

IFC White Paper

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Executive Overview

The International Alliance for Interoperability (IAI) is an organization of building industry stakeholders for the creation of an industry standard for data interoperability across Building Information Modeling (BIM) applications used over a building's life cycle. This standard is regarded as a prerequisite for improving building workflows using BIM methods, thus eliminating the high cost and waste created by inadequate interoperability. A vendor-independent neutral file format, IFC (Industry Foundation Classes) capture both geometry and properties of 'intelligent' building objects and their relationships within building information models, thus facilitating the sharing of information across otherwise incompatible applications. Bentley is fully committed to the objectives of the IAI and their buildingSMART initiative and is involved in several regional chapters of the IAI as well as in other IFC-related projects and initiatives, e.g. the adoption of IFC-based BIM technology by the US General Services Administration (GSA) and the OGC (Open Geospatial Consortium) AECOO-QTO testbed. 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.

Terms of Reference

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

IAI

In 1995, the IAI ('International Alliance for Interoperability' or in Germany 'Industrieallianz für Interoperabilität') http://www.iai-international.org/iai_international/ was founded to define and develop an industry-standard, vendor-independent, and neutral file format for data interoperability across software applications used for design, construction, procurement, maintenance and operation. The key objective of this initiative was to improve communication, productivity, delivery time, cost, and quality throughout the whole building life cycle by facilitating the sharing of relevant information by project participants regardless of the applications they use. Organizations within the alliance now include architects, engineers, contractors, building owners, facility managers, manufacturers, software vendors, information providers, government agencies, research laboratories, universities and more.

Increasingly, the IAI is seen as a key driving force in the industry, as organizations such as the General Services Agency (GSA), the US Army Corps of Engineers, major owner/operators, and some large architectural and engineering firms are more and more demanding the specification, development, and implementation of an industry standard for interoperability between BIM applications. Having realized their poor brand image, the IAI is now re-branding itself under the term '*buildingSMART*', which includes 'Smart Planning', 'Smart Design', 'Smart Construction', 'Smart Procurement', etc. Greater interoperability is a prerequisite to significantly improve building processes, thus avoiding the high cost and waste as the result of inadequate interoperability. The IFC data model is regarded as the key enabler to achieve such interoperability, thus to overcome the inefficiencies of a distributed and fragmented industry.

BuildingSMART International is organized in Regional Alliances representing a country or a group of countries acting together. Currently, buildingSMART International has Regional Alliances serving Australasia, Benelux, China, the French Speaking countries, the German Speaking countries (Germany, Austria and Switzerland), the Iberian countries (Spain and Portugal), Italy, Japan, Korea, North America, the Nordic countries (Denmark, Finland, Norway and Sweden), Singapore and the United Kingdom and Ireland.

IFC

Specified by the IAI, IFC (Industry Foundation Classes) is a 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, e.g. architecture and building services (MEP),
- data sharing and exchange across IFC-compliant applications,
- extraction and re-use of data for analysis and other downstream tasks.

IFC is registered by ISO as ISO/PAS 16739 and is currently in the process of becoming an official International Standard ISO/IS 16739. It is an object-oriented database of information that enables data sharing via ifcXML and aecXML. IFC-compliant applications can import IFC files and (re)use 'intelligent' data created in other IFC-compliant application, and export 'intelligent' model information as IFC files for (re)use in other applications. This is especially effective for interoperability between authoring applications, such as Bentley Architecture, and analysis applications, for instance to calculate quantities and costs, heat loss, cooling loads, lighting requirements, etc.

Bentley's position

As a founding member of the IAI, Bentley is active at board level in several chapters (US, UK, Germany, ...). We provide significant funds for the definition of the IFC data format and spend considerable development resources to develop the IFC interface for the Bentley Building applications.

Coordination View

In May 2003, Bentley's IFC2x interface for the 3D Coordination View was certified, which allows import and export of 'intelligent' 3D building models. Bentley did not apply for IFC2x2 certification, because this version, although used on some projects, is specifically aimed at support of 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, Bentley Building Mechanical Systems, and Bentley Building Electrical Systems effectively also support IFC2x3.



