Collaborative Design and Engineering

History, Current Practice and Possible Future
Léon van Berlo

To create a data driven industry

@berlotti

Carpenter → Architectural Engineer → “Researcher”

Netherlands organisation for applied Scientific Research TNO
  Mission to improve quality of life and competitiveness of industry
  Developing, implementing and disseminating technology
  Focus on openBIM; avoiding any kind of lock-in for industry

Open source BIM collective; BIMserver.org; BIM Bots; BIM Quickscan®; BIM Execution plan generator; National BIM Guidelines; geoBIM.org and many more....
Unlock your BIM collaboration potential

Take your BIM to the next level with our data driven approach
BIM → Collaboration
Common Data Environment (CDE)

Traditional Information Sharing
- Client
- Manager
- Main Contractor
- Sub-Contractor
- Engineer
- Supplier
- Project Manager
- Facilities Manager

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“SHARED DATA MODEL”
Common misconception:

• Shared data model is **NOT** equal to:
  • Shared data(base)
  • Shared BIM model instance

• *Shared data model* comes from the need to share/distribute data in a standardized way…. *“let’s agree this is a door”*

**shared data model == creating agreements**

(interoperability)
IfcWallStandardCase

**Definition from IAI:**
The standard wall (IfcWallStandardCase) defines a wall with certain constraints for the provision of parameters and with certain constraints for the geometric representation. The IfcWallStandardCase handles all cases of walls, that are extruded vertically

- along the positive z-axes of the wall local placement coordinate system and
- along the positive z-axes of the global (world) coordinate system

and have a single thickness along the path, i.e.:
- parallel sides for straight walls
- concentric sides for curved walls.

The following parameter shall be given:

- Wall height, taken from the depth of extrusion, provided by the geometric representation.
- Wall thickness, taken from the material layer set usage, attached to the wall
- Wall offset from axis, taken from the material layer set usage, attached to the wall

The material of the wall is defined by the IfcMaterialLayerSetUsage and is attached by the IfcRelAssociatesMaterial objectified relationship. It is accessible by the inverse HasAssociations relationship. The material layer set usage has to be given (enforced by where rule).

**HISTORY** New entity in IFC Release 2x.

**Type Use Definition**
The type information relating to the IfcWallStandardCase is defined at the supertype IfcWall. As an additional use agreement for standard walls, the IfcWallType should have a unique IfcMaterialLayerSet that is referenced by the IfcMaterialLayerSetUsage assigned to all occurrences of this IfcWallType.

![Diagram of IfcWallStandardCase](image)

**Property Set Use Definition**
The property sets relating to the IfcWallStandardCase are defined at the supertype IfcWall.

**Quantity Use Definition**
The quantities relating to the IfcWallStandardCase are defined at the supertype IfcWall.

**Geometry Use Definitions**
The geometric representation of IfcWallStandardCase is given by the IfcProductDefinitionShape, allowing multiple geometric representation. Included are:

- **Local Placement**
  The use of local placement is defined at the supertype IfcWall.

- **Geometric Representation**
  The standard geometric representation of IfcWallStandardCase is defined using the following multiple shape representations for its definition:
  - **Axis:** A two-dimensional open curve (IfcBoundedCurve) defining the axis for the standard wall. The material layer offset is measured from the wall axis.
  - **Body:** A SweptSolid Representation or a CSG representation defining the 3D shape of the standard wall

**First representation: Curve2D representation of wall axis**
The wall axis is represented by a two-dimensional open curve within a particular shape representation. The wall axis is used to apply the parameter to the wall geometry. The following attribute values shall be used

- **IfcShapeRepresentation** shall have the following values:
  - **RepresentationIdentifier:** "Axis"
  - **RepresentationType:** "Curve2D"

In case of a straight wall, the set of items shall include a single geometric representation item of type IfcPolyline or IfcTrimmedCurve with the BasisCurve being an IfcLine.
In case of a straight wall, the set of items shall include a single geometric representation item of type IfcPolyline or IfcTrimmedCurve with the BasisCurve being an IfcLine.

In case of a curved wall, the set of items shall include a single geometric representation item of type IfcTrimmedCurve. The curve shall have a BasisCurve of type IfcCircle.

