

# INDUSTRY FOUNDATION CLASSES



# THIS IS OUR TEAM

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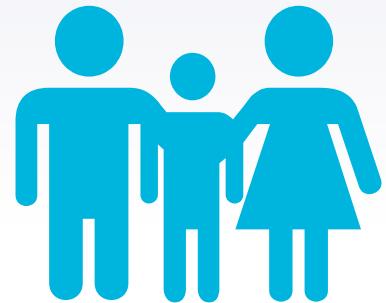
Ibrahim Mohamed  
Ibrahim Saad

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Abdelrahman Fathy  
Abdelhalim Aly

## MARWA MOHAMED

Marwa Mohamed  
Abdalla



01

...

IFC OVERVIEW

02

...

IFC DATA MODEL

03

...

PROPERTIES

04

...

THE FUTURE

1

# IFC OVERVIEW

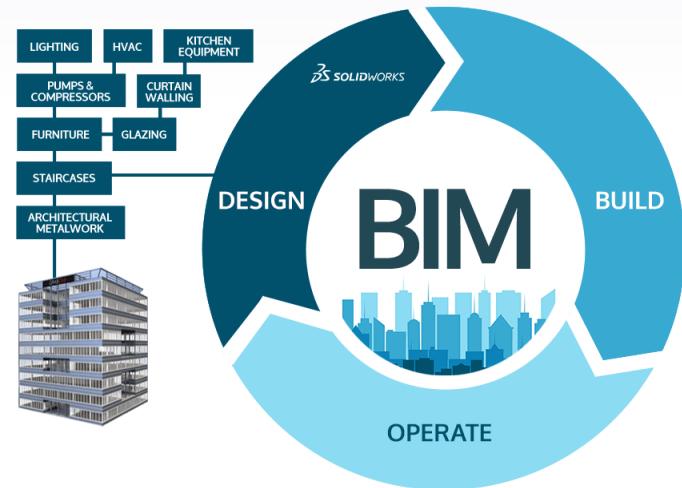


# BACK TO THE IDEA OF BIM



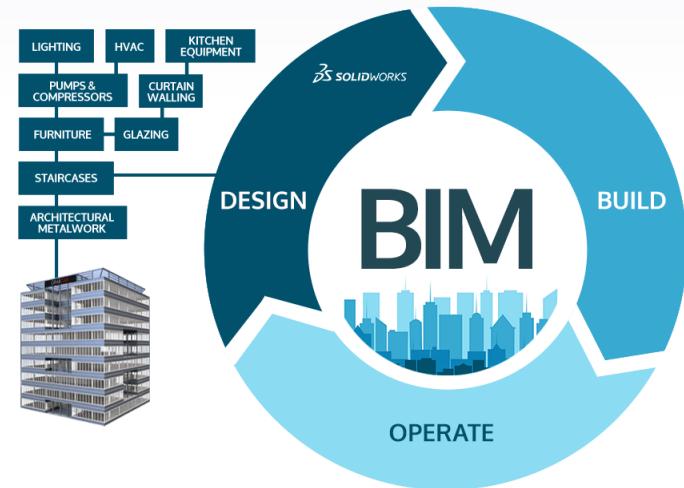
# BACK TO THE IDEA OF BIM

- ▶ Building Information Modeling (BIM) is an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure.



# BACK TO THE IDEA OF BIM

- ▶ Traditional: Lined, 2D, Paper – Based.
- ▶ BIM: Object, 3D, Digital – Based.





BEGIN.

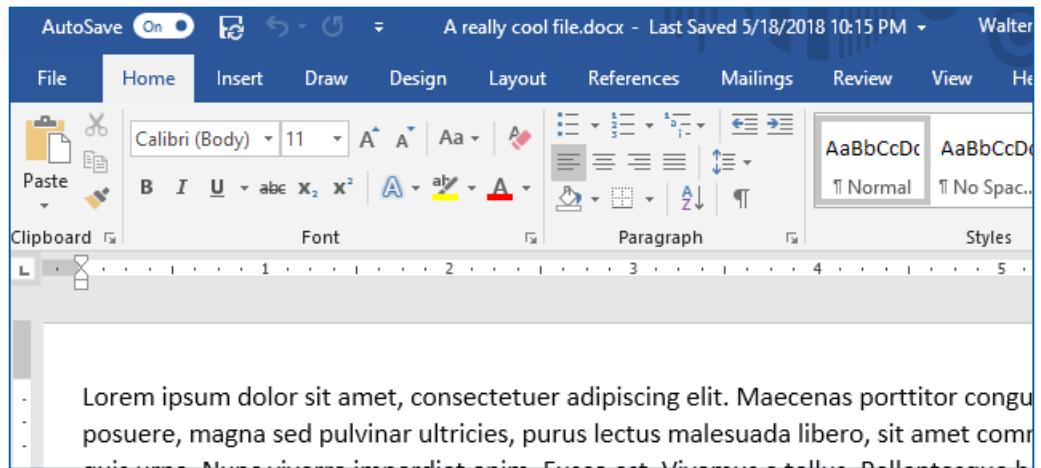
# Open BIM

- ▶ Open BIM simply means working with BIM using open Standards.
- ▶ Well, what are open Standards?



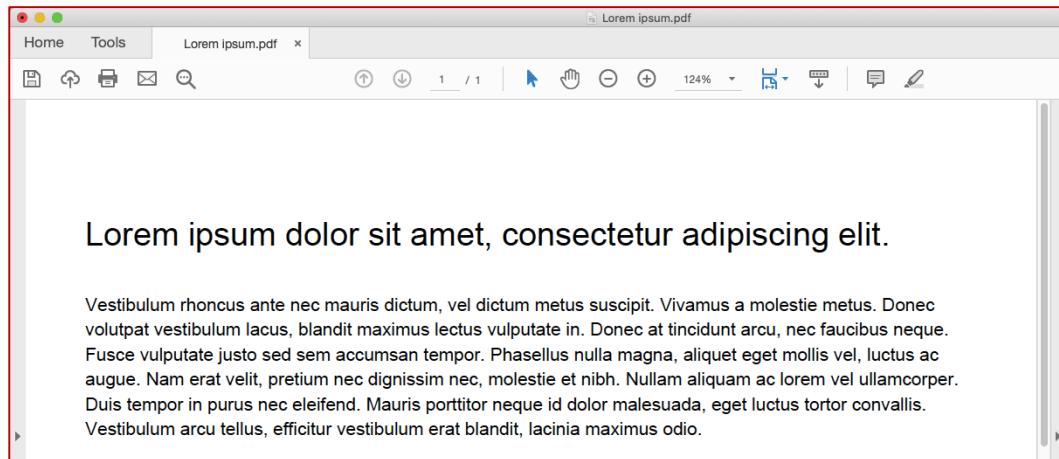
# Open BIM

- To write a report you typically use a word processing application. Maybe, Microsoft Word.



# Open BIM

- Once the report is complete, you probably want to share it with your audience. Typically, you don't send out your reports as a native file, you usually publish a PDF copy.



# Open BIM

There are a number of reasons for this:

- ▶ Firstly, if you send a native file, anyone can make changes to your document without you knowing.
- ▶ Secondly, the native files are proprietary, or closed, formats. This means the receiver needs to have the same application, or a compatible application, to view them.

