

# Industry Foundation Classes (IFC)

## BIM Interoperability Through a Vendor-Independent File Format

A Bentley White Paper

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## Executive Overview

buildingSMART International, formerly the International Alliance for Interoperability, is an alliance of organizations within the construction and facilities management industries. Its mission is to *contribute to a sustainable built environment through smarter information sharing and communication*. It also develops and maintains the specification for Industry Foundation Classes (IFC), an open vendor-independent neutral file format that captures both geometry and properties of 'intelligent' building objects and their relationships within building information models. This facilitates the coordination of information across incompatible applications, which is a prerequisite for improving building workflows using building information modeling (BIM) methods. The process eliminates the high cost and waste created by inadequate interoperability.

Bentley is fully committed to the objectives of buildingSMART and is actively involved in several regional chapters as well as IFC-related projects and initiatives. Some examples include the adoption of IFC-based BIM technology by the U.S. General Services Administration (GSA), the Open Geospatial Consortium (OGC) AECOO-QTO test bed and Construction Operations Building information exchange (COBie) challenge projects.

Bentley's IFC2x interface was certified in 2003, and in March 2007 Bentley Architecture officially passed the certification for IFC2x3. Built on the Bentley building technology platform, the IFC interface is also supported by Bentley Structural, Bentley Building Mechanical Systems, and Bentley Building Electrical Systems. Certification for IFC2x3 Coordination View V2.0 will focus on IFC export, while providing IFC open and reference functionality in BIM authoring and project collaboration applications. As the leading proponent for interoperability, Bentley provides architectural, engineering, construction, and operations (AECO) professionals access to its no-cost interoperable software from its iWare Apps site.

## Terms of Reference

Fragmentation among project disciplines (architects, engineers, manufacturers, contractors, owner-operators) and the lack of standard file formats for applications (CAD, BIM, FM, analysis, and engineering document management) cost the building and construction industry billions of dollars in lost productivity, wasted materials, and increased liability. In its 2004 report *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*, the National Institute of Standards and Technology (NIST) estimated the cost of fragmentation and lack of standards to be about US\$15.8 billion or about 1 to 2 percent of the industry's revenue (see <http://www.bfrl.nist.gov/oa/publications/gcrs/04867.pdf>).

The IFC data model is regarded as one of the key enabling technologies to overcome the inefficiencies of a distributed and fragmented industry.

## buildingSMART

Dedicated to improving Integrated Project Delivery (IPD) processes for building projects, buildingSMART's mission is to *contribute to a sustainable built environment through smarter information sharing and communication*. It is an alliance of organizations within the construction and facilities management industries that includes architects, engineers, contractors, building owners, facility managers, manufacturers, software vendors, information providers, government agencies, research laboratories, universities, and more.

Founded in 1995 as the International Alliance for Interoperability (IAI), buildingSMART's initial goal was to define and develop an open industry standard for data interoperability across software applications used for design, analyses, construction, procurement, maintenance, and operation. The key objective of this initiative was to improve communication, productivity, delivery time, cost, and quality throughout the entire building lifecycle by facilitating the coordination of relevant information by project participants regardless of the applications they use.

Increasingly, buildingSMART is seen as a key driving force in the industry for process change, as organizations such as the General Services Agency (GSA), the U.S. Army Corps of Engineers, major owner-operators, and large architectural and engineering firms lobby for the specification, development, and implementation of an industry standard for greater interoperability among BIM applications. This is a prerequisite for significantly improving building processes. The IFC data model is regarded as one of the key enabling technologies to overcome the inefficiencies of a distributed and fragmented industry.

buildingSMART International is organized by regional alliances that represent a country or a group of countries. Current alliances serve Australasia, Benelux, China, the French speaking countries, the German speaking countries (Germany, Austria, and Switzerland), the Iberian countries (Spain and Portugal), Italy, Japan, Korea, Middle East, North America, the Nordic countries (Denmark, Finland, Norway, and Sweden), Singapore, and the United Kingdom and Ireland.

## IFC

Specified and developed by buildingSMART, IFC is an open, vendor-neutral BIM data repository for the semantic information of building objects, including geometry, associated properties, and relationships to facilitate:

- cross-discipline coordination of building information models, including architecture, structural, and building services,
- data sharing and exchange across IFC-compliant applications,
- handover and re-use of data for analysis and other downstream tasks.

IFC-compliant applications can open or import IFC files, re-use intelligent data created in other IFC-compliant applications, and export intelligent model information as IFC files for coordination and re-use in other applications.

