

# Integrating use case definitions for IFC developments

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**ABSTRACT:** Advantages of BIM-based working are well recognized by the AEC/FM industry, but it is still barely used in practice. It is not only to understand the idea behind BIM. There are couple of questions that have to be answered to benefit from BIM-based working. The article argues that use case definitions are a main source of information. They not only provide necessary details about available BIM solutions but also enable to integrate and maintain all kinds of BIM developments. This understanding is reflected in a number of recently published specifications of the international IFC standard. The article provides a survey of use case based IFC developments and discusses their application, identified difficulties and suggested solutions.

## 1 INTRODUCTION

It is widely acknowledged that Building Information Models (BIM) and buildingSMART/IFC enable significant improvements of design processes and facilitate collaboration (Howard & Bjork 2007, Kiviniemi et al. 2008). But BIM based working is not yet able to integrate all design domains or to support design processes from the very beginning to the end. IFC developments concentrate on a set of realistic use cases that provide a sound basis for further extensions. Additionally, the quality of IFC implementations is sometimes not fully compatible so that IFC-based data exchange still requires a lot of experiences (Kiviniemi 2007).

Today, BIM based working means to decide about use cases that should be supported in a specific project and thus requires substantial knowledge about the BIM software that shall be used in the project and their IFC capabilities (Bazjanac 2002). Such knowledge is starting to be reflected in different IFC guidelines describing the result of IFC extension and implementation processes. Ideally, the requirements that were initially formulated and results of IFC developments are described in the same way in order to be aware of the differences between required and implemented IFC functionality.

Typically, use case definitions are the first step of model specifications (Turk 2001) and therefore should gain special attention in the IFC development process. The aims of this paper are to explain the importance of use case definitions and to show the current situation of IFC developments and available guidelines.

### 1.1 Challenges of IFC development

The overall mission of IFC is defined to be the “... *specification for sharing data throughout the project life-cycle, globally, across disciplines and across technical applications ... in the construction and facilities management industries.*” (www.ifcwiki.org). It is a pretty clear message but unclear about the use cases that are really supported by the current IFC release. According to the overall mission, IFC developments are faced with two challenges:

- provide a data structure that is able to fulfil the information requirements of involved disciplines
- supporting the implementation of a data structure that exceeds the scope of typical domain specific design applications

After several years of development the idea of buildingSMART is based on a huge and complex data structure, whereas always only a ‘small’ part is needed for specific use cases.

### 1.2 Overview of the IFC development process and involved actors

IFC development involves not only different domains of the AEC/FM industries but also professions from the IT. Each of them contributes to the IFC standard, starting from initial requirements to the final feature in a software product. Moreover, IFC is an international standard and thus has to deal with different cultural backgrounds and languages. Consequently, the specifications supporting IFC development (1) have to be defined according to the needs

of involved users and (2) should enable to keep track of all kinds of IFC development, i.e. the way from initial requirements till the use of IFC interfaces.

There are basically three types of users: (1) business experts, (2) modelling specialists and (3) software developers. Each of them can be assigned to one of the ten pillars of IFC development (Liebich 2007), which address four main areas:

- Business requirement specification
- IFC extension modelling
- Use case implementation
- End user guidance

It is a sequential process that is typically done in the given order, i.e. it starts with requirements and ends with user guidelines. Each step tries to reuse existing specifications so that a gap analysis is one of first and main activities in all of these areas. Thus, before starting a new development it is important to get familiar with the overall methodology and the specifications that already exist.

### 1.3 Structure of the paper

The paper is inspired by the InPro project ([www.inpro-project.eu](http://www.inpro-project.eu)) that aims at introducing BIM based working in early design. One of the first tasks was to define business processes that are of interest to be supported and optimized by a shared BIM. It is the start for further IFC developments that are discussed in paper, i.e. each of the four main areas are presented together with specifications being used for a gap analysis and the work that has to be carried out in the project.