**Second representation: SweptSolid or Clipping representation of wall body**

The body of the IfcWallStandardCase is defined by using 'SweptSolid' representation for walls without clippings or 'Clipping' representation for walls with clippings (e.g. under sloped roof slabs).

*IfcShapeRepresentation shall have the following values:
- RepresentationIdentifier: 'Body'
- RepresentationType: 'SweptSolid' or 'Clipping'

**SweptSolid representation**

The standard geometric representation (for body) of IfcWallStandardCase is defined using the 'SweptSolid' representation. The following additional constraints apply to the swept solid representation:

- **Solid**: IfcExtrudedAreaSolid is required.
- **Profile**: IfcArbitraryClosedProfileDef and IfcRectangleProfileDef shall be supported.
- **Extrusion**: The profile shall be extruded vertically, i.e., in the direction of the z-axis of the coordinate system of the referred spatial structure element. It might be further constraint to be in the direction of the global z-axis in implementations agreements. The extrusion axis shall be perpendicular to the swept profile, i.e., pointing into the direction of the z-axis of the position of the IfcExtrudedAreaSolid.

The profile of a wall is described in the ground view and extruded vertically. The profile (also identical with the foot print of the wall) is defined by the IfcArbitraryClosedProfileDef (excluding its subtypes). The profile is given with all wall connections already resolved.

- In case of a straight wall the two sides of the profile shall be parallel to the wall axis, i.e., the wall has a single unchanged thickness.

- In case of a curved wall the two sides of the profile shall be parallel (with defined offset) to the wall axis, i.e., the wall has a single unchanged thickness.
Example of clipping using an IfcHalfSpaceSolid as second operand in the IfcBooleanClippingResult.

**EXPRESS specification:**

ENTITY IfcWallStandardCase;
  SUBTYPE OF (IfcWall);
  WHERE
  WR1 : SIZEOF (QUERY(temp <= USELINK( self, 'IFCRELASSOCIATES.RELATEDOBJECTS') | ('IFCPRODUCTEXTENSION.IFCRELASSOCIATEMATERIAL' IN TYPEOF(temp)) AND ('IFCMATERIALRESOURCE.IFCMATERIALLAYERSETUSAGE' IN TYPEOF(temp, RelatingMaterial))) ) = 1;
END_ENTITY;

**Formal Propositions:**

WR1

: The IfcWallStandard relies on the provision of an IfcMaterialLayerSetUsage.

**Inheritance graph**

ENTITY IfcWallStandardCase;
  ENTITY IfcWall;
    GlobalId
    OwnerHistory;
    Name;
    Description;
  ENTITY IfcObjectDefinition;
    INVERSE
      HasAssignments;
      DecomposesBy;
    DECOMPOSERS
      HasAssociations;
    ENTITY IfcObject;
      ObjectType;
    INVERSE
      IsDefinedBy;
    ENTITY IfcProduct;
      ObjectPlacement;
      Representation;
    INVERSE
      ReferencedBy;
    ENTITY IfcElement;
      Tag;
    INVERSE
      HasStructuralMember;
      FillsVoids;
      ConnectedTo;
      HasCoverings;
      HasProjections;
      ReferencedInStructures;
      HasPore;
      HasOpenings;
      IsConnectionRealisation;
      ProvidesBoundaries;
      ConnectedFrom;
      ContainsInStructure;
  ENTITY IfcBuildingElement;
  ENTITY IfcWall;
  ENTITY IfcWallStandardCase;
END_ENTITY;
BIM data flow through standards: reducing interfaces
Collaborative engineering with IFC: new insights and technology

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ABSTRACT: The concept of working in one central Building Information Model (BIM) is becoming increasingly popular. Reports in literature as well as industry practitioners describe the lack of good implementations for IFC import/export in current software tools. The so-called “round tripping” of an IFC model cannot be performed without data loss, making the merging of data into one central data repository impractical. This feedback discusses about the workability of IFC in relation to a homogeneous software environment. In the Netherlands several experiments were conducted to research if IFC still meets the needs from the AEC industry. The observations and opinions from users reflect current theories and perceptions on collaborations using IFC. This paper describes a collaboration process called “reference modes”. User opinions from the research state that the use of IFC, in an eligible collaboration process, meets the needs of the industry even better than homogenous proprietary software environments.