Registered with ISO as ISO 16739, IFC is an object-oriented database of information that enables data sharing via ifcXML and aecXML. IFC-compliant applications can open or import IFC files, re-use intelligent data created in other IFC-compliant applications, and export intelligent model information as IFC files for coordination and re-use in other applications. This is especially effective for interoperability among BIM authoring applications, such as AECOsim Building Designer, and analysis applications to calculate quantities and costs, heat loss, cooling loads, lighting requirements, etc., or to handover data to facilities management applications for operations and maintenance.

## Bentley's Position

As a founding member of the IAI, Bentley is active at the board level of several alliances and participates in the Implementers Support Group (ISM). Bentley provides significant resources for the definition of the IFC data format and the development of an IFC interface for Bentley's building applications.

## Coordination View

In May 2003, Bentley's IFC2x interface for 3D Coordination View, which allows the import and export of intelligent 3D building models, was certified. Bentley did not apply for IFC2x2 certification, because this version is specifically aimed at supporting the automated Code Checking system in Singapore.

In March 2007, in accordance with the official IAI facilitated approval procedure, Bentley Architecture 8.9.3 passed the certification for IFC2x Edition 3 (IFC2x3), which is based on the Extended Coordination View definition. As the IFC interface is built on the common Bentley building technology platform, Bentley Structural Modeler, Bentley Building Mechanical Systems, and Bentley Building Electrical Systems also effectively support IFC2x3.

Our certification effort for the IFC2x3 Coordination View V2.0 will focus on IFC export from AECOsim Building Designer and speedikon, while providing IFC open and reference functionality in our BIM authoring, MicroStation, and project collaboration applications, such as Bentley Navigator.

IFC2x3 supports common property sets, including object attributes agreed upon by the Model Support Group of the IAI and the IFC implementers. Bentley's BIM applications handle these properties via IFC-specific DataGroup definition files, which can be downloaded from SELECTservices and appended to a project workspace. Non-common properties can be accommodated by customizing the application schema.

As there are no building services or structural model view definitions (MVD) defined by buildingSMART, IFC cannot be used to export to or import from mechanical or structural analysis applications. But generic 3D geometry of Bentley Structural and Bentley Building Mechanical Systems can be exchanged using part mapping to IFC entities, like IfcBeam and IfcFitting, as the Coordination View supports structural and mechanical items.

Bentley's GSA-specific IFC View implementation has consistently met the administration's benchmark requirements.

For true intra-operability across enabled applications required for intelligent structural design, analysis, and fabrication, Bentley has established Integrated Structural Modeling (ISM), the industry's first comprehensive interoperability methodology for structural information.

### Other IFC/buildingSMART initiatives

Among the IFC-based project initiatives in which Bentley has been an active participant are:

#### *Development of the National Building Information Model Standard (NBIMS)*

The National Institute of Building Sciences (NIBS) Facilities Information Council has completed an intelligent model-based companion to the document-based U.S. National CAD standard.

#### *Development of the IFC Early Design View*

The objective of this developmental and testing project was to create an IFC-based standard view definition for the exchange of project planning, programming, and early design information with downstream applications.

#### *General Services Administration (GSA) Public Building Service (PBS)*

The objective of this project was to test, document, and pilot the creation of the GSA PBS Preliminary and Final Concept Design Submission IFC view for GSA capital construction programs. This provides the basis for automated checking and validation of A/E design submissions in IFC format against original GSA building program requirements. Bentley's GSA-specific IFC View implementation has consistently met the administration's benchmark requirements.

#### *The Open Geospatial Consortium (OGC) OWS-4 Project*

OGC is extending its existing open web services model to include an IFC-based BIM web service client and server components to provide the GIS community access to information contained in building information models (BIM).

#### *Construction Operations Building Information Exchange (COBie)*

COBie is defining a standard for the hand-off of information accumulated during the design and construction process to the owner in order to ensure that the building operations and maintenance (O&M) phase of the building lifecycle can leverage information accumulated during the design and construction phases.

#### *The Model-Based Quantity Takeoff Utilizing the IFC Model Project*

The projects aimed to connect design and engineering, quantity takeoff, and cost estimation and calculation. Proper classification of elements and the description of the methods of measurement for the generation of proper quantities should enable country-specific cost estimation and calculation from standardized IFC models.

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### *OGC (Open Geospatial Consortium, Inc.) AECOO-QTO Test Bed*

This test bed fosters business transformation as defined in the United States National Building Information Modeling Standard, Part 1 (NBIMS) with technology for interoperability involving intelligent building models with 3D geometric capabilities. It does so by extending the IFC schema to support quantity takeoff information per OGC exchange requirements. This MVD was tested during a public demonstration in 2009.

