevant information defined within an information model to fulfil the requirements of an information exchange between two business processes at a particular stage of the project.

An exchange requirement might be simple as in the case of an order that results from a purchasing process enabling a supplier to provide the required components. Alternatively, it might be complex as in the case of an architect providing a basic building model to an HVAC consultant to enable thermal analysis calculations to be undertaken.

Typically, for IDM as presently established, the set of information should be defined within the IFC model. However, the IDM approach will also work with sets of information defined within other industry standard models such as the Geographic Mark-up Language (GML) as defined by the Open Geospatial Consortium (OGC).

An exchange requirement provides a description of the information supporting the exchange in non technical terms. The principal audience and creator of an exchange requirement is the user (architect, engineer, constructor etc.). It is used by the MVD team sand solution provider as it provides the key to the technical detail that enables the solution to be provided.
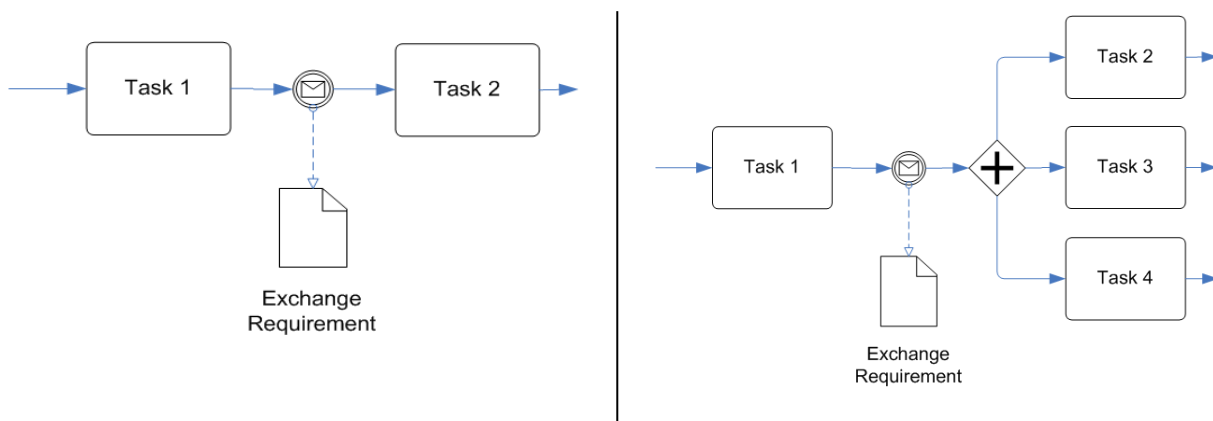
**Figure 7 Exchange Requirement notation for single and multiple downstream tasks within Process Map**

An exchange requirement is shown on the process map as the target of a message from a 'message driven event' in the IDM extensions to the BPMN notation.  An exchange requirement may provide the required information for multiple downstream operations. This is shown using an 'AND' gateway in the above process model. For instance, a space model provided by a building designer may be used in energy analysis, HVAC design, and structural design.

### 6.1.8. Exchange Requirements Documentation

As the name implies, an exchange requirement documents the information shared between parties and applications or any additional referenced information required for a process identified in the IDM. **Example**:  A schematic column grid would be information shared by the architect to

**Figure 8- Courtesy GA Tech - geometric representations and functional capabilities**

a. surface model — loose surfaces not tied together-- is not editable, is viewable, allows surface measurements but not volume

b. boundary representation — surfaces well formed to enclose a volume - - not easily editable, but supports clash detection, measurements and mass properties

c. sweep model — closed polygonal face swept along a path -- polygon points and path parameters editable, easily converted to B-rep

d. constructive solid geometry — tree of sweeps, added and subtracted features, combined with union/intersection operations -- all features & sweep parameters editable, easily converted to B-rep

the structural engineer. In an exchange, the data is defined to a Level of Detail (LoD) including geometry and attribute or property data for objects and elements. The ER template defines the types of objects and elements needed for the exchange and their properties/attributes as necessary to satisfy the use case. The geometry requirements should be identified in the exchange requirements.

### 6.1.9. Exchange Requirements Model

An exchange requirement model is the technical solution of an exchange requirement. It provides a complete schema that can be supported by a software application for the exchange of information for a particular purpose, at a particular point in time on a project, and at a particular location. That is, it satisfies all the conditions for supporting a project workflow according to the rules and methods of working defined for a region, country or framework agreement.

An exchange requirement model is a specific technical solution developed from and for an exchange requirement. However, the exchange requirement model is dependent of the release version of the information model from which it is derived, e.g. releases of IFC. Therefore, an exchange
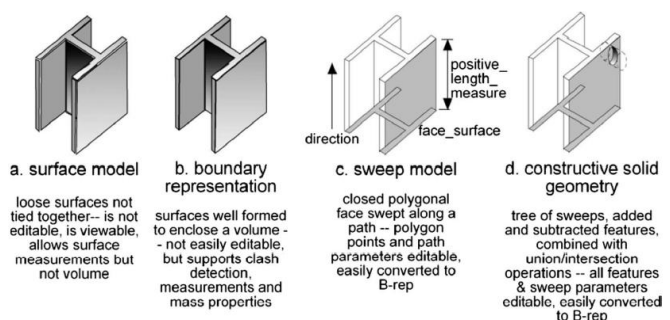
requirement may have several exchange requirement models as technical solutions, each technical solution supporting a particular release of the information model.

| Project Stage | What is the Omniclass design stage? |
|---|---|
| Exchange Disciplines | Who are the parties to this exchange?<br>By Omniclass discipline number and name?<br>(can be >2 disciplines, but using the same basic data.) |
| Description | Verbal description of:<br>1. The purpose of the exchange<br>2. The required contents of the exchange<br>3. The optional contents of the exchange<br>4. Example software in the exchange<br>5. Whether the exchanges are round trip or one-way |
| Related Exchange Models | Other exchanges this one interacts with (proceeding and succeeding exchanges) |

Figure 3: Exchange model content example (Eastman et al. 2009)

| Preliminary Structural System Design | |
|---|---|
| Project Stage | 31-20-10-00 Preliminary Project Description |
| Exchange Disciplines | 33-21-00-00 Architecture<br>33-21-31-14 Engineering<br>33-25-41-11-11 Building Product Manufacturing |
| Description | 1. Purpose is to define/review basic structural system design, in terms of span directions, vertical transfers, major bracing, foundation pads<br>2. Architectural concept model involves basic spatial layout of the building including external skin and building shape. It should identify potential locations for vertical load transfers.<br>3. It might involve major architectural finishes, structural system selection, structural grid and site analysis.<br>4. Revit, Archicad, SDS/2, Tekla, STAAD Pro, RISA, ETABS<br>5. May be one-way or round trip |
| Related Exchange Models | A_EM.1, P_EM.1, S_EM.1 |

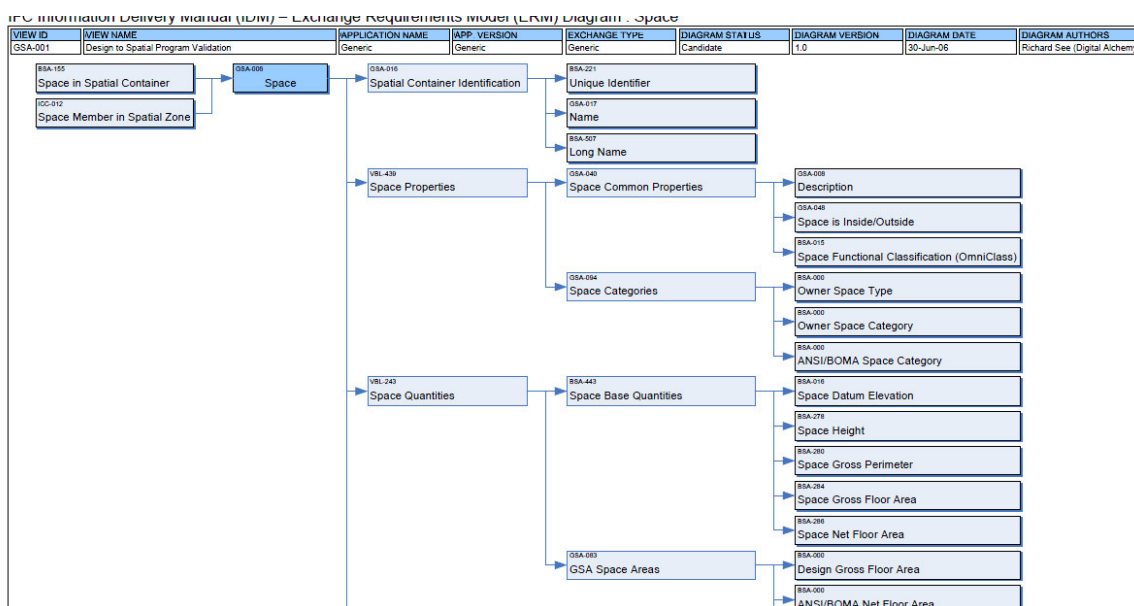**Figure 9 - Courtesy GA. Tech, USA**



**Figure 10 - Courtesy Digital Alchemy/GSA**

### 6.1.10.    Exchange Concept Use in IDM

An exchange concept focuses on the individual actions that are carried out within a business process. An action is concerned with a particular unit of information within an exchange requirement. For instance, to exchange a building model, it is typical necessary to model the walls, windows, doors, slab, roof etc. The action of modelling each of these elements is described within an exchange concept.

Each exchange concept provides a detailed technical specification of the information that should be exchanged as a result of the action. Since that action may occur within many exchange requirements, it follows that an exchange concept may also relate to many exchange requirements. For this reason exchange concepts are specifically designed to be reusable within many exchange requirements. However, certain exchange concepts deal with more general ideas and may be expected to participate more frequently. Examples include exchange concepts dealing with relation-

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|---|---|
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ships (such as applying a classification to an element) or those dealing with geometric shape representation.