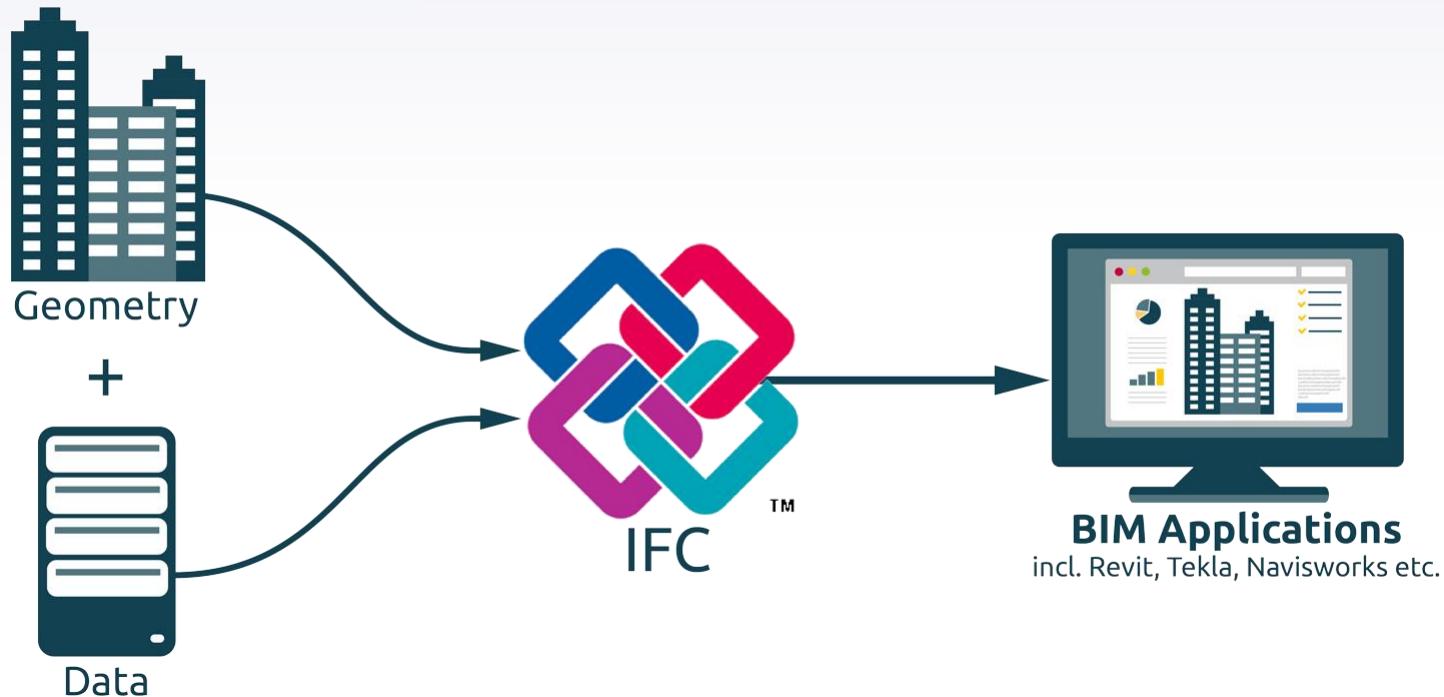


# Open BIM

- If you issue a PDF, on the other hand, the document can be viewed with a simple PDF viewer. PDF is an open standard. It is a lightweight file, but still has a lot of functionality.
- The recipient can view the document, search for words, add comments or markups but they cannot change the original text.



# What Is IFC?



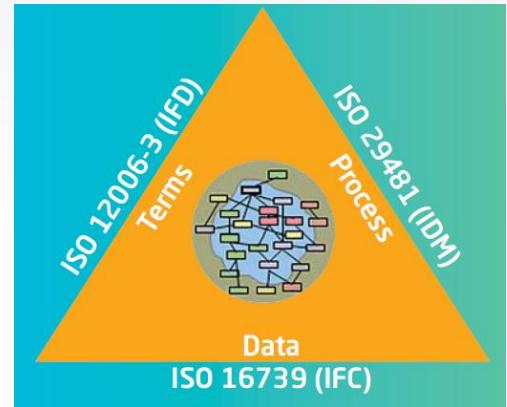
# What Is IFC?

- ▶ IFC, or industry Foundation Classes, is a standard, some would say the primary standard, for openBIM data exchange.
- ▶ IFC is commonly referred to as an exchange format. This is not entirely correct. IFC is a schema, not a format.



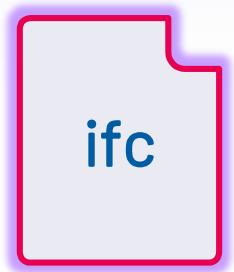
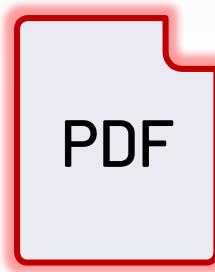
# What Is IFC?

- ▶ IFC, or "Industry Foundation Classes", is a standardized, digital description of the built environment, including buildings and civil infrastructure.
- ▶ It is an open, international standard (ISO 16739-1:2018).



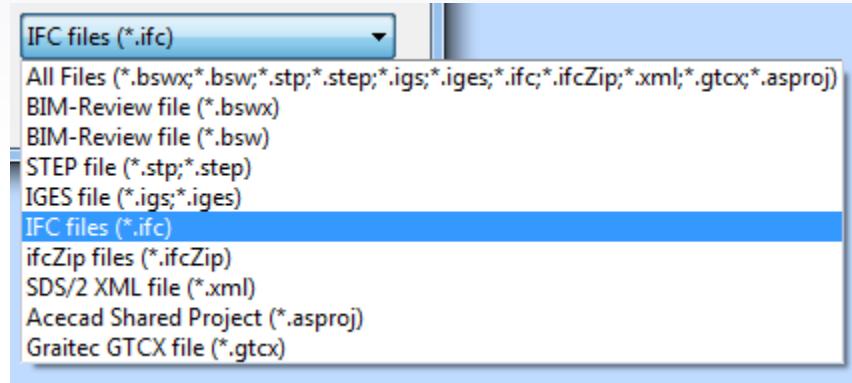
# What Is IFC?

- ▶ IFC as the PDF of BIM. Like PDF, an IFC file is a **“frozen copy of the original content.”**
- ▶ It can be viewed, measured, used for clash detection, cost estimation, simulation and innumerable other uses, but should not be edited.