### *FM Handover Aquarium and COBie Challenge 2009*

On Dec. 8, 2009, Bentley successfully participated in the 'COBie Challenge' at 'ecobuild' in Washington, D.C. This challenge was part of the FM Handover Aquarium project, which is organized by the buildingSMART Alliance of North America and sponsored by the Engineer Research and Development Center of the U.S. Army Corps of Engineers, the CAD Stelle Bayern, Staatliches Bauamt München (Germany), and Statsbygg (Norway).

### *FM Handover Aquarium and NFMT/COBie2 Challenge 2010*

On March 17, 2010, Bentley successfully concluded the 'COBie2 Challenge 2010' at the National Facilities Management & Technology (NFMT) Conference in Baltimore, Md., which is also part of the FM Handover Aquarium project.

## **Problems and Limitations**

The IFC2x3 Coordination View is a vendor-neutral consensus BIM schema that supports coordination across a wide range of proprietary vendor formats. Therefore, its specification does not cover or allow for 'native' application-specific object definitions. This means that when importing IFC, applications must interpret and transform imported objects to their native objects as best as possible. As a complete 1-to-1 match is typically not possible, imported elements differ from natively created elements. Therefore, round tripping of IFC data is an unrealistic expectation.

### **Round tripping**

Round tripping of IFC data (importing an IFC file into the application that exported it or any other IFC-compliant application without any loss of data or functionality) is neither an objective of the IFC2x3 Coordination View nor a certification criteria, industry requirement, or use case for the following reasons:

- As an exchange format, IFC is only concerned with results of application functions, and not how they were obtained or produced. Software vendors would be opposed to exporting semantic data that exposes proprietary information and trade secrets.

NB: Applications that can round trip IFC data provide an export switch to store proprietary application data in a container. However, such IFC files can only be used by the same application (and possibly only by the same version).

Bentley advocates IFC Open and IFC Reference, which display IFC objects within a native model environment with superior geometric fidelity, including all meta data and property values.

- The IFC specification does not cover export of certain proprietary data types that support application functions. As these cannot be exported, an IFC file re-imported (round tripped) cannot create the original application data; thus, certain features can no longer work.
- Complex parametric IFC object types, such as doors, windows, curtain walls, stairs, railings, or complex walls, slabs, columns, etc., are not supported, because applications have different and proprietary methods to create such entities with parameters, rules, and constraints. To export these in a format that other parametric engines could support would not only be a tremendous development, coordination, and agreement effort, but also increase file size and processing time enormously.

Consequently, when an AECOsim Building Designer model is exported to IFC and then imported back into AECOsim Building Designer, it is no longer identical to the original model; hence, application functions to manipulate objects generally do not work on re-imported elements.

Likewise, elements imported into AECOsim Building Designer from IFC files exported from other BIM-authoring applications will not behave like natively-created elements. Although the geometry and property values are available for coordination with native models, they cannot be manipulated with application tools or used for downstream tasks, such as drawing generation, analyses, etc.

To address this problem, Bentley advocates IFC Open and IFC Reference, which display IFC objects within a native model environment with a greater degree of geometric fidelity, including all meta data and property values. These accurate and information-rich reference models can be used for true coordination (as the name Coordination View suggests) across models created by disparate applications to

- measure distances, angles, areas, volumes, and minimum distances
- create schedules
- snap to elements
- visualize the design
- create markups
- perform clash detection

This functionality is available in MicroStation V8i, AECOsim Building Designer, speedikon, Bentley Navigator, and ProjectWise i-model Composer.

Bentley recognizes that the ability to open files in other user formats is crucial to the successful, cost-effective design, delivery, and operation of infrastructure assets.

## Support for Other Industry Standards and Formats

For Bentley, IFCs are just one way to share information and interoperate with other CAD, BIM, and analysis applications, as the company provides

- full DGN/DWG compatibility,
- 3D PDF and Google Earth support,
- import/export tools for the main general purpose industry standards, such as STEP, STL, IGES, DXF, SKP (SketchUp), etc.,
- import/export tools for many dedicated industry standards, such as CIS/2 and SDNF,
- seamless integration with Bentley's STAAD.Pro and RAM International structural analysis products.

## Bentley's Commitment to Interoperability

As the industry leader on interoperability, Bentley recognizes that the ability to open files in other user formats is crucial to the successful, cost-effective design, delivery, and operation of infrastructure assets. To enable AECO professionals to collaborate with applications and technologies Bentley provides:

- i-models to facilitate infrastructure information exchange,
- support for multiple file formats,
- Integrated Structural Modeling (ISM) methodology,
- OpenPlant ISO 15926-based offerings.

In addition, Bentley provides AECO professionals access to no-cost iWare Apps to enable interoperability – with links also available to documentation and training.

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