This is a very important idea within IDM since it provides the basis for the idea that the technical support of an exchange requirement can be provided by 'shopping' for a basket of exchange concepts that can then be compiled to provide the exchange requirement model schema.

Exchange concepts describe an action in close detail. Whereas an exchange requirement describes information in non-technical detail, exchange concepts describe the use of every entity, every attribute, every property set and every property concerned. Because of the detail included, exchange concepts can also be broken down into other exchange concepts. That is, an exchange concept may call on the services of other exchange concepts in the same way as exchange requirements.

### 6.1.11. Business Rules in IDM Creation

Business rules describe operations, definitions and constraints that may be applied to a set of data used within a particular process or activity. They enable controls to be applied to:

- use of specific entities,
- attributes and properties that must be asserted (or not asserted),
- values, ranges of values or value limits that should be observed,
- dependencies between entities or attributes or attribute values.

Business rules can be used to vary the result of using an information model without having to change the information model itself. This provides the model with agility so that, through the application of different sets of business rules to the same information model, different local applications of the model can be defined.

Note that it is possible to add to, amend or even delete business rules without affecting the underlying information model.

Business rules may be expressed as formal propositions in terms of their actions on exchange requirements. However, they must be expressed in an appropriate coded form for specific actions on the concepts that are contained within an exchange requirement.

An example of a business rule expressed as a proposition is the requirement that 'the area of a space whose type is "Executive Office" must be greater than or equal to $10m^2$'. In this form, it is applicable to the exchange requirement. When applied to a concept, this is coded in the logical form appropriate to the manner in which the attribute/property is expressed.

In IDM, a technical expression of an exchange requirement can be derived by compiling the constituent concepts. This defines a coherent schema that can be used as a specification for information exchange within the scope of the exchange requirement.

However, IDM also seeks to provide a finer degree of control over information exchanged such that it can be applied in national, local or even project contexts. It does this through the provision of business rules that can act on the content of an exchange requirement model.

The primary intention of a set of business rules is to enable an exchange requirement model to be modified and tailored to a specific business need. For instance, a generic exchange requirement model may be developed for a particular purpose (e.g. cost modelling at the detailed design stage of a project). Business rules can configure this requirement so that it is specific to a place without having to actually change the schema underlying it. For instance, two different sets of business rules might be applied to a single exchange requirement model to e.g.:

- cost modelling at the detailed design stage of a project in UK
- cost modelling at the detailed design stage of a project in Norway

Business Rule Validation – Business rules are documented in two ways so that conformance can be verified in real projects exchanges. The Generic BIM Guide for the exchange informs the user of the rule, as normally the user provides the data that must adhere to the rule.

| Rule Id | Name | Proposition | Allowed Value |
|---------|------|-------------|---------------|
| DK-GOV-Area_Rule01 | SpaceMustContainValidClassification | Ensure on valid values for classification of spaces are used. | Standard list of space functions provided by the Palace and Properties Agency in Denmark |

Figure 11 Sample of a Business Rules

### 6.1.12. Generic BIM Guide

A Generic BIM Guide should be developed for every IDM/information exchange. The BIM Guide provides "How-To" and best practice information for users of certified applications that support the exchange. Generally, it is based on information developed in the IDM narrative, the process map, information exchanges. At the point in time when this guide is developed, no applications will yet support the exchange, so it can only be 'generic' in its description of what the user needs to do. Often, it is focused in defining for the end user:

- The objects that must be included in the exchange
- The properties that must be defined
- The reference standards that must be applied (e.g. classification standard to be used in this exchange)

Later in the integrated process, vendors of applications that become certified are strongly encouraged to develop application specific BIM Guides that can include instructions and screenshots that are specific to that application.

## 6.2. Reusable Exchange Concepts

The main enabling mechanism for re-use of 'packages of data to be exchanged' is Exchange Concepts. All advanced view definition formats make use of this idea; including ProIT, pre-integrated IDM and pre-integrated MVD. The core idea is: commonly useful packages of information are identified in the Exchange Requirements Model as Exchange Concepts. The technical solution for exchanging them in software (bound to IFC model entities) is called MVD Concepts.

Exchange Concepts are independent from any IFC Model View Definition. Technically an IFC Model View Definition is created by choosing (or defining) a group of concepts and defining their relationships. For example a "rectangular profile" concept could be selected into an IFC Model View Definition, but defined to only be used with beams and columns, not spaces and walls. Another form of re-use is to separate the idea of a concept from the IFC binding of that concept. This makes it possible to re-use the same concept ideas when the underlying IFC Model Specification changes. For example the idea of a "space name" does not change if moved at some point from IfcSpace.LongName to some other location in the IFC Model Specification.

In the integrated IDM-MVD process Exchange Concepts are independent of IFC and color-coded with blue whereas the MVD Concepts that are bound to an IFC schema are orange.

Although not a part of the IDM/MVD formats, software tools are highly important for re-using definitions. These formats defines a system which makes it possible to re-use definitions, but tools can make it much easier to know what has already been defined. Tools also help share the definitions

with large groups making it less likely that the same definitions are reinvented.  Example Tool Sets are listed in Appendix C

## 6.3. IDM Coordination

Since most business process and exchange in the building industry, due to its project based nature, not are formalized it is necessary not only to follow the methodology specified in this document, but to define the desired processes and data exchanges. It is therefore almost inevitable for IDM developing teams to create overlapping IDM and difficult to agree on IDM at national or international level. Each IDM developing team should therefore work actively for coordinating their IDM initiative with other teams or organisations. buildingSMART has establish a network of IDM coordinators which can be found at idm.buildingsmart.org. buildingSMART is hosting a database of IDM project incl. contact information for project lead or regional IDM Coordinator.

If a team are seeking to become a official buildingSMART IDM they should contact the regional or international IDM coordinator that will assist the team to make preparations for submission as an official buildingSMART IDM.  Official buildingSMART IDM are published at idm.buildingsmart.org.

Teams are encouraged to related their IDM to the project stages according to ISO 22263 in order identify where in the lifecycle of a building an specific IDM is belonging to. Teams should also indicate for each IDM to whom the IDM is relevant.

A key aspect in reusing parts of an IDM, simplifying implementation and data validation is to reuse Exchange Concepts whenever possible. This means that coordination across many teams developing IDMs and MVDs is very important.  It must be easy for any developer to find existing concepts and for them to register new concepts for others to find and reuse.

## 6.4. Exchange Requirements Model

The final stage in developing an IDM is development of the Exchange Requirements Model (ERM). The ERM is a diagrammatic representation of the Exchange Requirements – which show the packages of data to be exchanged (Exchange Concepts), the relationships between them, and the business rules that constrain some concepts – from an end user perspective.

It is important to study existing concepts and to re-use them whenever possible. Also the structure of existing definition (patterns) should be re-used as much as possible.

When the ERM is done, the IDM is complete and development of an MVD that can be implemented in software can be considered.

### 6.4.1. ERM Description

The purpose of the ERM description is to document the scope of the Exchange. It defines an overview of the exchange and is used as a discussion paper in the process of defining the ERM. The description should be limited to one page.

| Generic AEC/FM View Description | | | | | |
|---|---|---|---|---|---|
| Exchange Requirements Model Description Template | | | | | |
| **Reference** | <Reference field> | **Version** | <Version field> | **Status** | <Status field> |
| **History** | | | | | |
| **Authors** | RichSee | | | | |
| **Document Owner** | Digital Alchemy (www.DigitalAlchemyPro.com) | | | | |
| **Description** | | | | | |
| 1 - What type of data is exchanged between what type of software | | | | | |
| 2 - Diagram or picture explaining of the scope 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 IFC Model View Definition Format version 1.1.0. of buildingSMART | | | | | |
| Template Licensed for use in buildingSMART Projects –By The BLIS Consortium – All Other Rights Reserved | | | | | |

**Figure 12** MS Word template for the ERM Description[19]

| Field | Description |
|---|---|
| <Title field> | The name of the MVD |
| Reference | The reference number of the MVD.<br><br><Author ID>-<MVD number> |
| Version | The sequential version number of the MVD |
| Status | The status of the MVD.<br>Sample, Draft, Proposal, Candidate, Official or Deprecated |
| History | The history of the MVD, e.g. a version history |
| Document Owner | The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address. |
| Description | 1. What type of data is exchanged between what type of software<br>2. Diagram or picture explaining of the scope of the view<br>3. What is in scope for the view<br>4. What is out of scope for the view<br>NOTE: If a copyright is asserted this can be done in the description field. |

---

[19] ExchangeRequirementsModel_Description.dot

## 6.4.2. ERM Diagrams

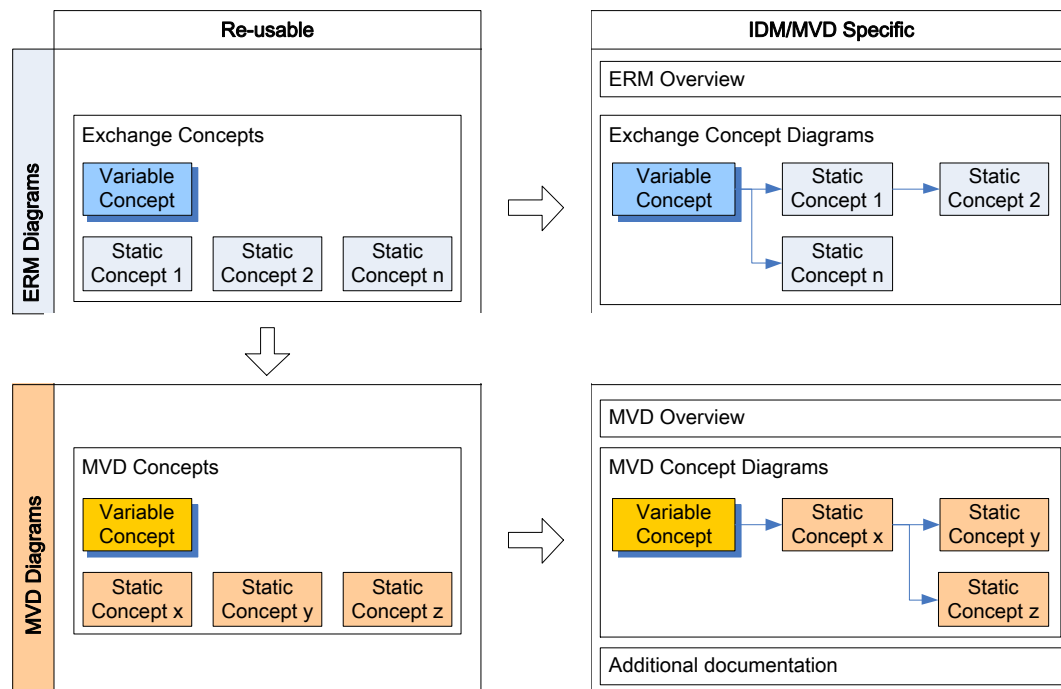6.4.2.1.1. ERM/MVD Diagrams Relationship



**Figure 13** Diagramming Formats Overview

As part of the integrating IDM and MVD, the IFC independent concept diagrams were moved to IDM and became the Exchange Requirements Model (ERM). The ERM serves as a machine readable version of requirements defined in the IDM -- that could be used later for BIM Validation.