# IFC Formats

Format	Extension	Size	Notes
STEP Physical File (SPF)	.ifc	100%	The most widely used
Extensible Markup Language (XML)	.ifcXML	113%	Provides enhanced readability
ZIP	.ifcZIP	17%	FC data may be embedded within a ZIP file



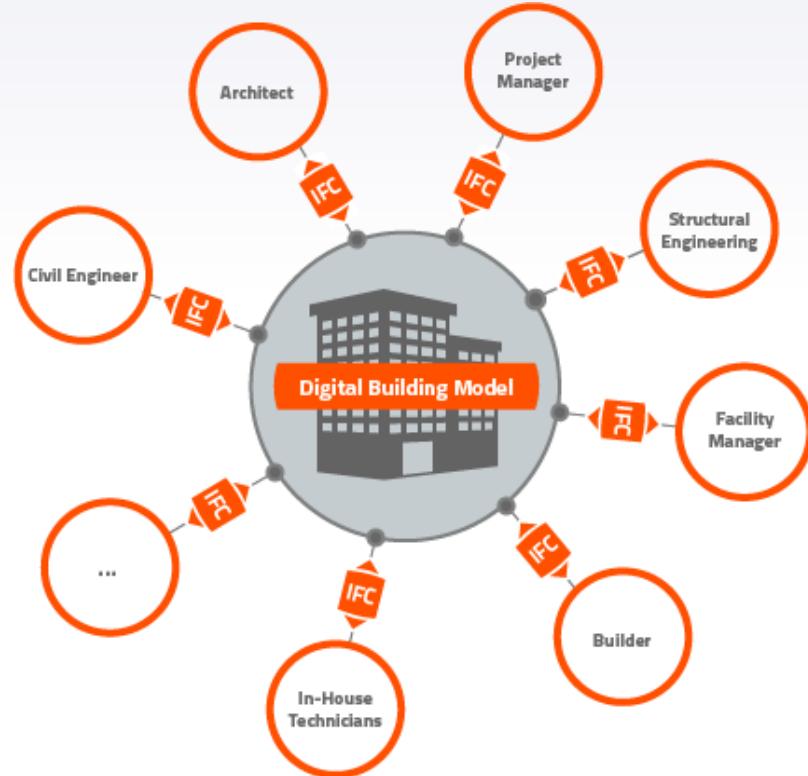
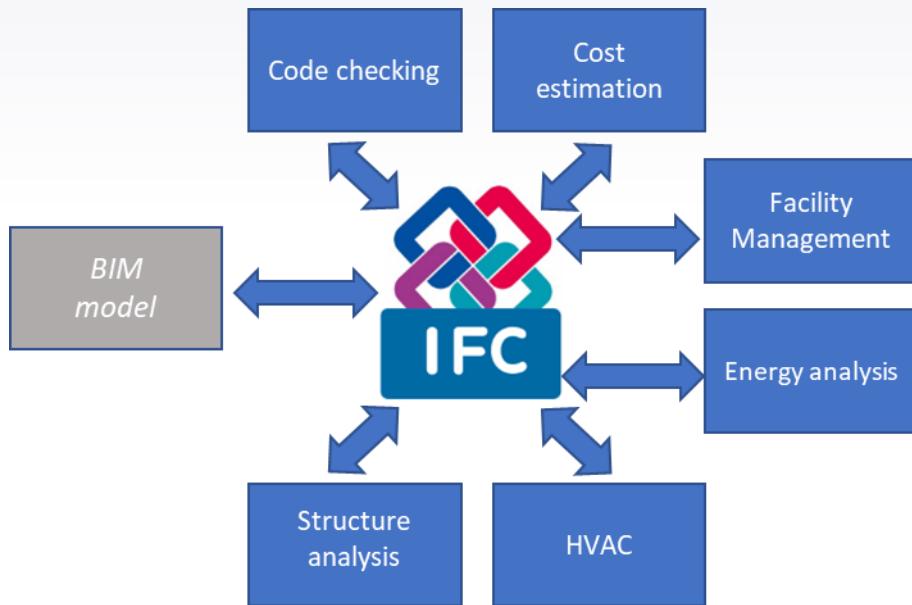
# ► IFC Formats

- ▶ Converting .ifc to .ifcXML using C# code

```
}

1 reference
static void ConvertToXML()
{
    //using method calls dispose method automatically if the type implements IDisposable
    string fileName = "simple column";
    string filePath = "D:\\ITI\\BIM1\\Examples\\";
    using (var stepModel = IfcStore.Open($"{filePath}{fileName}.ifc"))
    {
        stepModel.SaveAs($"{filePath}{fileName}.ifcxml");
    }
}
0 references
```

# IFC Workflow



# ► IFC Workflow

An typical IFC workflow could be the following:

- ▶ An architect creates their design model and exports an IFC version to share with the HVAC engineer.
- ▶ The HVAC engineer can reference this file into their own software and use this for coordination.

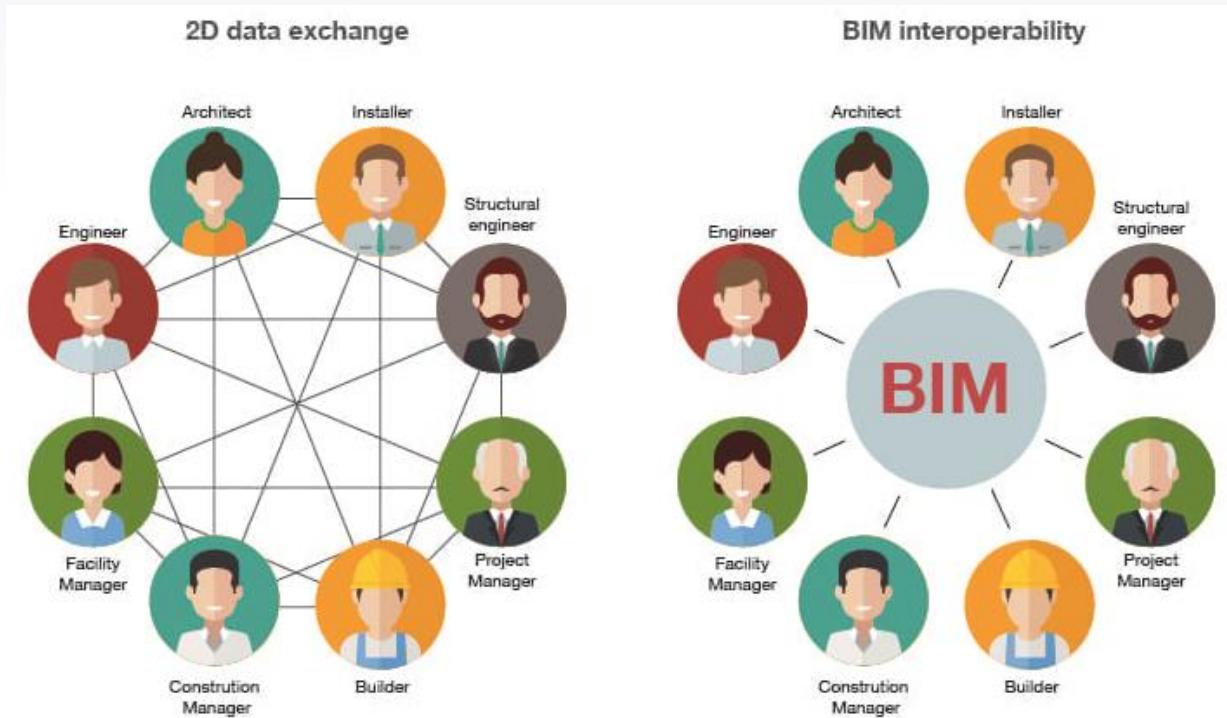


# ► IFC Workflow

- ▶ More than that, the engineer can also use the IFC model as a basis for energy analysis. Which is pretty impressive.
- ▶ The IFC transports enough information for the simulation software to read and analyse the IFC spaces in the referenced model.