It is worth mentioning that the methodology of IFC development is principally agreed within the IAI. However, not all details of required specifications are fixed yet. There are a couple of new proposals and agreements about intertwining them, but there is a lack of experiences in using these specifications. Therefore, their application, identified difficulties and suggested solutions are discussed in the end of each section.

## 2 BUSINESS REQUIREMENT SPECIFICATION

Business requirements demand improvements of the current situation and thus initiate further developments. It is business experts who know the shortcomings of their daily work and therefore should play the main role in the first step of model developments.

The purpose of IFC is to provide design information that is needed to fulfil specific design activities such as energy analysis, quantity take-off etc. Traditionally, requirements were mainly used to define the scope of IFC extension projects and often got lost after integration into a new IFC release. This shortcoming has been answered by the Information

Delivery Manual (IDM, Wix 2006) providing a formal way for capturing business requirements and the binding to a product data model.

The work that has been done so far with the IDM methodology ([idm.buildingsmart.no](http://idm.buildingsmart.no)) is motivated by making a more user friendly start in using BIM and IFC in design projects. These developments were brought forward by the Norwegian chapter of the IAI and the HITOS project ([www.statsbygg.no/Projekt](http://www.statsbygg.no/Projekt)), which have specified several IDMs for different project stages, e.g. for the electrical and structural design. IDM in its pure form comprises three parts; (1) the Process Maps, (2) the Exchange Requirements and finally (3) the Functional Parts and Business Rules. Whereas these steps can be applied to any data structure there are additional agreements for IFC developments aiming at a tight integration with the IFC implementation and certification process.

### 2.1 Process Maps

Process Maps (PM) define the processes, responsible actors and the data flow that shall be supported by the BIM approach. The IDM guide (Wix 2007) recommends to use the Business Process Modelling Notation (BPMN, [www.bpmn.org](http://www.bpmn.org)), which was developed by the Object Management Group (OMG) with the aim to provide a unified process modelling notation. Accordingly, BPMN has merged appropriate ideas from a number of prior process modelling notations including IDEF0 ([www.idef.com](http://www.idef.com)), which is traditionally used for STEP developments (ISO 10303).

IDM also gives recommendations how to use BPMN for AEC/FM developments, which also provides a set of actor roles and project stages, for example according to the Omniclass classification ([www.omniclass.ca](http://www.omniclass.ca)) and standards such as the RIBA in the UK, the German HOAI and the Generic Process Protocol (ISO 22263). Furthermore, it defines how to connect tasks with the BIM and other data sources. The process information is assigned to swim lanes, which either contain the tasks of an actor or the Exchange Requirements of a data source. Accordingly, the BIM has its own swim lane that identifies the requirements of the tasks, i.e. their input and output. Additionally, tasks can be connected to each other to define a logical sequence of activities, which is also used to attach further information such as events (messages, timer, rules, etc.) or gateways defining branching and merging of tasks. It is also possible to refine tasks by introducing subprocesses that enable to be as detailed as necessary while keeping the complexity of each Process Map on readable level. Thus, BPMN provides the typical features for process modelling that are defined according to the state-of-the-art in the IT.

Process modelling is not yet in focus of BIM developments but is gaining more and more interest as it provides the basis to improve the management of BIM data. For instance, the InPro project was starting with process definitions to figure out the use of BIM in early design and to derive further requirements (Outters & Verhofstad 2007).

The initially specified Process Maps enabled a good start for further developments but left-out a couple of IT-related questions that are necessary to extend IFC and to implement a workflow-based data management system. Accordingly, refinements of the generic Process Maps were initiated with two aims: (1) to figure out the dependencies between different business processes and (2) to be specific enough for implementation. It also means making a reasonable differentiation between BIM require-

ments and requirements for other data sources such as unstructured text documents or highly specialized domain models as shown in Figure 1.