Exchange Concepts in the ERM define re-usable packages of information to be exchanged. An ERM diagram defines the scope of data to be exchanged about a top level 'Variable Concept'.

MVD Concepts define a way to realize the Exchange Concept in software data exchange. An MVD diagram also defines the scope of data to be exchanged about the top level 'Variable Concept'. The top level concepts generally correspond between ERM and MVD diagrams, but occasionally some additional top-level concepts may be introduced in the MVD for software implementation purposes.

Both ERM and MVD will have 'Overview' sheets that describe the entire scope of the ERM/MVD. In this section we are focused on the ERM.

ERM diagrams define which of the re-usable Exchange Concepts are used in a specific ERM, and the relationships between those concepts. A diagram may for example define that walls can have a classification reference. ERM diagram headers are always shaded blue so that they are readily recognized. ERM diagrams should be understandable to industry practitioners (i.e. people without knowledge of IFCs or software implementation).

Exchange Concepts define data sets to be exchanged in generic terms. They may even be used to define concepts that are not exchanged through IFCs.

### 6.4.2.2. ERM Diagram Specifics

The format for ERM diagrams and configuration is defined by an XML schema[20].  These diagrams can be created manually, or using tool sets provided by vendors (see appendix C).

The XML schema for ERM diagrams supports three different styles, which may be combined into the same XML dataset

- **Definition**: the concepts used in a diagram and their relationships in the context of that diagram.

- **Configuration**: The status of the concepts (ON/OFF) and diagram specific comments for concepts.

- **Layout**: The position, visibility and other layout related settings of concepts in a diagram. The layout is typically specific to the coordinate system of the diagramming application (e.g. the MS Visio). Layouts are not part of the ERM format per se, but are important to the presentation of ERM diagrams.

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

Since the format for ERM diagrams is defined in an XML schema, there is no official page size or orientation. Large diagrams will require one 'page'.  That is: there is no provision for splitting a diagram over several pages. Some vendor diagramming tools have features to help accommodate large diagrams by hiding parts of the diagram in certain contexts.  Such settings are saved in the diagram layout, as explained above.

A separate ERM Diagram is created for each Variable (or high level) Concept in the ERM.

---

[20] ViewDefinition.xsd
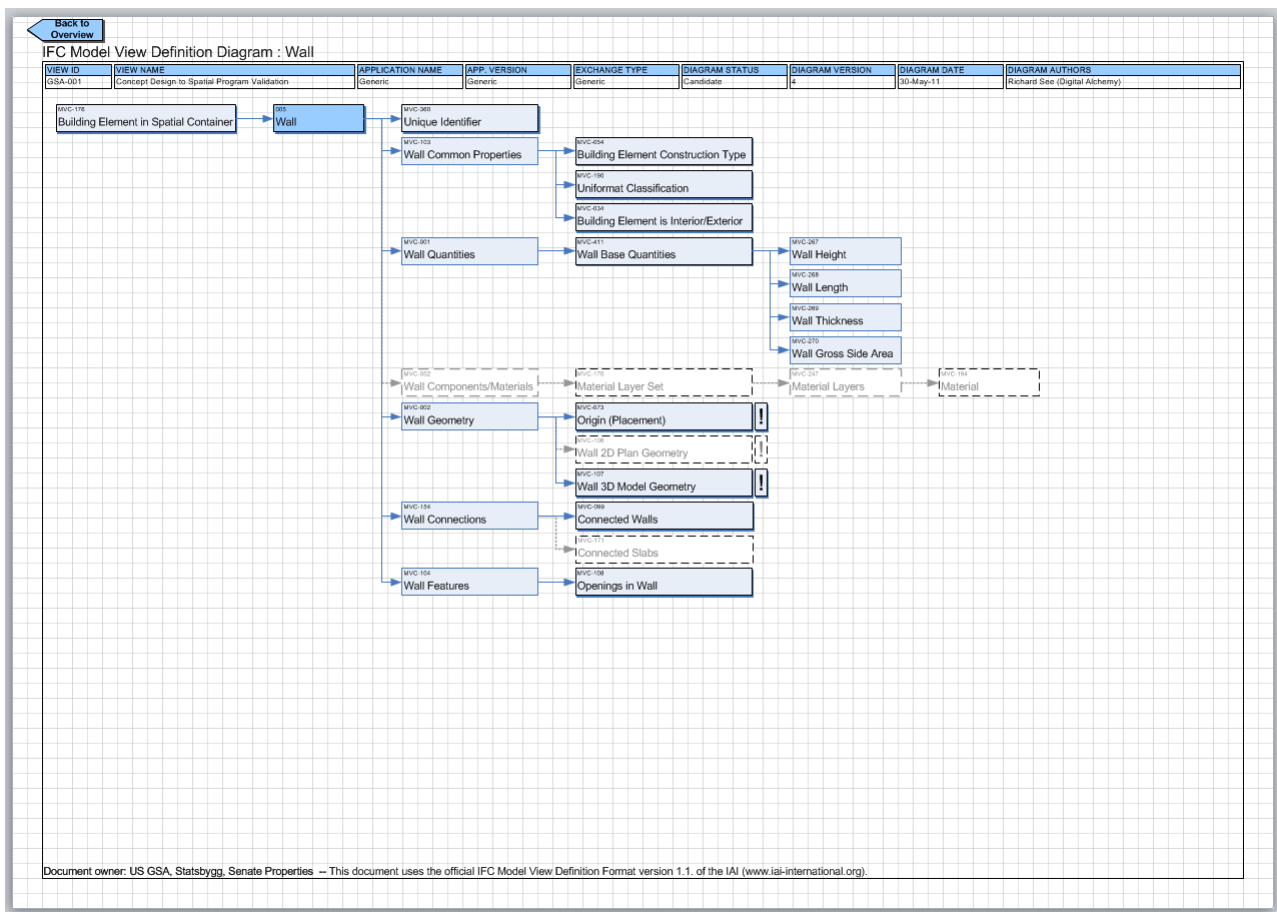
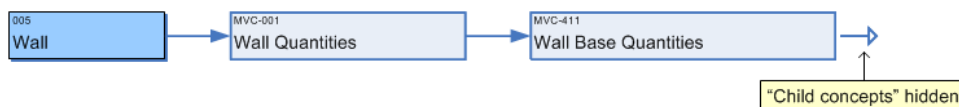**Figure 14** Example ERM Diagram

| Field | Description |
| --- | --- |
| Diagram name | The name of the diagram is the name of the variable concept of the diagram. The name is shown in the title. |
| View Name | The name of the MVD |
| Application name (optional) | The name of the software application for which the diagram is made. |
| Application version (optional) | The version of the software application for which the diagram is made. |
| Exchange type | Generic, Import, Export or Roundtrip |
| Diagram status | Sample, Draft, Proposal, Candidate, Official or Deprecated |
| Diagram version | The sequential version number of the diagram |
| Diagram date | The data the version of the diagram was completed |
| Diagram authors | The authors of the diagram |
| Document Owner | The person or organization responsible for maintaining the diagram. Should contain some contact information, e.g. email address. |

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

A concept may be marked as optional if it is not essential to the exchange, but desirable. Concepts are marked as optional by turning them off (light grey, dashed line boxes). Software may still be certified for support of the view if they don't support optional concepts, but may be more preferred by end users if they do support them.



Diagrams may be configured using two mechanisms: making concepts optional (turning them off) and adding comments to the concepts. Making concepts optional reduces scope. Commenting is used to make diagrams more specific or to enhance understanding about relationships or data included in the exchange. In addition diagrams may contain any text or graphical elements, but such elements will not be captured in the XML format generated from the diagram.
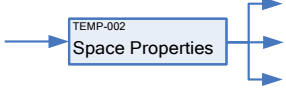


Large diagrams may be placed on one page by hiding concepts. Hiding a concept does not mean that it is turned off. Hiding is used purely for layout purposes.

## 6.4.3. ERM Concept Definition

### 6.4.3.1. Exchange Concepts

Exchange Concepts enable clear definition and reuse of data packages, as well as unambiguous requirements specification for that will be addressed by the corresponding MVD concepts(s) to be supported in software applications (see MVD section).

| Exchange Concepts | |
|---|---|
| Variable Concept<br><br>TEMP-001<br>Space | The same variable concepts can be used in different MVDs, but their content may vary. Hence the variable concept must be configured separately for each MVD. This configuration is done by creating a diagram in which other concepts (group and static) are attached to the variable concept.<br><br>Examples: space in quantity take-off, wall in HVAC design |
| Group Concept | Group concepts provide structure for the concept diagrams by grouping together static concepts and/or other |

| | |
|---|---|
| TEMP-002 Space Properties | group concepts.<br>Examples: space properties, wall geometry |
| Static Concept<br><br>TEMP-003 Space Number | Static 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.<br>Examples : space number, bounding box geometry |

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

**<Author ID>-<Concept Number>**

For example; TEMP-001, ABC-123

Please note: The Author ID "MVC" (Model View Concept) is assigned only to concepts that have been proven and are shared across multiple IDMs, as determined by the IDM Coordinator.