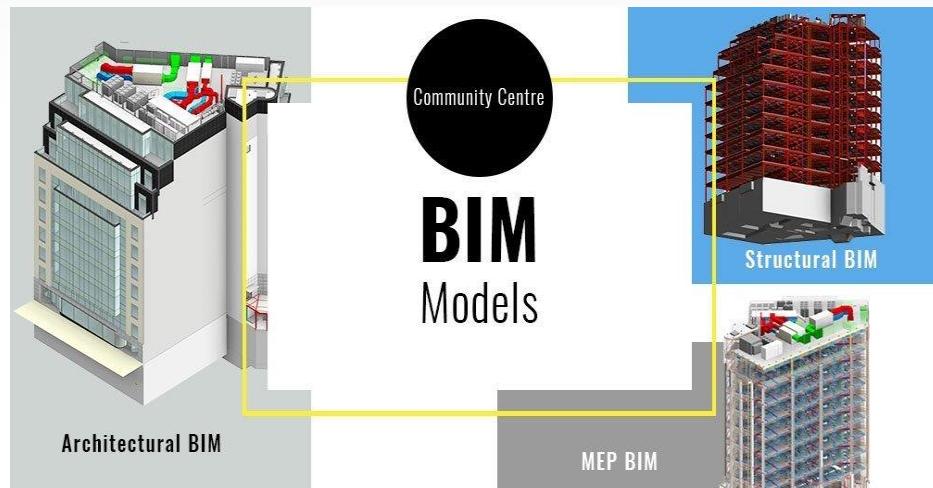


# ► Interoperability



# ► Interoperability

Developing new IFC classes or new standard approach/semantics to fill the gap between architects and civil engineers is a must for better interoperability.



# BIM Collaboration Format (BCF)

- ▶ Construction projects usually involve team members from different companies. During design reviews issues arise, which need to be addressed by one of those team members.
- ▶ In most cases this means working on one project using different software. That's where IFC comes in; exchanging the actual models via an 'open standard'.



# BIM Collaboration Format (BCF)

- ▶ But how do you transmit the issues found? IFC contains data (GUID's) linked to the building objects, and is therefore not suitable for documenting issues or workflows.



# BIM Collaboration Format (BCF)

- ▶ BCF (BIM Collaboration Format) is an open file format that allows the addition of textual comments, screenshots and more on top of the IFC model layer for better communication between coordinating parties. It separates the communication from the actual model.



# BIM Collaboration Format (BCF)

- ▶ BCF is like the WhatsApp of BIM. It allows you to send model mark-ups, clash reports, and general comments between all project members.
- ▶ Each BCF issue is registered with a unique ID, making it easier to track how many issues are open, who is responsible for what issues, and to see when the issues are resolved..



# BIM Collaboration Format (BCF)

- ▶ What is particularly cool about BCF is the communication between IFC tools and native modeling software. The BCF will identify exactly which objects are involved in an issue and will even record the screen view.
- ▶ So, when someone opens up a BCF issue is directed to the exact same view in the model. No need to navigate around the model looking for that one missing electrical socket.

Collaborating  
together,  
Coordinating  
better.

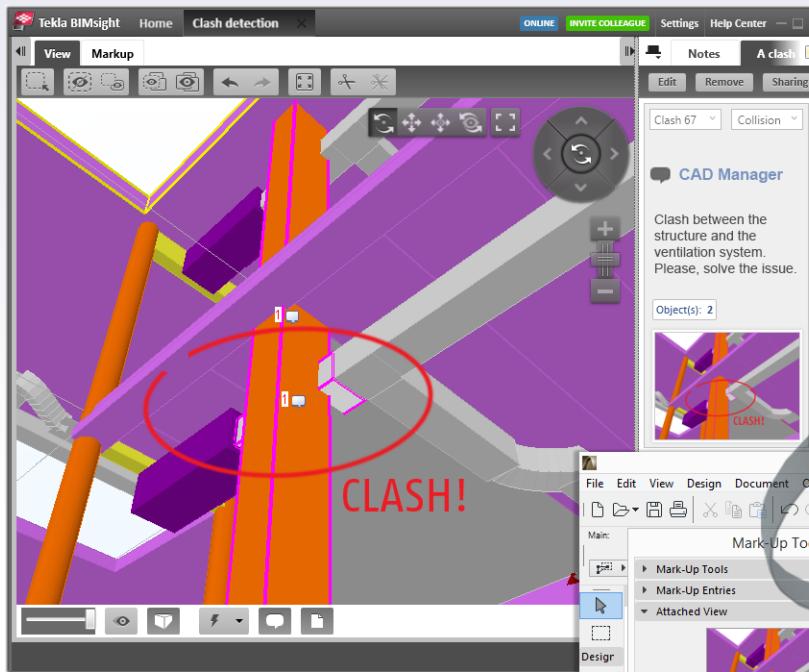
# BIM Collaboration Format (BCF)

BIM Collaboration Format (BCF): a structured file format suited to issue tracking with a building information model.

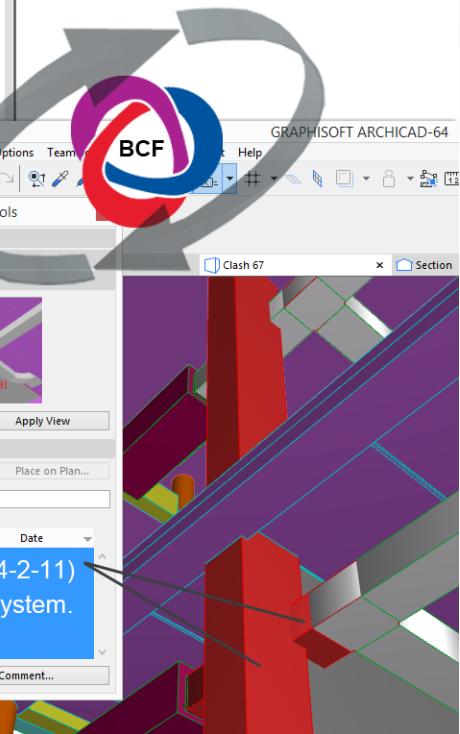
**About BCF**  
**The little brother of IFC**



# BCF



CAD MANAGER  
STRUCTURAL ENGINEER  
MEP ENGINEER  
ARCHITECT



CAD Manager  
10:54 (2014-2-11)  
Clash between the structure and the ventilation system.  
Please, solve the issue.

# BCF

**BCF Manager**

**Topics**

Title: Revision A		
Type: Coordination		
Status: Open		
Last: 12-04-2016 09:03:23		

Title: Revision B	1 comment(s)
Status: In progress	

**Viewpoints**

Views Components

1 2 3

**Comments**

Author: Mikael  
Comment: Cooling beams are to close to lum  
Date: 12-04-2016 08:56:09

Author: Mikael  
Comment: ATDs needs to be moved 200 mm to the right  
Date: 12-04-2016 09:04:16

Author: Mikael  
Comment: Sprinkler is o close to ATD?  
Date: 12-04-2016 09:06:09

**Import** **Export selected** **Export all** **Clear** **Settings**

This one!