The specification of Process Maps is faced with two main problems: (1) to find a proper level between generalization and specialization of processes and (2) to manage all details needed for implementation. Executable processes soon become too complex for business experts as they typically include too much IT-related information. Furthermore, the combination of independently defined processes might be automatically deduced from Exchange Requirements, but due to often mismatching definitions it is not really practicable. Thus, dependencies between process maps have to be defined by hand, which also increases the complexity of process definitions.

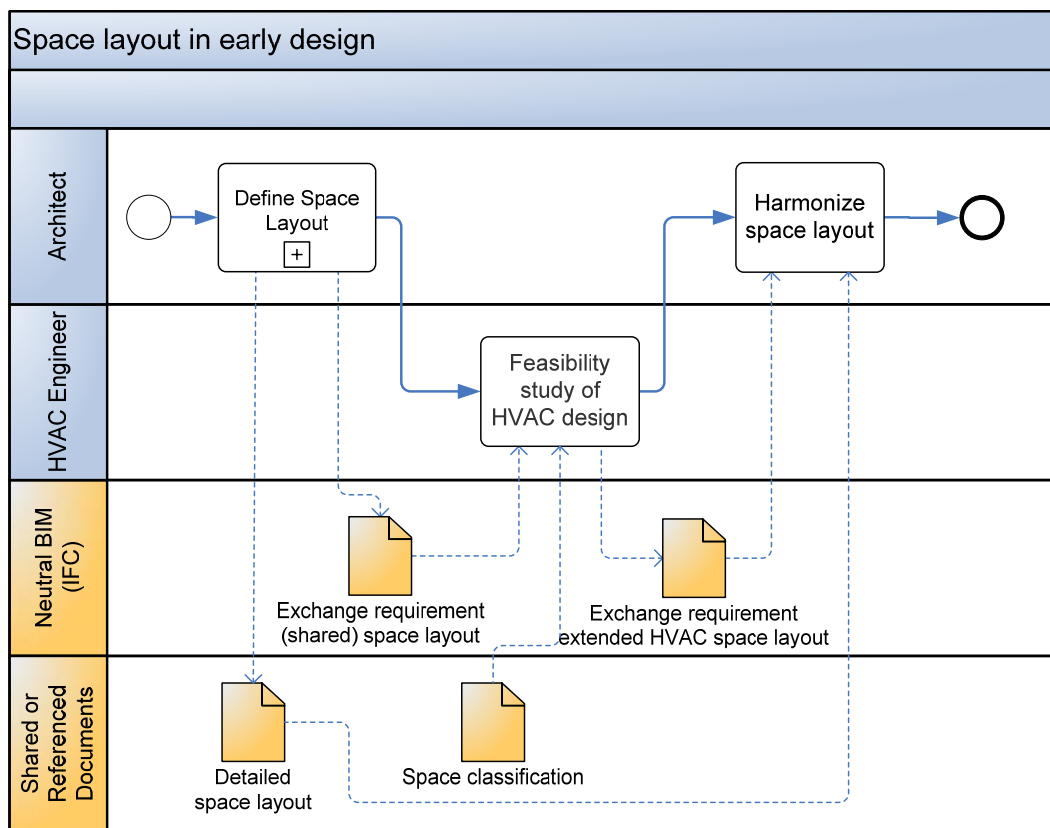


Figure 1: Simplified example of a Process Map with two swim lanes for the processes and responsible actors and two swim lanes for the Exchange Requirements and expected data sources (Liebich & Weise 2008).

## 2.2 Exchange Requirements

Whereas Process Maps identify required information by unique names and assign them to tasks, either as input or output, all details of the requirements are described in an Exchange Requirement (ER) that are defined by business experts. Therefore, Exchange Requirements are always described according to business concepts that have to be mapped to IFC or other data structures.

Required information is typically provided in tables that help to structure requirements, to define further details about the concepts and to differentiate between required, mandatory and optional informa-

tion. Similar to Process Maps that identify Exchange Requirements of tasks the Exchange Requirements can set a link to reusable IT concepts, the so called Functional Parts, which provide further details about the implementation of business concepts.