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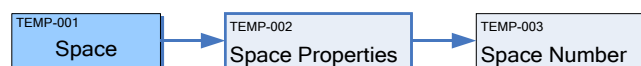


If the example above was from MVD with the Reference "TEST-01", the fully qualified name for "Space Number" would be.

**Test-01:TEMP-001:TEMP-002:TEMP-003**

### 6.4.4. Concept Documentation

There is a separate description document for each IFC independent and IFC release specific concept.

The official format for the documents is PDF. A Microsoft Word template is provided for creating the documents but any other software or system may be used as well.

In documents based on the template any field marked with <… field> should be edited through the document properties of the MS Word document.

#### 6.4.4.1. Exchange Concept Description
The IFC independent concept description contains the detailed definition of the concept.

| Generic AEC/FM Concept Description | | | | | |
|---|---|---|---|---|---|
| Exchange Requirements Model Concept Description Template | | | | | |
| **Reference** | <Reference field> | **Version** | <Version field> | **Status** | <Status field> |
| **Relationships** | | | | | |
| **History** | | | | | |
| **Authors** | RichSee | | | | |
| **Document Owner** | Digital Alchemy (www.DigitalAlchemyPro.com) | | | | |
| Usage in view definition diagram | | | | | |
| Definition | | | | | |
| This document uses the official IFC Model View Definition Format version 1.1.0. of buildingSMART | | | | | |
| Template Licensed for use in buildingSMART Projects –By The BLIS Consortium – All Other Rights Reserved | | | | | |

**Figure 15** MS Word template for the IFC independent concept description document [21]

| Field | Description |
|---|---|
| <Title field> | The name of the concept |
| Reference | The reference number of the concept.<br><br>          <Author ID>-<Concept number> |
| Version | The sequential version number of the concept |
| Status | The status of the concept.<br>Sample, Draft, Proposal, Candidate, Official or Deprecated |
| Relationships | Relationships to other concepts<br><br>   • Extends : the group concept the concept is based on |
| History | The history of the concept, e.g. a version history |
| Document Owner | The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address. |
| Description | The free form description of the concept, preferably only one page long. If a copyright is asserted this can be done in the description field. |

### 6.4.5. Transition to MVD

Once there all of the IDM deliverables have been developed and there is consensus among the developing team, it is time to begin development of the Model View Definition (MVD). MVD devel-

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[21] ConceptDescription_IFCIndependent.dot

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opment is much more technical work that requires expertise in software, the IFC schema, construction industry, and data modelling.

# 7. Developing an MVD

## 7.1. MVD Background

Traditionally IFC Model View Definitions have been understood as subsets of the IFC Model Specification and have been defined primarily for IFC implementation purposes. The format defined in this document covers the same scope. However, it is important to understand the connections it has to a larger picture, in which requirements come from the value chain of the end user and the primary role of IFC Model View Definitions is to ensure that IFC implementations support those requirements.

For definition of IFC Model Views the goal must be to define an exchange of IFC data that will meet the end user's needs, as defined in the IDM, and is implementable for both sending and receiving software applications.  The Model View Definition Format is designed to document that implementable exchange with the least ambiguity possible.

The format must be well defined and unambiguous, but the format is only one part of what is needed.

- **Format**: The type of data that needs to be captured and how that data is structured

- **Content**: The data that is needed in a specific case. For example the IFC Schema is content that is captured using the EXPRESS format and an IFC Model View Definition is content that is captured using the IFC Model View Definition format.

- **Process**: The roles and responsibilities of different involved parties, for example how a model view definition becomes official and how certification is organized.

- **Tools**: The tools used for creating content, e.g. defining concepts and concept diagrams, and managing the process of creating content. Tools are highly important, but the format itself must be independent from any specific tools.

Although the format is, in theory, independent from the other parts it must in practice support all of them. It is also clear that the format is not the full answer, but having a commonly agreed format is the starting point. Without a common format it is very difficult to reuse content and tools, or to define a clear process.

This format is based on the IFC Model View Definition and related formats developed by the BLIS[22], ProIT[23] and IDM[24] projects and it has been developed and validated by the people behind these efforts.  It was originally targeted only at defining the scope and details of IFC implementations, and for providing a way to certify such implementations. In essence MVD provides the specification for IFC based data exchange implementation, and certification tests how well implementations comply with this specification.

However, in addition to certification the question of BIM Validation has become increasingly important. BIM Validation does not test the software application, but rather, how the implementation is applied by a software user in a project. Certification may for example test that a classification reference <u>can be exchanged</u> between software products, whereas BIM Validation may test that a

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[22] http://www.blis-project.org

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

[24] http://idm.buildingsmart.com

classification reference <u>is provided</u> by a software user, and that the provided reference is from an agreed local classification system.

In 2008, two major improvements were added to the IDM and MVD definition formats, tools, and process. The first was the inclusion of an IFC based technical solution for BIM Validation. This is accomplished by attaching business rules to the concepts defining the required data exchange capabilities. Certification is done against concepts, validation against business rules. The concept in the example above could be 'Classification reference', and the business rule 'Must use classification system xyz'.

The second major improvement was a further simplification of the interface between IDM and MVD. This was done in two areas. First the language for defining end user requirements for data exchange between software products was harmonized. This enables a simpler and more effective way to communicate such requirements to software implementers, and on the other side, to communicate the capabilities of IFC implementations to software users. Secondly moving the IFC based technical solution for validation from IDM to MVD made IDM a pure requirement definition methodology and MVD a pure methodology for IFC based technical solutions. While this change does not provide any additional features to the combination of these two methodologies, it does help significantly in explaining and applying the integrated IDM/MVD methodology.
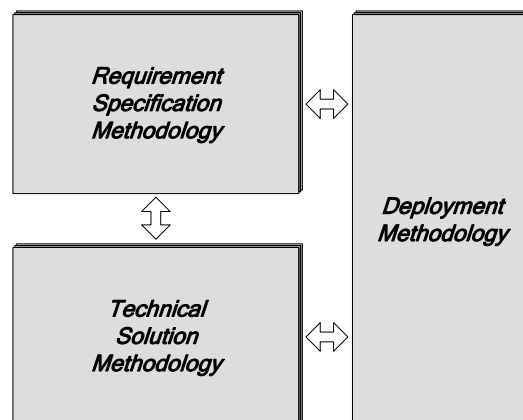
## 7.2. The context for MVD



**Figure 16** Overall architecture

The goal of any IFC related activity must be deployment in projects. In order to reach deployment the requirements of deployment must be known and there must be a technical solution for satisfying these requirements. The architecture shown here has a loose coupling between the different parts. This means, for example, that there can be many technical solutions for satisfying the same data exchange requirement, or many different requirement documentations based on the same deployment needs. As a theoretical development process the requirements of deployment are captured, a technical solution is developed to satisfy these requirements and finally the technical solution is deployed. In reality the process is often different, mainly because the development of technical solutions is commercial activity and guided by many other factors in addition to well defined and document end user requirements.
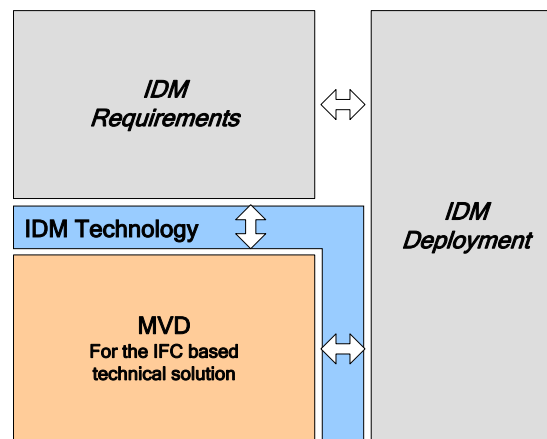
**Figure 17** The role of MVD (with IDM as an example for the requirement and deployment definition methodology)

The role of MVD is to provide an IFC based technical solution for end user requirements captured and documented using any requirements definition methodology. However, MVD has a well defined interface to IDM, which provides several important benefits.

1. The requirements defined using the IDM methodology, i.e. Exchange Requirements (ER) share the same IFC independent requirement definition format with MVD. This makes it easy to merge several ERs (which define data exchange between actors in a project) into one MVD (which defines data exchange between software application types). This connection helps ensure that the requirements for software implementation (MVD) cover the requirements of data exchange between actors in a project (ER).

2. MVD is used in software certification as the requirements specification for IFC based data exchange. The results of certification are documented using the IFC independent requirement definition format, which is shared with IDM ERs. This makes it easy to relate the certification results of a specific software application to the requirements for data exchange between actors in a project, i.e. knowing if that software application can be used successfully in a given end user scenario. When data exchange in a project is defined in a contract, it is of utmost importance to know, if a selected software application can be used for satisfying the terms of the contract.

3. The requirements for data validation are captured in IDM ERs as business rules (BR). The business rules can be mapped to the IFC based technical solution for data validation and implemented in data validation software. This helps ensure that the technical solution for data validation matches the requirements for data validation.
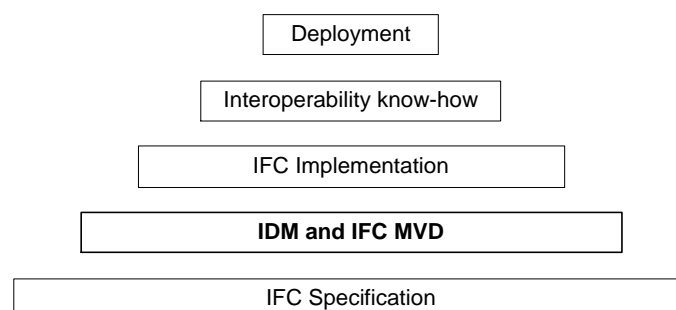


**Figure 18** Steps needed for reaching deployment[25] *(modified)*

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[25] Based on "The Interoperability Pyramid" (Hietanen, 2003)

The figure above shows the different steps that are needed for creating IFC based interoperable solutions that are successfully deployed in AEC/FM projects. It is like a 'task list' for all the things that must be taken care of. The picture is shaped like a pyramid, because the shortcomings of any level limit the possibilities of the levels above it. For example shortcomings in IFC implementations would naturally limit their deployment in projects. Also the possibilities build into the lower levels are not automatically available on the higher levels. For example expanding the scope of the IFC specification does not automatically mean that the new scope is available in IFC implementations. In short, it is necessary to build a solid foundation for the deployment of IFC based solutions. The IFC specification, i.e. the IFC schema and its documentation, is naturally at the core of any IFC based solution. In addition to a solid foundation the structure must reach deployment before being valuable to the industry.