1 THE PROMISE OF A CENTRAL BIM

For many years the central BIM collaboration concept has been idealized. Some of the current problems of the industry that can be attributed to the lack of up-to-dateness of data can be addressed by using central data repositories [Flannern et al 2003 & Froese 2003]. The concept where all project partners work simultaneously in the same central building model has raised a range of new questions, both technical as well as legal and about project workflows.

1.1 New concepts raise new questions

The following scenario raises new questions every time it is discussed. The famous problem that always pops up is the one where an architect wants to change the placement and/or properties of a structural wall. The structural wall is “owned” by the structural engineer who is responsible for it. Many systems these days “flag” objects in a database to an owner. That way the architect cannot edit the structural wall, but has to place a change request in the text to change specific parts like finishing, but not the material or placement.

Working in a central BIM model also raises a lot of legal questions like “who owns the data”, “who owns the intellectual property” and “what happens when the structural engineer doesn’t reply to a request?”

1.2 History of the central model concept

The concept of working in a central data model was introduced years ago. The famous picture with the central model in the middle was originally introduced as a concept for a “shared data model”. A data model in software engineering is an abstract model, that documents and organizes the business data for communication between team members and is used as a plan for developing applications, specifically how data is stored and accessed. A data model explicitly determines the structure of the data or structured data. The most common data model in AEC is the IFC (Industry Foundation Classes) model. The IFC data model is the central model that was meant to be in the middle of the circle because the standardized structure of the data is shared by all team members.
“There is no CENTRAL model”

(in a multi discipline project)
Denmark 2006:
Common (mis)conception of integrated BIM
Common (mis)understanding: IFC data is the master model

Basic assumptions:
- IFC based model server is “Master”.
- IFC model is basically one logical model created and updated by several applications.
- Any application can technically read and write any data.

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Found conclusion:

Working (live) in a ‘central’ BIM has more downsides than advantages.

(ownership of objects, legal aspects, BIM manager, change requests, etc...)
“Centralizing data stimulates wrong behaviour”
So now what?
Split in the BIM market

- Practitioners
- Policy makers
Split in the BIM market

- Practitioners
  - BIM is not a goal, but a great way to achieve the goal
- Policy makers
  - BIM is the goal
Split in the BIM market

- Practitioners
  - BIM is not a goal, but a great way to achieve the goal
  - Bottom up
  - What is needed to finish the work

- Policy makers
  - BIM is the goal
  - Top down
  - What is needed to finish the story
Split in the BIM market

- Very high level of knowledge
- Work with what is available
- Focus on working with BIM/data

- Write documents
- Get their inspiration from the UK
- Focus on mandating working methods, tools and creating ‘standards’
Split in the BIM market

- Very high level of knowledge
- Work with what is available

Focus on **working** with BIM/data

- IFC, Basic ILS

- Write documents
- Get their inspiration from the UK

- Focus on **mandating** working methods, tools and creating ‘standards’

- CDE; LOD; Execution Plans; etc
Is the split a problem?
Collaborative Engineering with IFC: common practice in the Netherlands

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6 Recommendations and future work
The results and conclusions from this research have led to recommendations. In this chapter we present them:

1. The research finding support the conclusion from Miettinen & Paavola (2014): top down policy makers and bottom up users don’t seem to meet in the middle. A recommendation is done to the top down policy makers to take knowledge of the rising movement of advanced and experienced users.

2. There are many myths and ignorance towards actual working solutions. We recommend increasing the priority of high quality BIM education. This might also increase the adoption of BIM in general because the risk for organizations would be lowered. This is why we also recommend software vendors to actively support education initiatives from the industry.

3. Concept libraries are not mentioned by users as an important part of the described process, some reason non-users are still reluctant to the use of IFCs and thereby obstruct an open discussion about it. In a risk avoiding industry, the potential of BIM is therefore limited. The debate is further
Lessons learned

In a fragmented industry, with fast developing technology, we see a constantly growing ecosystem of data.