So far, most work on Exchange Requirements has been done in the HITOS project, also showing the link to Functional Parts. Consequently, they roughly include the mapping to the data structure, which has to be added by the modelling specialists. But here there is some overlap with the *Model View Definition* format (MVD, Hietanen 2006), which has been developed to support the implementation of IFC use cases.

The overlap between both stand-alone approaches has been eliminated by the harmonised IDM/MVD approach, which will be used by the InPro project and means to reuse the concept definitions of the Exchange Requirements in the development of MVDs, i.e. the release independent part of an MVD. The difference between both parts remains for the specification of business rules, which are related to business processes and thus to the ERs, and the further detailing of business concepts, which is necessary to support the implementation of IFC.

### 2.3 Functional Parts and Business Rules

The purpose of Functional Parts (FP) is to define reusable IT modules that describe the implementation of Exchange Requirements. They can be grouped together to create new Functional Parts and thus can be defined on any appropriate level that helps improving reusability. Furthermore, Business Rules are added to Functional Parts to specify consistency and completeness of required data, which in case of using a machine interpretable specification would enable an automatic checking of IFC data, as shown in the CORENET project ([www.corenet.gov.sg](http://www.corenet.gov.sg)).

The harmonized IDM/MVD approach partially shifts the content of Functional Parts to a Model View Definition so that all process related requirements and rules are specified in the so called Exchange Requirements Model (ERM). There is no recommendation for using a particular specification for the definition of IFC subsets or Business Rules. However, as IFC borrows many concepts from the STEP standard available developments mainly have been based on EXPRESS (ISO 10303-11) and EXPRESS-X (Denno 1999).

Exchange Requirement Models are of particular interest for implementation of a data sharing environment, especially if the process-related knowledge is available in a machine interpretable form. Such knowledge is gaining more and more interest for controlling the quality and the increasing complexity of BIM-based design data. The main sources for data validation are building codes, regulations and additional agreements that have to be fulfilled to deal with national, local or project specific requirements.

The identification and coding of Business Rules are for instance targeted by the SMARTcodes™ technology ([www.iccsafe.org/SMARTcodes](http://www.iccsafe.org/SMARTcodes)), which addresses the problem of making machine interpretable rules out of paper-based codes and regulations. The availability of such rules would further raise the benefit of BIM-based working. However, this kind of development, which should be based on an efficient rule coding strategy, is not in focus of InPro and therefore is discussed for selected examples only to show the benefit of such Business Rules.

## 3 IFC EXTENSION MODELLING

The IFC model shall provide the basis for the exchange of BIM-data as defined by the Business Processes and related BIM requirements. Accordingly, if the current IFC release is not able to support these requirements it has to be extended by using one of the three extension mechanisms of the IFC platform. An IFC extension has to be coordinated with the Model Support Group of the IAI (MSG), which decides about appropriate extension strategies and the scope of the next IFC release.

The main actors of IFC extensions are modelling specialists, who are familiar with the IFC data structure and the modelling concepts. Furthermore, they are responsible for the mapping of Exchange Requirements to IFC, which is the first step of any IFC extension project as it enables to identify existing gaps.

### 3.1 Gap analysis

The IFC documentation is actually a set of different specifications comprising:

- a machine interpretable schema definition that is available in EXPRESS (ISO 10303-11) and XML schema,
- the documentation of the IFC schema describing the meaning of entities, attributes and references,
- a set of implementation guidelines and additional agreements that restrict the use of IFC for specific purposes (Liebich 2004, [www.iai.fhm.edu](http://www.iai.fhm.edu)).

All these specifications have to be analysed for the mapping of Exchange Requirements to IFC in order to follow the goal of defining a BIM-based data integration standard. Furthermore, identified gaps shall be compared with the scope of ongoing IFC extension projects ([www.iai-tech.org](http://www.iai-tech.org)) to avoid double work and to join international efforts.