## 7.3. Goals for MVD

The main goal of MVD is to enable high quality IFC implementations that satisfy a given set of data exchange requirements defined in one or more IDMs. The MVD format should further satisfy the following requirements.

- Enable data exchanges, as defined in the IDM process and formats, in building industry projects. The MVD process does not change these requirements, but may refine and merge data exchange requirements into packages that are meaningful from the viewpoint of software implementation.

- Provide a way for software developers to implement meaningful IFC support in software without wasting resources. Implementing an MVD should be the easiest way to implement IFC support in software.

- In order for IFC to become a mainstream data exchange solution, implementing IFC support must not require face-to-face meetings or attendance in workshops. This applies only to implementing support for an already agreed data exchange scenario. Face-to-face meetings can still be used in the process of defining data exchange scenarios.

- Certification must provide useful information about the capabilities and limitations of IFC based data exchange. It is important that industry practitioners understand the results of certification testing (i.e. what can and cannot be exchanged between the sending and receiving applications).

## 7.4. Reusable MVD Concepts

As discussed in the IDM section, reusable definitions of commonly useful packages of information are identified in the Exchange Requirements Model as Exchange Concepts. The technical solution for exchanging them in software (bound to IFC model entities) is MVD Concepts.

In our integrated IDM-MVD process Exchange Concepts (independent of IFC) are color-coded with blue and MVD Concepts (bound to an IFC schema) with orange.

Also mentioned above, software tools for developing IDMs and MVDs are essential to making re-use of concepts easy. Example Tool Sets are listed in Appendix C

## 7.5. Experience Required for MVD Development

Development of an MVD is a rather specialized process. It requires in-depth knowledge of the information model(s) for which bindings will be defined, as well as a good understanding of the requirements (and industry process) described in the IDM.

<RichSee to add more here>

## 7.6. MVD Coordination

In order for IFC BIM exchange to be widely used in the building industry, many teams should be developing IDMs and MVDs – addressing requirements in all regions of the world. Therefore it is important that our process encourage and support distributed development. On the other hand, such distributed development can easily lead to reinventing concepts instead of reusing them. This means that coordination across many teams developing IDMs and MVDs is very important. It must be easy for any developer to find existing concepts and for them to register new concepts for others to find and reuse.

MVDs are designed to make it possible for end users to exchange in real world business processes. In the transition from Exchange Requirements and associated ERM to MVD it is necessary to translate from end user domain definitions to software implementation definitions. The first deliverable in making this transition is a one page description of the new MVD. This one page description should be reviewed by all teams involved in developing MVDs – so that, if such an MVD already exists or is close, the teams involved can consider: is it better to expand the existing MVD or do develop a new one.

Since MVDs are of no use unless they are implemented in software, the developing team should also ensure that software vendors are willing (if not eager) to implement the MVD. In fact software implementer involvement is essential to the MVD development process. One of the key aspects of MVD Concept definition is the Implementation Agreements section that limits implementation requirements where the IFC model schema defines them vague or broad terms. For example: the IFC schema may allow for 5 different geometry representations for a given concept, yet the implementers may agree that limiting this to 2 alternative representations is sufficient for the Concept in the context of this MVD.

When MVD diagrams have been developed for all variable concepts included in the MVD, and implementation guidance documents have been developed for all implementable concepts included in those diagrams, the MVD is complete. Development of Certification Testing can then be addressed (see next major section).

## 7.7. MVD Deliverables

There are several documents that define an MVD. These include:

- IFC Release Specific MVD Description
- IFC Release Binding MVD Diagrams
- MVD Concepts – Implementation Guidance documents
- MVDXML – a machine readable definition of the subset of IFC used in the MVD

Each of these is described and examples given in the following sections.

### 7.7.1. IFC Release Specific MVD Description

The purpose of the IFC release specific MVD description is to document any general decisions that were made regarding the IFC binding.

| IFC Release Specific MVD Description (<IFC Release field>) <br> **<Title field>** | | | | | |
|---|---|---|---|---|---|
| **Reference** | <Reference field> | **Version** | <Version field> | **Status** | <Status field> |
| **History** | | | | | |
| **Authors** | <Author field> | | | | |
| **Document Owner** | <Company field> | | | | |
| **Description** | | | | | |
| 1 – Which version of the ERM definition is being used | | | | | |
| 2 – Basic principles applied when mapping the ERM to the MVD, including implementer's agreements. | | | | | |
| 3 – Limitations relative to the ERM | | | | | |
| This document uses the official IFC Model View Definition Format version 1.1.0. of buildingSMART <br> Template Licensed for use in buildingSMART Projects –By The BLIS Consortium – All Other Rights Reserved | | | | | |

**Figure 19** MS Word template for the IFC release specific MVD overview document [26]

| Field | Description |
|---|---|
| <IFC Release> | The IFC release for which the binding is defined |
| <Title > | The name of the MVD |
| Reference | The reference number of the MVD <br><br> <Author ID>-<MVD Number> |
| Version | The sequential version number of the MVD |
| Status | The status of the MVD. <br> Sample, Draft, Proposal, Candidate, Official or Deprecated |
| History | Any history specific to the IFC binding |
| Document Owner | The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address. |
| Description | 1. Which version of the generic view definition is being used <br> 2. Basic principles applied when mapping the generic view to the specific IFC release, including implementer's agreements. <br> 3. Limitations relative to the generic definition <br> NOTE: If a copyright is asserted this can be done in the description field. |

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[26] MVDDescription_IFCReleaseSpecific.dot

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### 7.7.2. MVD Diagrams
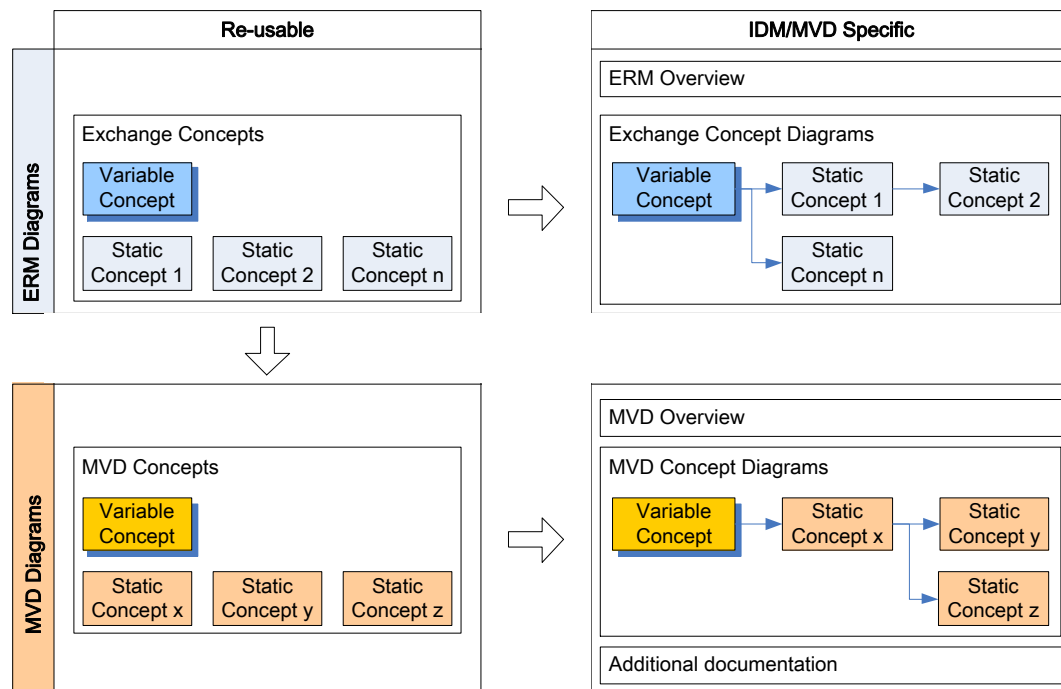
#### 7.7.2.1. ERM/MVD Diagrams Relationship



Figure 20 Diagramming Formats Overview

As described above, the IFC independent concept diagrams in previous versions of MVD were moved to IDM to become the Exchange Requirements Model (ERM). The ERM serves as a machine readable version of requirements defined in the IDM -- that could be used later for BIM Validation.

Exchange Concepts in the ERM define re-usable packages of information to be exchanged. An ERM diagram defines the scope of data to be exchanged about a top level 'Variable Concept'.

MVD Concepts define a way to realize the Exchange Concept in software data exchange. An MVD diagram also defines the scope of data to be exchanged about the top level 'Variable Concept'. The top level concepts generally correspond between ERM and MVD diagrams, but occasionally some additional top-level concepts may be introduced in the MVD for software implementation purposes.

Both ERM and MVD will have 'Overview' sheets that describe the entire scope of the ERM/MVD. In this section we are focused on the MVD.

For each Exchange Concept in the ERM, there will be one or more MVD concepts which define a way to exchange the data defined in that concept in software. In fact, the MVD concept has a 'Implements' relationship to the Exchange Concept it implements. MVD diagrams are targeted at software developers, especially people writing software code.