# BCF

The screenshot displays a 3D model of a staircase and surrounding structures. A red hand-drawn circle highlights a specific area on the left side of the stairs where two green cylindrical objects appear to be in contact or close proximity. The interface includes a toolbar at the top with icons for edit, remove, and sharing, and a control panel on the right with a zoom wheel and a stack of buttons. On the far right, a note from 'OBL' is visible, stating 'Hier fehlen Durchbrüche!' (There are missing openings!) and 'Object(s): 0'. Below the note is a preview image showing the highlighted collision area. At the bottom, there is a text input field 'Write a reply...' and a button 'Add Current View'.

Kollisions-Ergebnis

HKLS / BAU

Public note  Private note

OBL less than a minute ago

Hier fehlen Durchbrüche!

Object(s): 0

Write a reply... Add Current View

# BCF

Tekla BIMsight Home Tekla BIMsight demo pr... Logged in as: smoreau ONLINE INVITE COLLEAGUE Settings Help Center

View Markup

Notes Check the... X

Tag Last Updated Add Note Sharing

( 9 )

CIP ( 1 )

Critical ( 3 )

MEP Detailer - Small... S. Jones Last week or ea...

Check the level of th... S. Jones Last week or ea...

Move the ducts S. Jones Last week or ea...

Question ( 1 )

Urgent ( 2 )

Structural model nee... S. Jones Last week or ea...

CIP concrete vs MEP... S. Jones Last week or ea...

Play Set as a Slide Show

# BCF

Title:

Visible for:

Type:  Area:  Milestone:  Label(s):

Priority:  Assigned to:  Deadline:  Notify more users:

Description:

# BCF

BCF Manager

Project: AIG

New Connect Open Reload Publish New issue

Nr	Last modified on	Title	Assigned to	Status	#	To publish
28	05-02-2015	Niveau 2 - AE13-AE14	Ingerop Ingerop	Active	1	<input checked="" type="checkbox"/>
36	05-02-2015	Niveau 0.5-AE13-AE14	Ingerop Ingerop	Active	1	
4	05-02-2015	Nivea 0H - file AE12	Ingerop Ingerop	Active	1	
13	05-02-2015	Comment	Ingerop Ingerop	Active	1	
5	05-02-2015	Comment	Ingerop Ingerop	Active	1	
14	05-02-2015	Comment	Inceroo Inceroo	Active	1	

 Edit Resolve

Filter

All milestones

Hide closed issues

Assigned to me

For selected object(s)



Created on	Comment	Author
05-02-2015	Nivea 0H - file AE12	Ingerop Ingerop

# BCF

Resolve issue

Issue properties

Title: Nivea OH -file AE12

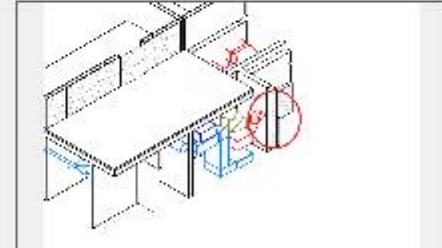
Type: Issue      Area: Not set      Milestone: Undecided

Priority: Normal      Assigned to: Ingerop Ingerop      Labels:

Description: Nivea OH -file AE12

Add comment and/or viewpoint

I move the duct



Link objects: Whole model

Status: Active

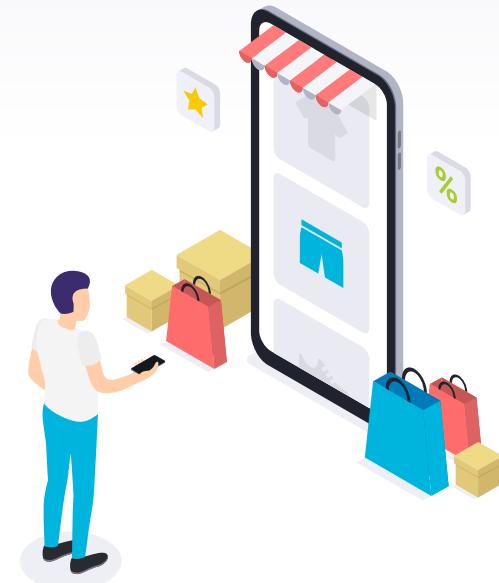
Resolve Cancel

# Model View Definition (MVD)

- ▶ **Model:** a data set, governed by the structure of an underlying schema, to meet certain data requirements.

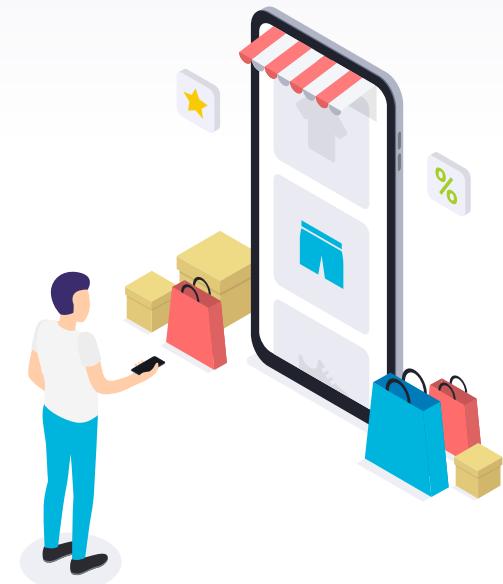
NOTE: Information models and building information models are examples for a model.

NOTE: In scope of this standard IFC models are populations of the IFC schema.



# Model View Definition (MVD)

- ▶ In an openBIM workflow, we can predefine exactly what information needs to be transferred when and by whom.
- ▶ This is achieved with **Model View Definitions**, or MVDs. An MVD is essentially a "filtered view of the IFC". It allows users to export specific packages of model information to meet a particular use.



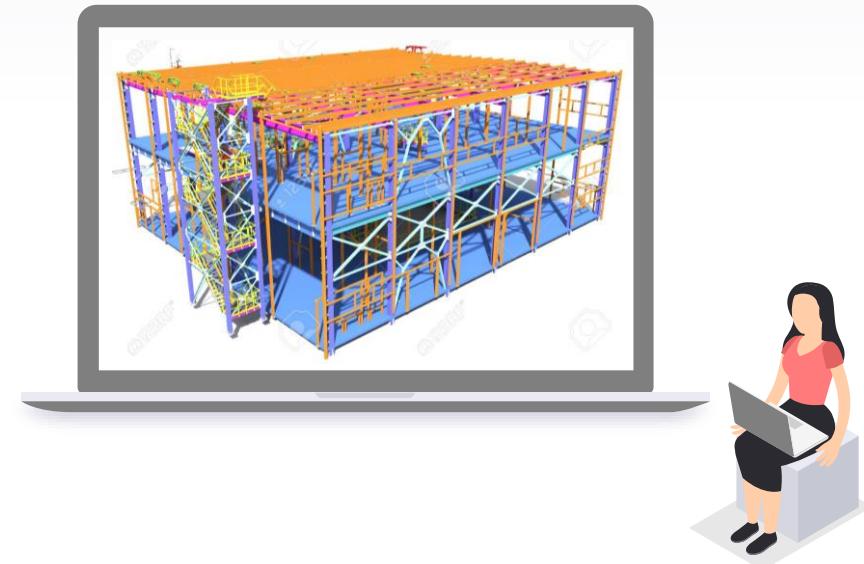
# Model View Definition (MVD)

- For example, if an architect needs to deliver their model for energy analysis, they don't just do a data dump of the entire model. They select the predefined IFC export called Energy Analysis MVD. This exports only the information that is relevant.