In order to achieve practical results the definition of BIM-related Exchange Requirements should bear in mind that there might be different priorities of IFC extensions, which would enable to set-up an extension strategy that first concentrates on most important requirements. Accordingly, IFC extension modelling basically has to find reasonable solutions that would fit to the overall constraints of the extension project, e.g. available resources, complexity of the implementation, interest of the industry, expected time frame for the take-up of results, plans for future extensions etc.

The Business Processes of InPro concentrate on the early design, which has not yet gained much attention in IFC developments. However, some Exchange Requirements can easily be handled by IFC as they only ask for a lower level of detail, e.g. for architectural and HVAC design. But some of them are not yet in scope of IFC, such as client requirements management, cost estimation or new approaches for BIM-based scheduling. As InPro aims

to start with BIM-based working in early design phases it also requires major changes of collaborative processes. In order to make a first step towards improved processes it is necessary to concentrate on data exchange scenarios that either continue ongoing IFC developments or can be implemented in prototypes within the project.

### 3.2 IFC schema extensions

IFC2x3 contains 653 entity and 327 type definitions, and meanwhile supports 9 domains. The IFC schema is divided into 44 sub schemata and the classification of entities is sometimes based on 8 specialization steps. This kind of modelling is based on the object-oriented approach and has been chosen to improve extensibility of the data structure. Thus, new entities and types shall be defined according to the overall IFC architecture and shall reuse existing specifications.

The IAI has defined a couple modelling constraints such as the ladder principle, single inheritance or the substitution principle of Liskow that are explained in the IFC modelling guidelines (Wix & See 1999). Furthermore, a new IFC release should ensure upward compatibility with the previous IFC release, in particular to the IFC platform to avoid conflicts when moving to a new release.

IFC schema extensions are long-term developments that depend on the IFC release cycles and have to be discussed with the Model Support Group of the IAI. It typically requires two or more years to integrate proposed extensions in a new IFC release, which then would enable to start the implementation. This time frame does not really fit to research projects like InPro, which have to start prototype developments within one or two years. Therefore, if possible the strategy of InPro is to avoid schema extensions, which means to use property sets, proxy elements and references to external data structures.

### 3.3 Use of property sets and proxy elements

Property sets and proxy elements enable to extend the scope of IFC without changing the schema, but require additional implementation agreements about the meaning of properties and proxies if they shall be shared with other CAD software. A single property is key-value pair that can be attached to nearly any kind of elements and thus enables to extend their attributes. A proxy element is an object that inherits main functionality from its super type like for instance a building element, but without having a pre-defined meaning. The meaning or class type is described by the name attribute, which enables to introduce new element types.

The dynamic extension mechanism comes with the risk that the IFC standard evolves into different dialects that are only agreed between few partners

and finally results in incompatible IFC files. As naming of properties and proxies typically depends on the context and language in which they are used there are always naming conflicts that are often leading to unusual definitions. However, the naming problem is going to be changed in IFC2x4, which supports multilingual property sets and links to dictionaries that for instance can be based on the International Framework for Dictionaries (IFD, ISO 12006). Such 'mapping tables' would help to make name-based extensions more understandable as they can be provided in different languages.

### 3.4 References to external data

The BIM approach is not claiming to support any kind of design data and thus to replace other data structures. Instead, the focus of the IFC standard is to provide a shared database that helps to integrate and manage the design data, whereas integration could also mean to set links to external data sources that contain very special domain information or further specify the shared data according to product catalogues, classification systems or national standards. Therefore, a BIM can be seen as a single point of coordination that enables to exchange shared information as well as to manage dependencies to other data sources.

As IFC already enables links to be set to external data, it is mainly a question of where and how to make use of such links. They might also enable a less radical cut between the traditional way of design and the BIM approach. The InPro partners agree that the ability to coexist with traditional documents is an important success factor for BIM-based working since this also takes care of the current situation that is only going to change rather slowly in the highly fragmented AEC industry. Therefore, InPro focuses on solutions that might be seen as an intermediate step, but would enable a smooth change to the BIM approach.