MVD Concepts define the binding of their corresponding Exchange Concepts into a specific IFC release. They define how the IFC Model Specification is used for exchanging the required data, e.g. that a classification reference is exchanged using the IfcClassificationNotation object. Each

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supported IFC release will have its own binding documentation, because the details of how the same data is captured may change between IFC releases.

### 7.7.2.2. MVD Diagram Specifics

The format for MVD diagrams and configuration is defined by an XML schema[27]. These diagrams can be created manually, or using tool sets provided by vendors (see appendix C).

The XML schema for MVD diagrams supports three different styles, which may be combined into the same XML dataset

- **Definition**: the concepts used in a diagram and their relationships in the context of that diagram.

- **Configuration**: The status of the concepts (ON/OFF) and diagram specific comments for concepts.

- **Layout**: The position, visibility and other layout related settings of concepts in a diagram. The layout is typically specific to the coordinate system of the diagramming application (e.g. the MS Visio). Layouts are not part of the MVD format per se, but are important to the presentation of MVD diagrams.

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

Since the format for MVD diagrams is defined in an XML schema, there is no official page size or orientation. Large diagrams will require one 'page'. That is: there is no provision for splitting a diagram over several pages. Some vendor diagramming tools have features to help accommodate large diagrams by hiding parts of the diagram in certain contexts. Such settings are saved in the diagram layout, as explained above.

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[27] ViewDefinition.xsd

A separate MVD Diagram is created for each Variable (or high level) Concept in the MVD.
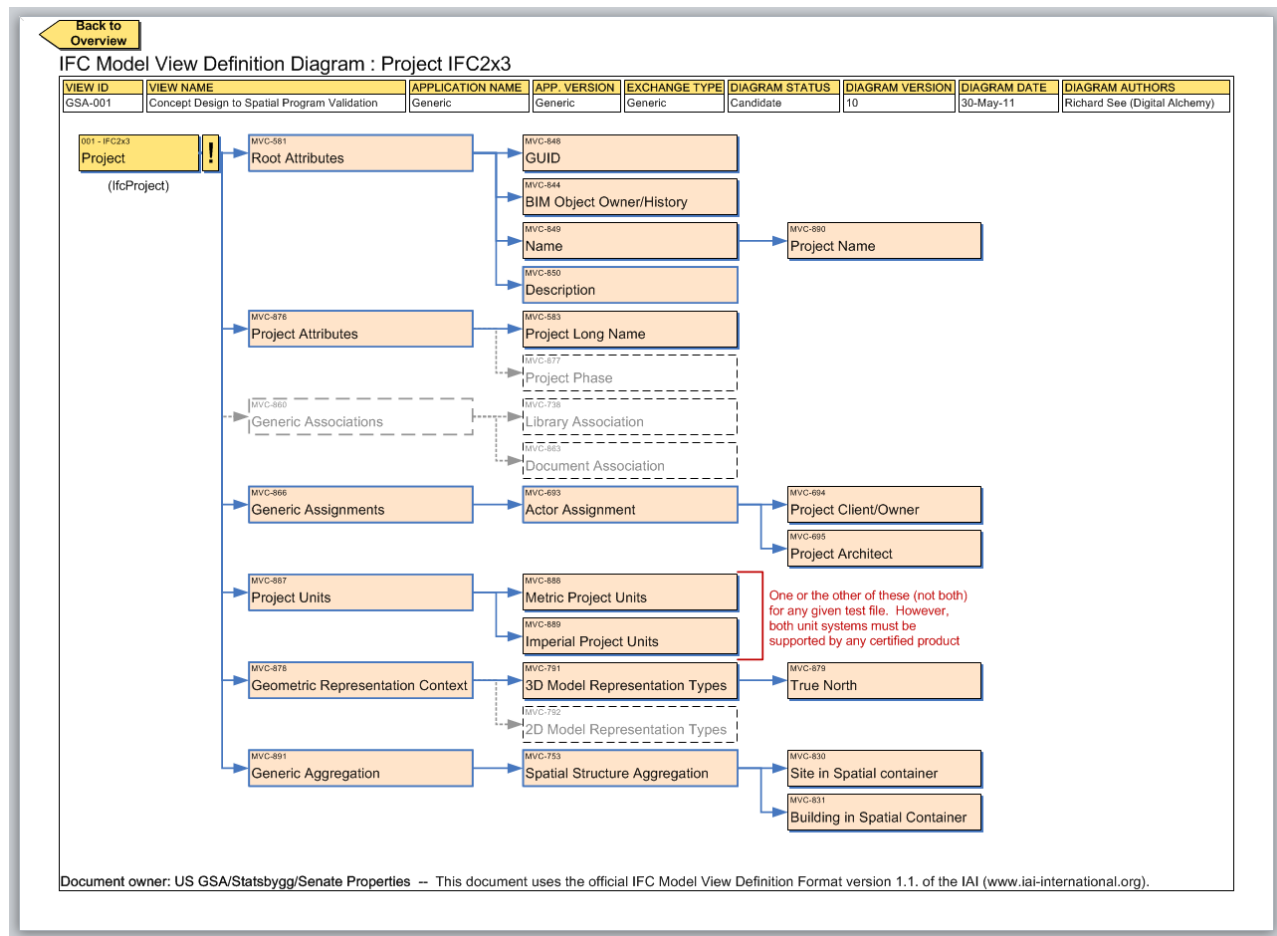


**Figure 21** Template for IFC release specific view diagram

| Field | Description |
|---|---|
| Diagram name | The name of the diagram is the name of the variable concept of the diagram. The name is shown in the title. |
| IFC Release | The IFC release the diagram is defining the binding for. The IFC release is shown in the title. |
| View Name | The name of the IFC Model View Definition |
| Application name (optional) | The name of the software application for which the diagram is made. |
| Application version (optional) | The version of the software application for which the diagram is made. |
| Exchange type | Generic, Import, Export or Roundtrip |
| Diagram status | Sample, Draft, Proposal, Candidate, Official or Deprecated |
| Diagram version | The sequential version number of the diagram |
| Diagram date | The data the version of the diagram was completed |
| Diagram authors | The authors of the diagram |
| Document Owner | The person or organization responsible for maintaining the diagram. Should contain some contact information, e.g. email address. |

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

A concept may be marked as optional if it is not essential to the exchange, but desirable. Concepts are marked as optional by turning them off (light grey, dashed line boxes). Software may still be certified for support of the view if they don't support optional concepts, but may be more preferred by end users if they do support them.



Diagrams may be configured using two mechanisms: making concepts optional (turning them off) and adding comments to the concepts. Making concepts optional reduces scope. Commenting is used to make diagrams more specific or to enhance understanding about relationships or data included in the exchange. In addition diagrams may contain any text or graphical elements, but such elements will not be captured in the XML format generated from the diagram.



Large diagrams may be placed on one page by hiding concepts. Hiding a concept does not mean that it is turned off. Hiding is used purely for layout purposes.

### 7.7.3. MVD Concept Definition

#### 7.7.3.1. MVD Concepts

MVD Concepts address the data exchange requirements defined in the corresponding Exchange Concept (see ERM subsection of IDM).

| IFC Release Specific Concepts | |
|---|---|
| Variable Concept  | The IFC binding of a variable concept implements a generic variable concept with the same name. Example: the IFC Binding of the variable concept "Wall" is "Wall", not "Wall standard case" |
| Adapter Concept  | Adapter concepts are reusable parts of the IFC model specification that connect static concepts to a variable concept. There is no correspondence between adapter concept and IFC release independent group concept. Instead, adapter concepts provide a proposal how to structure software code in IFC implementations for reach- |

| | |
|---|---|
| | ing maximal code reuse. |
| | Examples: classification assignment, property set assignment |
| Static Concept<br><br>TEMP-005 - IFC2x3<br>GUID | The IFC binding of a static concept implements one or more generic static concepts. The names of generic and IFC binding static concepts don't have to match. The documentation of the IFC binding contains a detailed definition how to apply the IFC Model Specification.<br><br>Example: "GUID" implements the IFC release independent concept "Software Internal ID". |

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

**<Author ID>-<Concept Number>**

For example; TEMP-001, ABC-123

Please note: The Author ID "MVC" (Model View Concept) is assigned only to concepts that have been proven and are shared across multiple MVDs, as determined by the MVD Coordinator.

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

TEMP-001 - IFC2x2 Space → TEMP-002 - IFC2x2 Space Properties → TEMP-003 - IFC2x2 Space Number

If the example above was from MVD with the Reference "TEST-01", the fully qualified name for "Space Number" would be.

**Test-01:TEMP-001:TEMP-002:TEMP-003**

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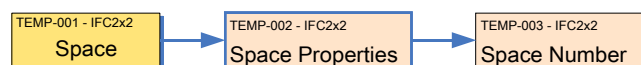
### 7.7.4. Concept Documentation

There is a separate description document for each IFC independent and IFC release specific concept.

The official format for the documents is PDF. A Microsoft Word template is provided for creating the documents but any other software or system may be used as well.

In documents based on the template any field marked with <… field> should be edited through the document properties of the MS Word document.
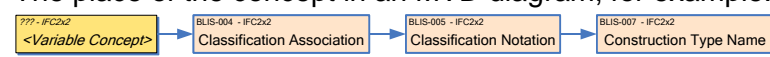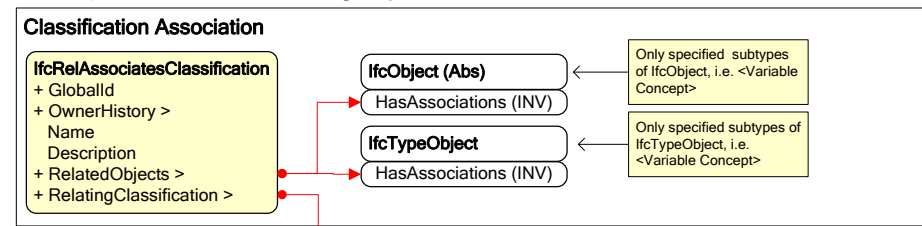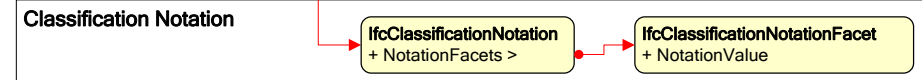
### 7.7.5. MVD Concept Description

The IFC release specific concept description contains the binding of the concept to specific IFC release.