For export to IFC, family/part definitions of Bentley Architecture objects are mapped to IFC entities via IFC-mapping files. 3D levels and symbology of objects imported into Bentley Architecture, unless specified in the IFC file, are determined by the family/part definitions in `ifc_imp_parts.xml` or `ifc_si_parts.xml`, which are delivered with every localized dataset. These also define drawing symbology, rendering properties, and quantity takeoff rules of imported objects.

IFC2x3 supports common property sets, i.e. object attributes agreed upon by the Model Support Group of the IAI and the IFC implementers. Bentley Architecture handles these properties through an IFC-specific DataGroup schema, which can be downloaded from SELECTservices <http://www.bentley.com/SELECT> and appended to a Bentley Architecture or project dataset. Non-common properties can be accommodated by customizing the Bentley Architecture DataGroup schema.

Building Services and Structural View

In addition to the Coordination View, there is a Building Services View and a Structural View in the early stages of specification.

The Structural Schema will not be defined until after the IFC2x3 certification and no official certification timeframe has been scheduled. However, Georgia Tech developed and is making available a free translator to exchange CIS/2 and IFC data as well as information and test cases at <http://cic.nist.gov/vrml/cis2.html>. Therefore, Bentley will focus development effort on the CIS/2 interface provided with Bentley Structural.

As there are no Building Services or Structural Views yet to support, IFC cannot be used to export to or import from any mechanical or structural analysis applications. However, 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 generic structural and mechanical items.

Other IFC/BuildingSMART initiatives

Bentley is supporting and actively participates in a number of IFC-based project initiatives, such as:

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 is to create an IFC-based standard view definition for the exchange of project planning, programming, and early design information with down-stream applications.

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

The objective of this project is to test, document, and pilot the creation of the GSA PBS Preliminary and Final Concept Design Submission IFC view for their capital construction programs, thus providing 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 GSA benchmark requirements.

The Open Geospatial Consortium (OGC) OWS-4 Project

OGC is extending their existing open web services model to include IFC-based BIM web service client and server components in order 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 handoff of information accumulated during the design and construction process to the owner in order to insure that the building operations and maintenance (O&M) phase of the building lifecycle can leverage information accumulated during the design and construction process.

The 'Model-based quantity take-off utilizing the IFC model' project

The projects aims to connect design & engineering, quantity take-off, and cost estimation & 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 & calculation from standardized IFC models.

OGC (Open Geospatial Consortium, Inc.) AECOO-QTO testbed

The testbed aims to foster 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, by extending the IFC schema to support quantity takeoff information per OGC exchange requirements. This Model View Definition (MVD) will be tested during a public demonstration in Q1, 2009.

Problems and Limitations

IFC are the 'lowest common denominator' of all involved applications, therefore, high-end functionality in some applications is being reduced to the level of functionality that all applications can support.

'Round tripping'

So-called 'round tripping' of IFC data, i.e. importing an IFC-file into the application which exported it or any other IFC-compliant application without any loss of data or functionality, is neither a current objective of the IFC2x3 Extended Coordination View nor a certification criteria, requirement, or use case for a number of reasons:

- ❑ As an exchange format, IFC is only concerned with results of application functions, not how they have been 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).
- ❑ 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.
- ❑ Parametric shapes can be exchanged for a subset of building objects, such as standard walls, beams, columns, slabs, openings, doors and windows. However, parametric shapes of complex IFC entities, such as curtain walls, stairs, railings, or more complex walls, slabs, doors, windows, 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.

The only requirement for round tripping of IFC data is the preservation of GUIDs, even if IFC entities are downgraded to proxies and the geometry is converted to more basic geometric representations. Therefore, when a Bentley Architecture model is exported to IFC, then imported back into Bentley Architecture, it is no longer identical to the original model; hence certain application functions no longer work as before.

Thus 'round-tripping' is an unrealistic and unjustified expectation by some people and organizations.

Support for other industry standards and formats

For Bentley, however, IFC are just one way to share information and interoperate with other CAD, BIM, and analysis applications, as we provide

- ❑ 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, like CIS/2 and SDNF,
- ❑ seamless integration with Bentley's STAAD.Pro and RAM International structural analysis products.

For further information, see 'Bentley's Commitment to Open Standards and Interoperability' [Interoperability.htm](#)