## 4 USE CASE IMPLEMENTATION

Use cases to be supported by BIM-based working are defined by the Process Maps and related Exchange Requirements. These requirements are then matched with the IFC specification to check whether it can be supported or has to be extended. The next logical step is the use case implementation, which has to make sure that each use case is implemented according to the IFC specification and all additional agreements. But it is typically only a subset of IFC that is needed to support a specific use case. Furthermore, the IFC specification might have to be clarified in that context to avoid misinterpretation and thus different implementations. Accordingly, the software industry is asking for implementation

guidelines that allow to focus on use cases and guarantees compatibility with other software implementations.

There are several additional agreements and specifications that are necessary to provide adequate support of the implementation process. They are defined and discussed within the Implementer Support Group (ISG) of the IAI, which is also responsible for the certification process that finally controls the quality of software implementations. Based on experiences of several years of implementation support the IAI has decided to establish the Model View Definition format (MVD, Hietanen 2006), which provides a basis for use case implementations. Furthermore, it is dealing with the documentation of certification results and maintenance issues that for instance are necessary in case of new software and IFC releases.

#### 4.1 Model View Definitions

The MVD format is divided into two main parts, (1) the generic part and (2) the IFC release specific part. Whereas the IFC release specific part provides the functionality that was previously captured in spreadsheets and additional implementation agreements the generic part was not covered by previous specifications. Both parts enable to bridge the gap between the Exchange Requirements and the IFC specification as they “translate” the business language to the IFC data structure. This connection is very important as it not only specifies how to implement our requirements but also enables that software developers can speak with business experts, i.e. to give feedback about the implementation.

There are a couple of view definitions that are discussed within the ISG. At the moment the most important one is the Coordination View that is the basis for available CAD implementations and the definition of further sub-views. They are defined in the ‘traditional’ way, i.e. with spreadsheets and a set of additional agreements, and gave valuable input to the development of the MVD format. The MVD format is used for new developments such as the “Structural design to structural analysis” or “Architectural design to thermal simulation” ([www.blis-project.org/IAI-MVD](http://www.blis-project.org/IAI-MVD)). The time will show if the new format will be accepted in practice and if a reasonable amount of reusability can be reached to speed up view definitions and software developments.

The InPro project is one of the first users of the harmonised IDM/MVD approach, which opens a couple of interesting research issues. There are for instance good reasons to merge Exchange Requirements with the generic part of an MVD, which could reduce the number of specifications of use case based IFC developments. Furthermore, the ‘same’ Exchange Requirements might be defined in differ-

ent languages so that national requirements could be much better integrated into international IFC developments. It even might be possible to deal with requirements from proprietary data structures of the CAD software that would help to clarify the mapping to and from IFC. This might contribute to the question how to benefit from IFD and ontology developments in context of IFC.

#### 4.2 Test beds

At some point of the IFC implementation the availability of proven examples are necessary to run through test cases that allow checking implemented IFC interfaces. Software developers are frequently asking for test files as it obviously supports the understanding of the IFC specification and not at least are needed for later certification. Accordingly, setting-up a test bed is important to ensure compatibility of software implementations and thus has to take care that all relevant conditions of practical data exchange are covered. However, the request for completeness most often contradicts to available resources so that the definition of a test bed has to concentrate on a set of well chosen and good documented test cases.

Most experiences with test-bed developments are available for the Coordination View that covers 15 main object types such as walls, beams, windows, stairs etc. A set of small artificial test cases are described for each object type checking different aspects of the implementation such as geometry, material properties, connections etc. The numbers of test cases vary from 5 (for piles and plates) to about 100 (for wall) that all are described in a spreadsheet and are available for software development and certification.