**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 IFC Model View Definition Format version 1.1.0. of the IAI (www.iai-international.org)
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**Figure 22** MS Word template for the IFC release specific concept description document [28]

| Field | Description |
|---|---|
| <IFC Release field> | The IFC release for which the binding is defined |
| <Tile field> | The name of the concept |
| Reference | The reference number of the concept |
| Version | The sequential version number of the concept |
| Status | The status of the concept. Sample, Draft, Proposal, Candidate, Official or Deprecated |
| Relationships | Relationships to other concepts<br><br>• Implements : the IFC release independent concept implemented by the IFC release specific concept |

---

[28] ConceptDescription_IFCReleaseSpecific.dot

| Field | Description |
|---|---|
| | • Extends : the adapter concept the concept is based on |
| History | The history of the concept, e.g. a version history |
| Document Owner | The document does not contain a field for copyright. The document owner is the person or organization responsible for maintaining the document, i.e. the only one allowed to make changes to the document. Should contain some contact information, e.g. email address. |
| Description | **Usage in MVD Diagram**<br>The place of the concept in an MVD diagram, for example.<br><br>**Instantiation Diagram**<br>The IFC entities, which need to be instantiated for the concept and the relationships between the entities. Instantiation diagrams may be freely commented and may contain clarifying drawings. Instantiation diagrams from other concepts may be inherited and further specified. Any IFC entity that requires implementation agreements (see definition below) are marked with light yellow.<br><br>There is no official format for instantiation diagrams, but the use of the notation in the example above is encouraged.  Templates are available for generating instance diagrams are available in vendor tool sets.<br>**Implementation Agreements**<br>Often the IFC specification contains ambiguity about how it should be applied in specific cases, i.e. it defines more than one way of doing the same thing. In such cases implementation agreements must be used for defining the one agreed way to do a single thing.<br>The basic format for implementation agreements is a table containing the attributes of an IFC entity used in the IFC binding of the concept (see instantiation diagram above). Example: |

| Field | Description |
|---|---|

**Description** (continued):

IfcRelSpaceBoundary

| Attribute | Implementation agreements |
|---|---|
| GlobalId | Must be given, but may change |
| OwnerHistory | Must be given, but may contain dummy data |
| Name | Reserved |
| Description | Reserved |
| RelatingSpace | No agreements needed |
| RelatedBuildingElement | No agreements at this point |
| ConnectionGeometry | If provided, must be IfcConnectionSurfaceGeometry |
| PhysicalOrVirtualBoundary | *<Open>* |
| InternalOrExternalBoundary | *<Open>* |

The following standard agreements can be used

| | |
|---|---|
| <Open> | The authors of the concepts have not dealt with the attribute yet. Should appear only in incomplete descriptions |
| No agreements needed | The IFC specification is unambiguous and no agreements are needed |
| No agreements at this point | There are no agreements defined in this concept, but agreements are made in concepts that inherit from the concept. |
| Reserved | There are no agreements currently, but the attribute is reserved for future use. This is usually used with labels and other descriptive strings. |

**Additional Information**

The concept may contain any number of additional information. Such information is not part of the official definition, but can make it easier to understand and implement the concept or help in creating certification test cases etc. Examples:

- EXPRESS-G diagram
- EXPRESS sub schema
- UML diagram
- Sample files

### 7.7.6. Concept Based Implementation Guidance Specifications

Detailed and unambiguous documentation of MVD Concepts is essential to the development process because it is the basis of Certification Testing and (together with IDM business rules) BIM Data Validation (see sections below). Specifically:

- Implementation diagrams identify the IFC entities that will be used to exchange the concept, as well as the relationships between them
- Implementation Agreements define the decisions that have been agreed by implementers in order to either (a) eliminate ambiguity (e.g. in the case were multiple alternatives would be possible) or (b) reduce scope that would otherwise be required by the underlying IFC schema
- MVD-XML is generated from the MVD diagrams and Implementation Guidance. This is a machine interpretable representation of these human interpretable documents.

Each of these is described in more detail below

### 7.7.6.1. Instantiation Diagrams

Instantiation diagrams illustrate all of the IFC entities, which need to be instantiated for the concept and the relationships between the entities. Instantiation diagrams may be freely commented and may contain clarifying drawings. Instantiation diagrams from other concepts may be inherited and further specified. Any IFC entity that requires implementation agreements (see definition below) are marked with light yellow.
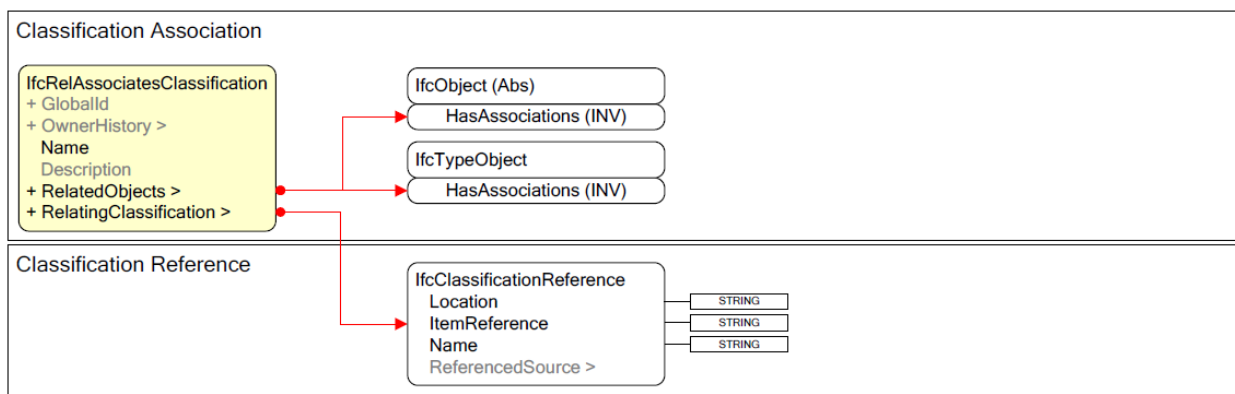


**Figure 23 - Instantiation Diagram Example**

Required entities and relationships are harvested from Instantiation diagrams to develop MVD-XML using tools provided in vendor tool boxes.

7.7.6.1.1.   Implementation Agreements

In the IFC Model View Definition format there is no separate documentation for implementation agreements. All implementation agreements are captured in the IFC binding of the MVDs.

The high level description of an IFC binding contains all agreements which are not specific to the use of individual concepts. This would cover cases like: use IFC2x3 property sets in IFC2x2 implementations. There will probably not be many agreements on this level, maybe even none.

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**Implementation agreements**

The classification reference contains a reference to a single item in an external classification system and a computer or human interpretable link to the definition of that item.

**IfcRelAssociatesClassification**

| Attribute | Implementation agreements |
|---|---|
| GlobalId | Providing a GUID is mandatory, but the GUID is allowed to change. |
| OwnerHistory | Providing an OwnerHistory is mandatory, but it is allowed to use dummy data. |
| Name | *<Open>* |
| Description | *<Open>* |
| RelatedObjects | *<Open>* |
| RelatingClassification | *Must be IfcClassificationReference.* |

**IfcClassificationReference** (definitions from IAI)

| Attribute | Implementation agreements |
|---|---|
| Location | Location, where the external source (classification, document or library). This can be either human readable or computer interpretable. For electronic location normally given as an URL location string, however other ways of accessing external references may be established in an application scenario. |
| ItemReference | Identifier for the referenced item in the external source (classification, document or library). The internal reference can provide a computer interpretable pointer into electronic source. |
| Name | Optional name to further specify the reference. It can provide a human readable identifier (which does not necessarily need to have a counterpart in the internal structure of the document). |
| ReferencedSource | <Open> |

The specific use of the Location, ItemReference and Name attributes may be further specified by concepts, which extend this concept.

Figure 24 - Implementation Agreements Example

A static concept has to be fully supported and there are no options inside a static concept. For software users the capabilities of IFC implementations are easier to understand if static concepts have a large scope. For implementations large concepts can be problematic because even software created for the same purpose is very different and a large concept may be discriminating.
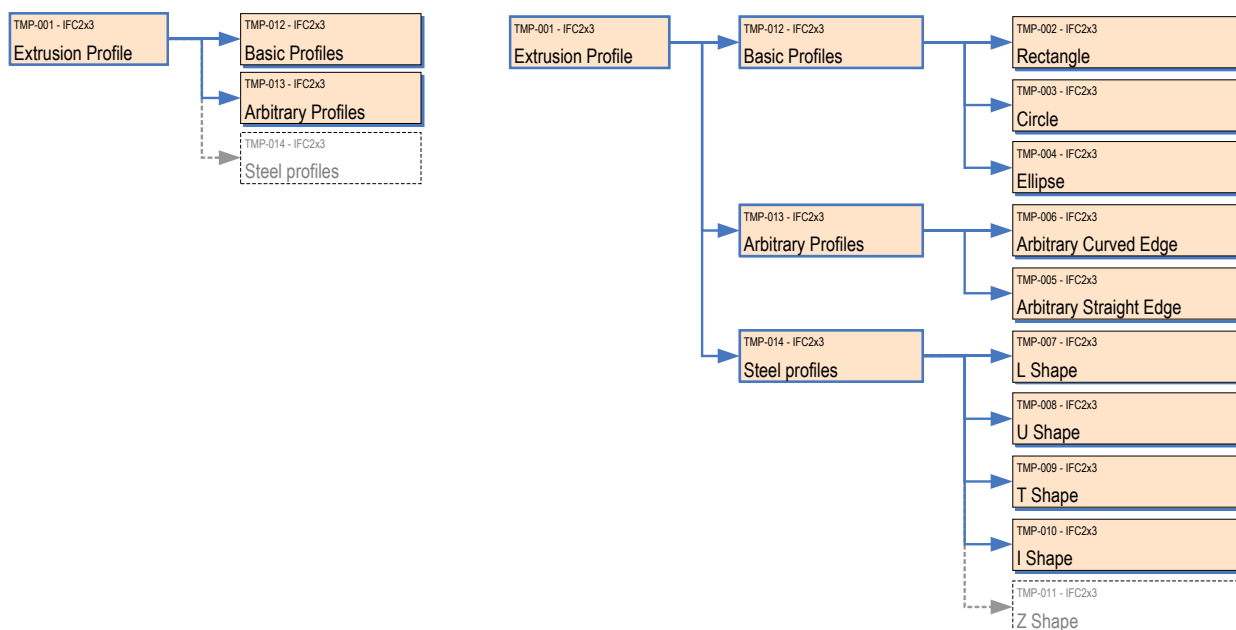


Figure 25 - Large concepts vs. small concepts

In the example above the software user would like to know if steel profiles can be exchanged. However, if an application can support all other steel profiles but not 'Z Shape', the certification results would say that the application doesn't support the exchange of steel profiles. Whenever this is a problem concepts have to be defined on a more granular level.