Mandating and dictating does not provide solutions, and always lacks behind practice.
Just to be clear:

Nothing wrong with an online system to help you do your work....
Current practise
Dataflow and Workflow of BIM

tno.nl/bim

BIM and Beyond: Digital Transition in Construction

ITÜ Süleyman Demirel Kültür Merkezi / Istanbul, 12 – 13 October 2018
The real questions are:

What do I need to do my job?
What do others need from me to do theirs?
These classification systems were chosen:
- SfB: 66.67%
- Own company standard: 33.33%

Who should be leading partner:
- Jeroen Vels: 33.33%
- Remko de Haan: 33.33%
- Lex Ransijn: 33.33%
BIM BASIC INFORMATION DELIVERY MANUAL (IDM)

1. WHY ARE WE SHARING THIS INFORMATION UNAMBIGUOUSLY?
In order to secure and reuse information more efficiently and effectively.

- SPEAK THE SAME LANGUAGE
- ELIMINATE MUSCLE TASKS

2. HOW ARE WE GOING TO SHARE THIS INFORMATION UNAMBIGUOUSLY?
Knowledge and practical experiences have shown that there is a significant common denominator. We are not developing something new, but rather using existing structures, based on openBIM IFC.

- NEW
- IFC

3. WHICH STRUCTURE WILL WE USE?
The agreements listed below help ensure that everyone involved party will always be able to find and supply the right information in the right place.

Checklist: basic information delivery manual

3.1 FILE NAME
- Ensure that uniform and consistent naming is used for discipline models within the project.

3.2 LOCAL POSITION AND ORIENTATION
- The local position of the building is coordinated and close to the origin.

3.3 BUILDING STOREYS AND NAMING
- As in Building Storeys only as itBuildingStory-Names.

3.4 CORRECT USE OF ENTITIES
- Use the most appropriate type of BIM entity, both in the source application and the IFC entity.

3.5 STRUCTURE AND NAMING
- Consistently structure and name objects.
- Correctly enter the object TYPE (IfcType, IfcObjectType or IfcObject_Type). Where applicable, also correctly enter the name (IfacName or NameOverride).

3.6 CLASSIFICATION SYSTEM
- Apply the existing classification system used in the relevant country. In the Netherlands this is the NL-GC.

3.7 OBJECTS WITH CORRECT MATERIALIZATION
- Allocate objects with a material description (IfcMaterial).

3.8 DUPLICATES AND INTERSECTIONS
- There are no duplicates or intersections permitted. Make sure this is checked in IFC.

3.9 LEARNING TO SPEAK THE SAME LANGUAGE IS SOMETHING WE DO TOGETHER.
When naming objects, consider whether the name meets the following criteria. Double-check this, and know what information you are sharing.

- Logical
- Understandable
- Insightful

4. HOW CAN WE SECURE OTHER/FUTURE OBJECT INFORMATION?
Object information is secured in the correct properties and property sets as defined in IFC.

4.1 LOADBEARING
- Allocate objects, when applicable, with the property Loadbearing (IfcPropertySet).

4.2 IS EXTERNAL
- Allocate objects, when applicable, with the property External (IfcPropertySet).

4.3 FURNITURE
- Allocate objects, when applicable, with the property Furniture (IfcPropertySet).

4.4 PROJECT SPECIFIC
- Define which IFC properties you are using for each specific project.
Shopping district Utrecht

250 IFC files
603,000 objects
258 million geometrical triangles
Rhapsody

>300 IFC files
7Gb IFC data

Almost everything curved
Prominent Amsterdam location
316 apartments
(including most expensive penthouse in Amsterdam)
100 million construction costs

- Everything in BIM from the beginning
- Quotations and contracts based on IFC
- Rule checking
- Just in time logistics based on IFC
- Suppliers deliver data in IFC
- Cranes and support constructions in 4D BIM
- Fire safety analyses with IFC
- Simulations (wind, fire, energy) base on IFC
- And so much more...

Pontsteiger
Quantity take off
Comparing design with supplier data
Comparing design with supplier data
Site management
Issue management with BCF
Pontsteiger statistics

• 230 IFC files (actually almost 350)

• 15.1 Gb data

• 236 Million IFC objects
Pontsteiger statistics

- BIM Protocol on a A3 paper
- No CDE
- No LOD definitions
- No conceptlibrary
- Etc.
It works
It works

but only when it comes from bottom up
Future practise
BIM and Beyond: Digital Transition in Construction

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Thank you!

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