A research project like InPro it is not able to take the effort of defining complete test beds. However, some examples might be developed to explain implementation agreements as suggested for the support of needed use cases. An interesting development within the IAI is to translate implementation agreements to certification rules that enable an automatic checking of exported and round-tripped IFC models. This development could speed up the provision of valid test files and will support the later certification process. However, it does not help for the documentation and a proper composition of test cases.

#### 4.3 Certification

IFC-enabled software can get a certificate from the IAI showing conformance with the quality criteria of a specific use case. Meanwhile, the IAI is using a two-step certification procedure that first tests an application with a set of artificial test files (based on the test bed) and then, after end-users have proved

the application for at least 6 months, the application is tested with data from real projects. A certificate is given for passing each step and thus shows the status of the implementation.

Today, a certification step can be either passed or failed. This means that the entire use case has to be supported for getting the certificate. The MVD approach suggests a differentiation of certification results that documents all supported and failed concepts. The beauty of that solution is that it describes the capability of an interface and thus enables to decide case by case if an application is suitable for a specific data exchange scenario or not. The problem of that solution is that the end user is burdened with additional decisions, which might become too technical. Nevertheless, such information is very interesting for data management environments, which can give a warning if available data is not properly supported by an application. But that kind of tool support requires an additional specification that can be evaluated by a data management tool, not only for checking software capability but also for supporting the roundtrip of design data (Weise et al. 2004).

Similar to business rules that enable data validation there are discussions about improving the certification process using automatic checking services. However, rule-based checking services are not able to support the whole certification process as they are limited to checking data against implementation agreements. Accordingly, it is not possible to verify the understanding of the data as needed for testing the import or the roundtrip of IFC data. Whereas the import and export of IFC data is currently in focus of the certification by the IAI the InPro project wants to go forward roundtrip scenarios, for instance by limiting allowed data changes that helps to manage and update the shared database.

## 5 END USER GUIDANCE

All developments are worthless without proper user guidelines showing where and how to use IFC-enabled software. The initial BIM requirements have to be matched with results of the software implementation to assemble guidelines that meet national requirements. Accordingly, these guidelines are typically localized documents and are provided in the language of the end users. In essence, these documents are an indicator for the take-up of IFC developments in different countries.

User guidelines are typically less recognized by the international community as they are mainly presented to the national audience. Thus, a survey of available guidelines will help to compare achievements within different countries. Even if there are a couple of global software players who sell the same software in different countries there are noteworthy

differences, either because of special demands from national authorities or because of localized tools that are able to reuse BIM data, e.g. for checking the energy consumption according to national regulations. The scope of these guidelines also reflects experiences that were made with pilot projects and thus shows what is considered to be achievable in practice.

### 5.1 Finland

Finland has gathered a lot of experience in using BIM and IFC. There are about 10 pilot projects of different scale that have been carried out in the last years to prove benefits and practicability of IFC-enabled software. Results of that study were used to define BIM requirements that are demanded from the Finish state since end of 2007. Senate properties, which is the „landlord“ on behalf of the Finish government for financing, managing and operating facilities, has released a set of guidelines that show there and how to use BIM, i.e. in which domains and project stages, and to what level of detail. The guidelines are divided into nine volumes describing a long-term vision of BIM-based working, but also consider the actual status of IFC-enabled software. BIM models are currently required in all projects exceeding EUR 2 million, but are limited to architecture, visualization and cost control. Further potential use cases are MEP design, energy analysis and structural design. The guidelines are available for free download at [www.senaatti.fi](http://www.senaatti.fi).

### 5.2 Norway

Norway recently put a lot of efforts in IFC developments, also focusing on state-of-the-art technologies that go beyond traditional file based data exchange. Besides extensive testing of BIM software and IFC interfaces (Lê et al. 2006, Eberg et al. 2006) the use of IFC model servers and process-driven data access are in focus of BIM related R&D projects. These efforts not only gave feedback to the software development but also facilitated the specification of business processes, related exchange requirements and the IDM methodology as such. The background of these R&D initiatives is the very ambitious goal to establish BIM-based working in a relatively short time frame.