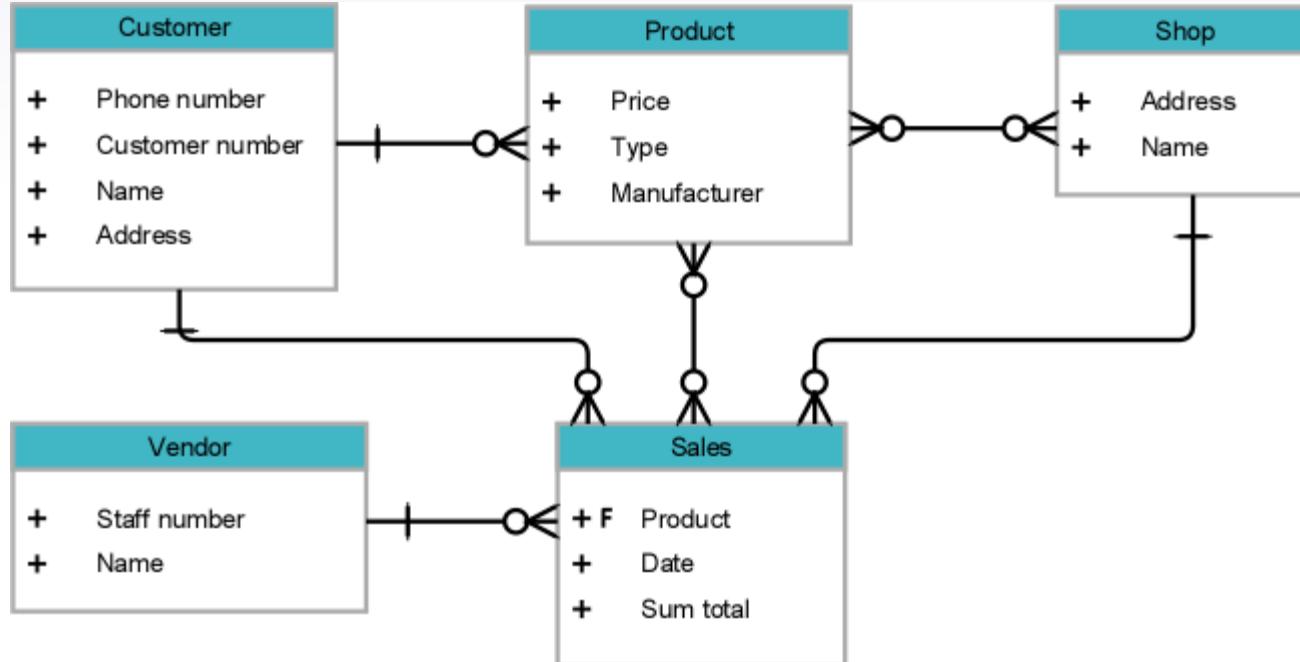


# Model View Definition (MVD)

- ▶ Similarly for cost estimation, you would choose the QTO Model View Definition, or for structural analysis, you would export the Structural Analysis view.



# Data Modeling



# Data Modeling

AUTHOR(Author\_ID: char, lastname: varchar, firstname: varchar,  
email: varchar, city: varchar, country: char)

Relation Schema

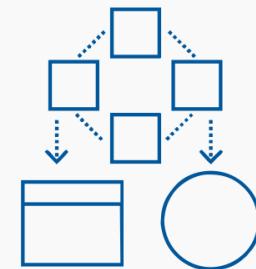
Relation Instance

ATTRIBUTES					
Author_ID	Lastname	Firstname	Email	City	Country
A1	Chong	Raul	rfc@ibm.com	Toronto	CA
A2	Ahuja	Rav	ra@ibm.co <del>ta</del>	Toronto	CA
A3	Hakes	Ian	ih@ibm.com	Toronto	CA
A4	Sharma	Neeraj	ns@ibm.com	Chennai	IN
A5	Perniu	Liviu	lp@univ.com	Transilvania	RO

TUPLES

# Data Modeling

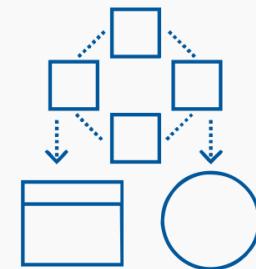
- ▶ Data modeling in software engineering is the process of creating a data model for an information system by applying certain formal techniques.
- ▶ Data models provide a framework for data to be used within information systems by providing specific definition and format



**Data Modeling**

# ► Modeling Language

- ▶ A modeling language is any artificial language that can be used to express information or knowledge or systems in a structure that is defined by a consistent set of rules.
- ▶ The rules are used for interpretation of the meaning of components in the structure.



**Data Modeling**

# ► Modeling Language

## Textual types

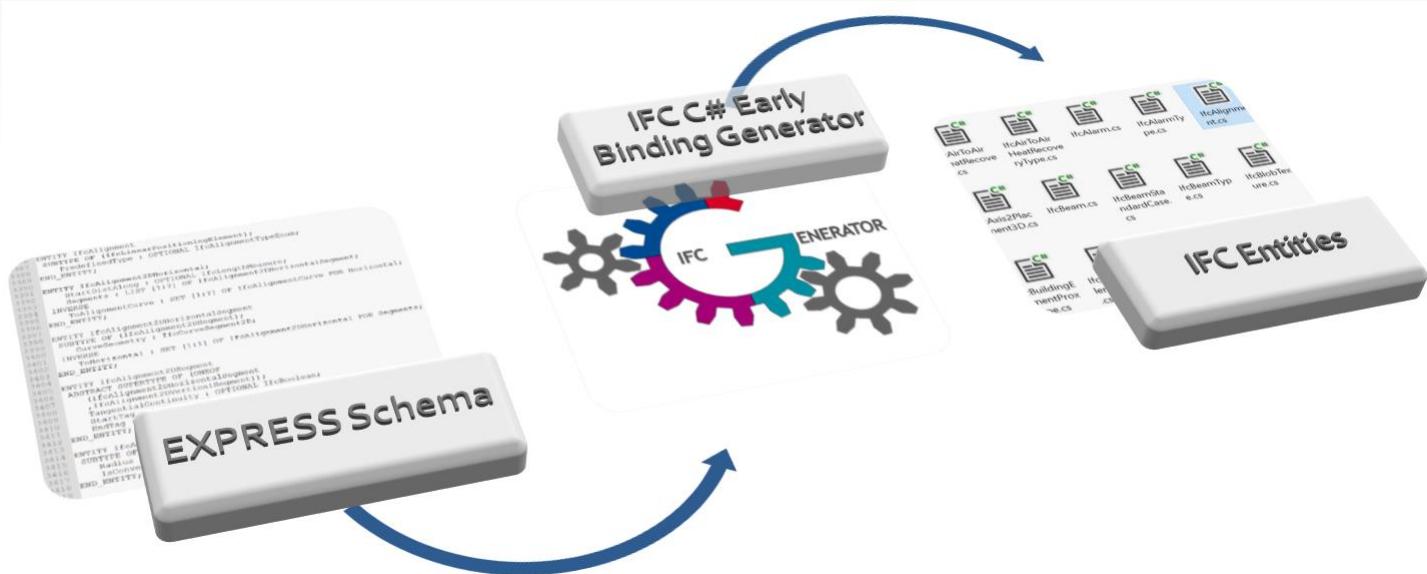
May use standardized keywords accompanied by parameters or natural language terms and phrases to make computer-interpretable expressions.