Detailed agreements about how the IFC Model Specification is used are captured in the IFC bindings of concepts. This would cover cases like: the name of a space is exchange using IfcSpace.LongName, the number of a space using IfcSpace.Name and all spaces must be contained by a building storey.

Implementation agreements provide the specification that must be followed when implementing IFC support in software. Certification checks that this specification has been followed. Certification test cases cannot be generated automatically from the IFC Model View Definition format, but the format allows capturing all information necessary for creating test cases manually.

### 7.7.7. MVD-XML

MVD-XML has existed in MVD tools for about 4 years now. The version of MVD-XML being generated by current tool sets is relatively limited in that it does not include IFC schema information that could be used in certification testing. Instead, a must more labor intensive approach has been used to achieve current certification testing. This is true for both iabi and Digital Alchemy, the two vendors currently providing certification testing.

As described in the introduction, a effort is underway to expand MVD-XML such that it will include schema information. Together with the programmatic capture of business rules (which are included in the Exchange Requirements Model (ERM)), this will enable many parts of certification testing to be more automated.

Version 0.5 of the proposed improvements for MVD-XML is now being reviewed. This document will be updated to reference that schema definition when it has been finalized.

Vendors currently providing IDM/MVD tool sets will be encouraged to update their MVD-XML generation feature sets to support the new version of MVD-XML when it has been finalized.

## 7.8. Lifecycle of an MVD

MVDs have a life cycle, which spans from the idea (originating e.g. from IDM Exchange Requirements) to the time the definition is superseded by another definition.

**Idea:** Someone has an idea for a new MVD, documents and publishes the idea for others to review.

**Draft**: Some interested party creates and documents a new MVD or extends an existing MVD. Any person or organization is allowed to do this without restrictions or limitation.

**Proposal**: If the author of an MVD wants to seek endorsement from an organization or standards group like buildingSMART or BLIS. When such a proposal is accepted by the endorsing organization, the MVD status will be set to Proposal – and the context of that proposal (i.e. proposal to buildingSMART or BLIS) will be made clear.

**Candidate**: When an MVD has been submitted to an organization for endorsement. That organization should review it using the following criteria.

- Has it been documented using the standard MVD format?
- Does it make correct use of the IFC Model Specification?
- Is there overlap or conflicts with existing MVDs?

The proposal may be refined based on the feedback from the endorsing organization. Once the MVD satisfies the set criteria it has Candidate status – for the endorsing organization only. As with

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Proposal status, the context of Candidate Status will be clearly shown on the MVD web site (i.e. Candidate as buildingSMART or BLIS endorsed MVD).

**Official**: The distinction between Candidate and Official MVD status is that Certification testing is available for the latter. Software certification must be organized by the organization endorsing the MVD, and must be openly available to any software vendor (at cost to the vendor). In most cases, Certification testing will be done under a contract organized by the endorsing organization (e.g. GTDS by buildingSMART international and Digital Alchemy by GSA). When more than one software application has been certified, the MVD status will be elevated to Official. After this any software can apply for certification against exactly the same definition.

**Deprecated**: When an MVD is superseded by another definition it should be Deprecated. In practice this means that certification testing is no longer available for the deprecated MVD.

# 8. Software Implementation and Certification

To date, there are two organizations performing certification testing under contract: Institute for applied Building Informatics (Germany)(for buildingSMART International – Coordination View 2) and Digital Alchemy (USA)(for the US General Services Administration(USA), Statsbygg (Norway), and Senate Properties (Finland).

# 9. BIM Validation - Using Certified Apps in Projects

## 9.1. BIM Validation Testing

Validation tests are tests carried out on the information exported from a software application according to the schema of an exchange requirement model. They are used to ensure that a stated exchange requirement is being satisfied according to a set of applied business rules.

Validation tests must be carried out using test files that have a known performance and that are specifically designed to validate particular aspects of the exchange requirement model.

The values assigned to attributes and properties within a test file may vary between locations in which validation tests are carried out. This is because different sets of business rules may be applied to the same exchange requirement model in different places.

Validation tests are applied for the purposes of:

- verifying that the export of information from a software application meets the quality criteria set out in an exchange requirement
- improving the quality of software implementations
- providing metrics against which claims made for software performance can be verified
- making comparisons between software applications fulfilling the same objectives (when compared using the same tests)
- estimating reliability

## 9.2. MVD for Data Validation

The original purpose of MVD was to provide a specification for the IFC based technical solution for data exchange between software applications. This includes the scope and details of IFC implementations, and enabling certification based on this specification. The goal was to create IFC based, reliable and useful data exchange capabilities for industry practitioners for either creating or consuming BIM data.



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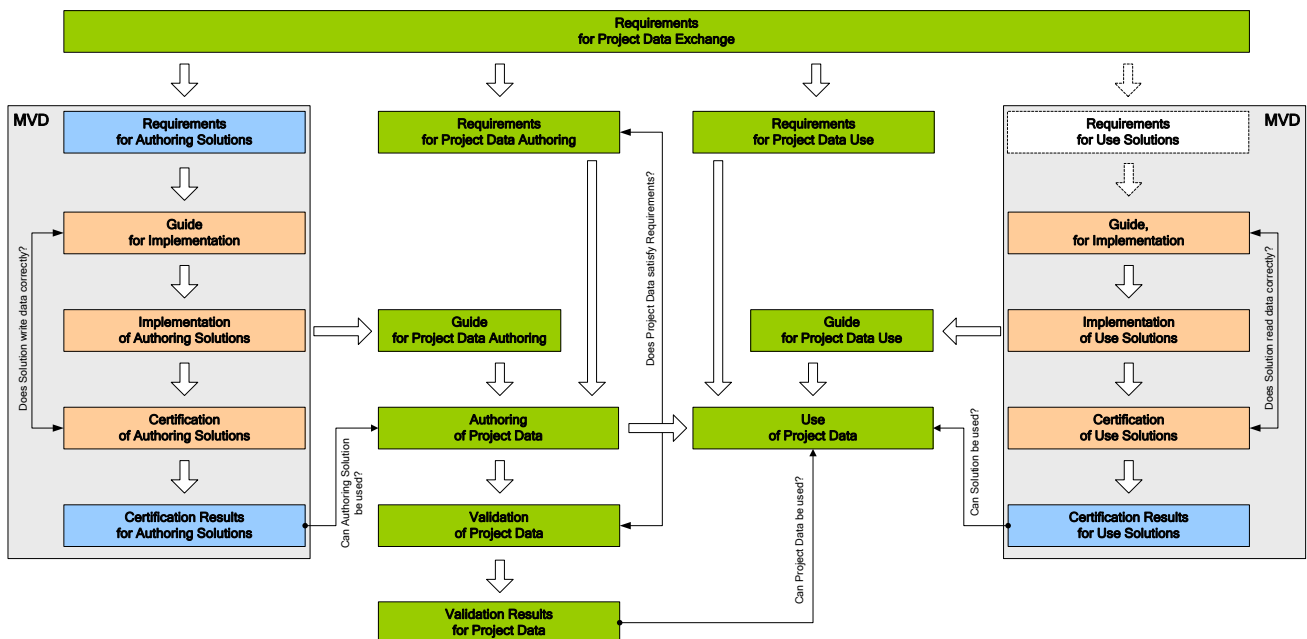
However, exactly the same format can also be used for the IFC based technical solution for data validation. This system has been defined for IDM based exchange requirements (ER), which are documented as an exchange requirement model (ERM).

In the original approach the concepts from several ERMs are rolled together into one MVD, which corresponds to the exchange between software application types. When MVD is used for data validation the business rules (BR) of an ERM are used instead, and rolled together into a meaningful package from the viewpoint of data validation software. The BRs become data validation concepts, which are defined like any other concept. In the IFC binding of these data validation concepts use the constraint model of the IFC specification.

When used in projects, data validation software reads in two files (or data sets); the design data and the constraint data. Both data are based on an MVD, the design data on a 'design MVD' and the constraint data on a 'validation MVD'. The implementations of both can be certified using the IFC certification process.

# 10.  Appendix A: IDM Templates

- BuildingSMART http://iug.buildingsmart.com/idms/template

# 11.  Appendix B: mvdXML Tool

- BuildingSMART http://www.buildingsmart-tech.org/specifications/mvd-overview

# 12.  Appendix C: IDM/MVD Development Tool Kits

- BLIS Toolkit for IDM/MVD – See: http://www.blis-project.org/IDM-MVD

# 13.  Appendix D: Testing Services

- MVD Certification Testing Services
    - GTDS – http://portal.bau.hm.edu/IABI  and
      http://87.106.252.103/apex/f?p=101:1:429082091739561
    - Digital Alchemy – http://digitalalchemypro.com/html/services/services.html
- BIM Validation Services for End Users
    - Digital Alchemy – http://digitalalchemypro.com/html/services/IfcBimValidationService.html