### 5.3 Singapore

A strong argument for BIM is the provision of intelligent building data. It is not only the 3D geometry of physical elements but also the knowledge about their type, function and relationships to other elements. The authorities in Singapore very soon recognized the benefit of BIM-based working and started the development of an IFC-based automatic

code checking service as part of an e-submission system. One of the outcomes was the IFC model implementation guide (Liebich 2004) that clarifies the use of IFC and thus gave valuable input to the worldwide implementation of IFC. Furthermore, important experiences could be made about coding of rules and the presentation of compliance checks to the end users. These experiences are now taken up by similar developments, for instance from International Code Council (ICC). Further information about the actual status of the code checking service can be found at [www.corenet.gov.sg](http://www.corenet.gov.sg).

#### 5.4 USA

The developments in the USA are focused on introducing BIM for improving maintenance and operation of governmental properties. The General Service Administration (GSA), which manages about 32 million square meters of workspace for the civilian federal government, has established a 3D-4D-BIM program that comprises the definition of a BIM guide, BIM pilot application on current capital projects and a contractual language for 3D-4D-BIM adoption. Thus, BIM and IFC are seen as a rewarding investment that is driven by the FM sector, but will facilitate the implementation and use of IFC in whole AEC sector. More details are provided at the web site [www.gsa.gov/bim](http://www.gsa.gov/bim).

Another focus is code checking, which is undertaken by the International Code Council (ICC). In addition to the developments in Singapore the coding of rules became the main challenge of the project, i.e. the transformation of thousands of paper based codes into machine interpretable rules. The answer to that problem is the SMARTcodes™ technology, which not only can speed-up the transformation of codes but also improves clearness and maintainability of rules. Further information can be found at the web site [www.iccsafe.org/SMARTcodes/](http://www.iccsafe.org/SMARTcodes/).

#### 5.5 Denmark

Denmark recently published a list of requirements that shall stimulate the use of modern ICT. These ICT requirements include recommendations regarding BIM and IFC. Depending on the size of a construction project there are different degrees of requirements, e.g. construction projects above EUR 2 million can demand building models in IFC format as as-built information and above EUR 5.3 million shall demand them in design competitions and detailed design. Further information about these requirements can be found at [detdigitalebyggeri.dk](http://detdigitalebyggeri.dk)

#### 5.6 Germany

In Germany, the initiative for providing a comprehensive user guideline mainly came from the Ger-

man speaking chapter of the IAI and was supported by the software industry in a joint effort. The aims of this guideline are to show the advantages of BIM-based working and to lower the barrier for using such technology. It tries to convince end users to make a start in gathering BIM experiences and gives very practical information about IFC-based data exchange. For instance, a small example was chosen to describe the import and export functionality of available CAD software and enables to play with their interfaces. The user guideline and all examples are available for free download at [www.buildingsmart.de](http://www.buildingsmart.de).

## 6 CONCLUSION

It has been shown that IFC developments are far more than defining a data structure that is supported by CAD interfaces. An answer to emerging problems of the BIM approach are provided by use case based developments. They enable integration of all parties that are involved in IFC developments, i.e. the requirements definition, the model specification, the software implementation and last not least the definition of user guidelines. Each component of these developments is already covered by the IAI but yet have to be further tested, integrated and used in broad scale. Thus, even though the general approach provides a sound basis for further IFC extension developments, there are still a lot of questions for making it robust and reliable.

The InPro project is running through the whole process of IFC extension developments and tries to apply the described approach. Therefore, we expect to get valuable experiences that help to give feedback to the IAI. Besides technical questions such as scalability, reusability and consistency the aim of our research is to improve the communication between the different types of users, so that for instance the architect better understands for which processes he actually can use IFC-enabled software or the modelling expert can keep the link to business requirements. As IFC developments are never finished, i.e. they are steadily going through refinements and have to be updated, the integration that is facilitated by use case based developments will become a crucial issue for improving the maintainability of IFC.

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