## Graphical types

Use a diagram technique with named symbols that represent concepts and lines that connect the symbols and represent relationships and various other graphical notation to represent constraints.

- ▶ An example of a graphical modeling language and a corresponding textual modeling language is **EXPRESS**.

# IFC Data Modeling (Schema)



# ► IFC Data Modeling (Schema)

**Schema:** the definition of the structure to organize data for storage, exchange and sharing, using a formal language.

**NOTE :** The formal languages EXPRESS [ISO 10303-11] and XML Schema [W3C Recommendation] are currently used to define the schemata of this standard.



# ► EXPRESS Schema

The Industry Foundation Classes specify a data schema and an exchange file format structure.

The data schema is defined in:

- ▶ EXPRESS data specification language, defined in ISO 10303-11.
- ▶ XML Schema definition language (XSD), defined in XML Schema W3C Recommendation.



# ► EXPRESS Schema

EXPRESS is a standard data modeling language for product data.

EXPRESS is formalized in the ISO Standard for the Exchange of Product model STEP (ISO 10303), and standardized as ISO 10303-11.



# ► EXPRESS Example

SCHEMA Family;

ENTITY Person

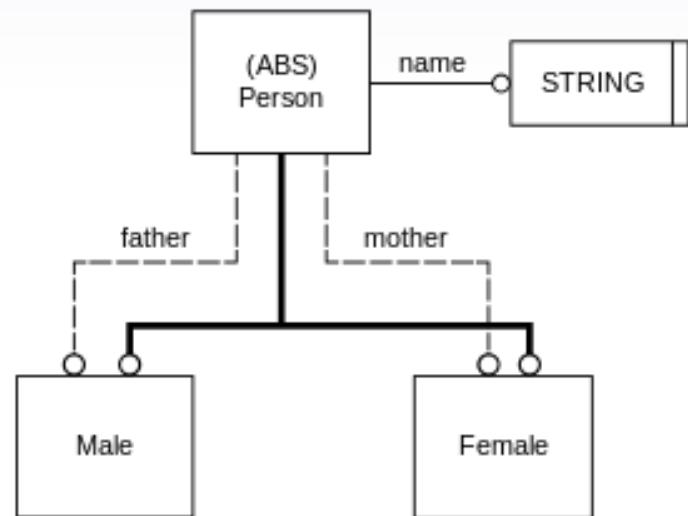
ABSTRACT SUPERTYPE OF (ONEOF (Male, Female));

name: STRING;

mother: OPTIONAL Female;

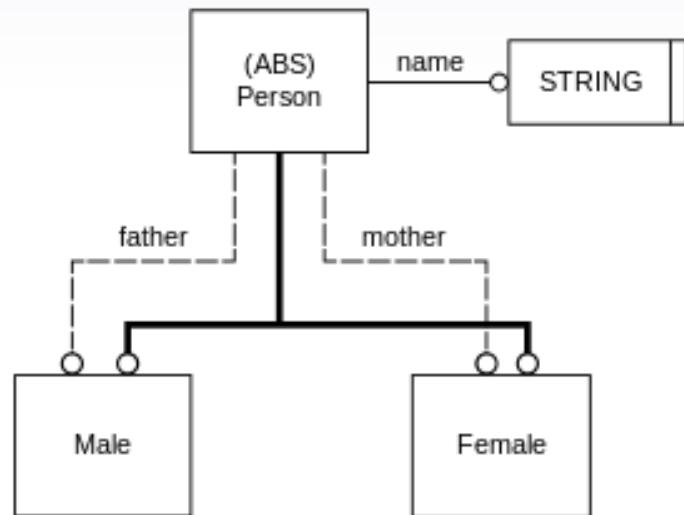
father: OPTIONAL Male;

END\_ENTITY;

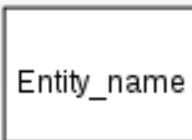


# ► EXPRESS Schema

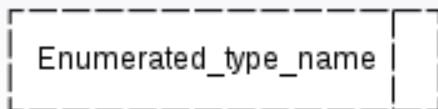
```
ENTITY Female  
    SUBTYPE OF (Person);  
END_ENTITY;  
  
ENTITY Male  
    SUBTYPE of (Person);  
END_ENTITY;  
  
END_SCHEMA;
```



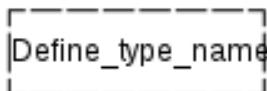
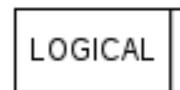
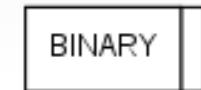
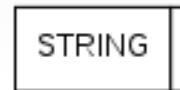
# EXPRESS Datatypes



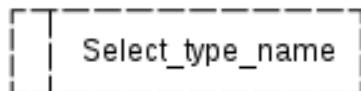
Entity Data Type Symbol  
(A)



Enumerated Data Type Symbol  
(B)



Defined Data Type Symbol  
(C)



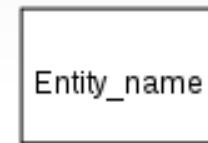
Select Data Type Symbol  
(D)



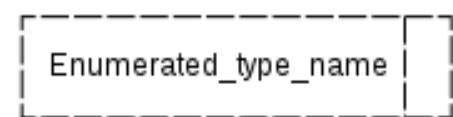
Simple Data Type Symbols  
(D)

# ► EXPRESS Datatypes

- ▶ **Entity data type:** This is the most important datatype in EXPRESS. It is covered below in more detail. Entity datatypes can be related in two ways, in a subtype-supertype tree and/or by attributes.
- ▶ **Enumeration data type:** Enumeration values are simple strings such as red, green, and blue for an RGB-enumeration. In the case that an enumeration type is declared extensible it can be extended in other schemas.



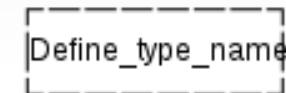
Entity Data Type Symbol  
(A)



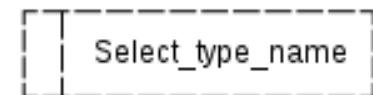
Enumerated Data Type Symbol  
(B)

# EXPRESS Datatypes

- ▶ **Defined data type:** This further specializes other datatypes—e.g., define a datatype positive that is of type integer with a value  $> 0$ .
- ▶ **Select data type:** Selects define a choice or an alternative between different options. Most commonly used are selects between different entity\_types. More rare are selects that include defined types. In the case that an enumeration type is declared extensible, it can be extended in other schemas.



Defined Data Type Symbol  
(C)

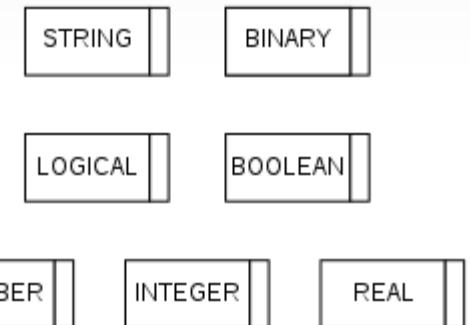


Select Data Type Symbol  
(D)

# EXPRESS Datatypes

## Simple data type

- ▶ **String:** This is the most often used simple type. EXPRESS strings can be of any length and can contain any character (ISO 10646/Unicode).
- ▶ **Binary:** This data type is only very rarely used. It covers a number of bits (not bytes). For some implementations the size is limited to 32 bit.

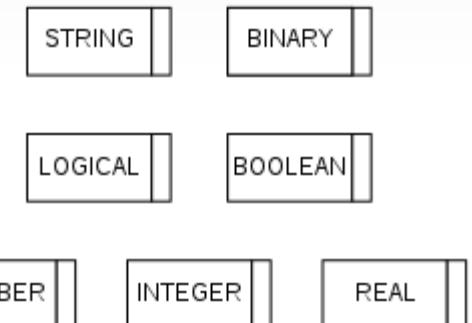


Simple Data Type Symbols  
(D)

# EXPRESS Datatypes

## Simple data type

- ▶ **Logical:** Similar to the boolean datatype a logical has the possible values TRUE and FALSE and in addition UNKNOWN.
- ▶ **Boolean:** With the boolean values TRUE and FALSE.

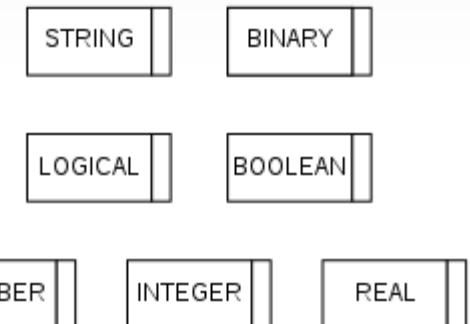


Simple Data Type Symbols  
(D)

# EXPRESS Datatypes

## Simple data type

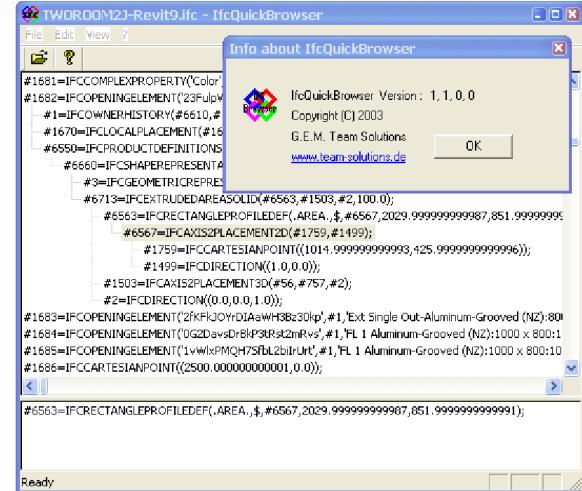
- ▶ **Number:** The number data type is a supertype of both, integer and real. Most implementations take uses a double type to represent a real\_type, even if the actual value is an integer.
- ▶ **Integer:** can have any length, but most implementations restricted them to a signed 32 bit value.
- ▶ **Real:** Ideally an EXPRESS real value is unlimited in accuracy and size. But in practice a real value is represented by a floating point value of type double.



Simple Data Type Symbols  
(D)

# EXPRESS & STEP

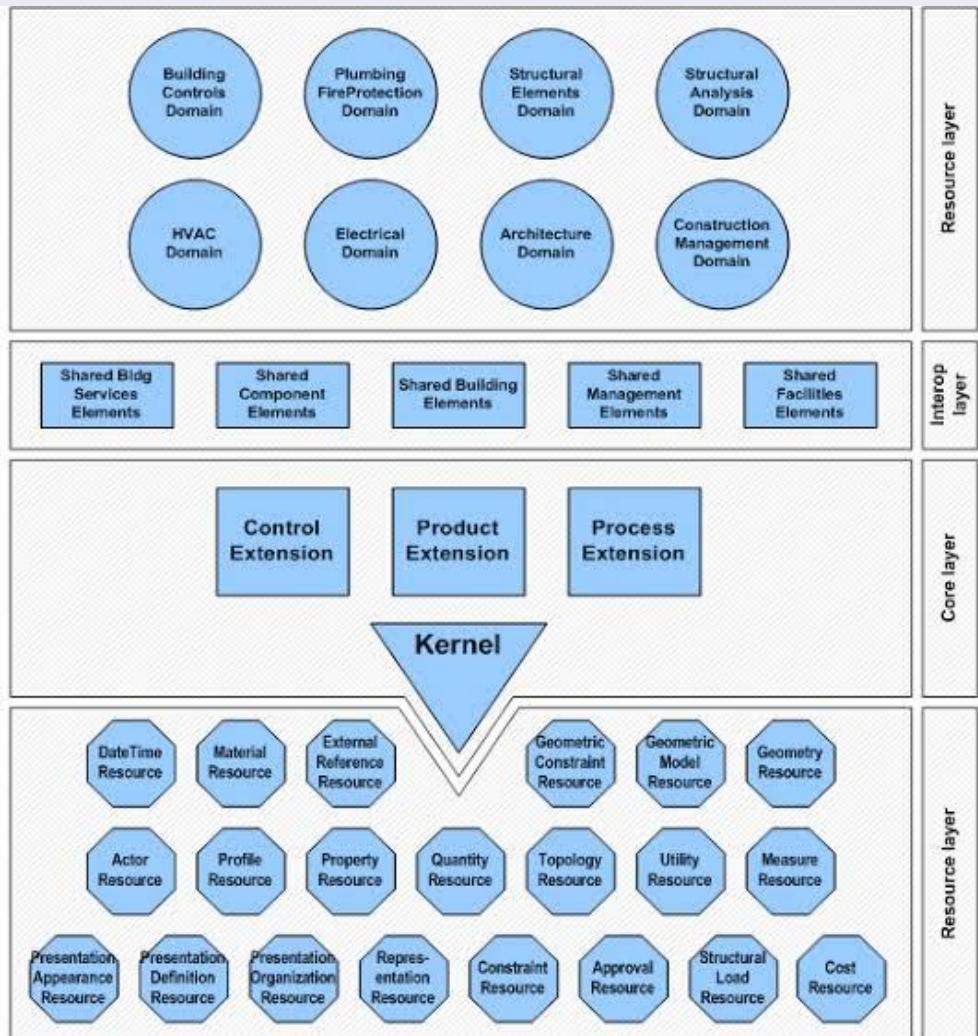
- ▶ **STEP**(STandard for the Exchange of Product data) is the colloquial term for the International Standard ISO 10303.
- ▶ Typically, STEP can be used to exchange data between CAD, CAE..... systems.
- ▶ EXPRESS is the language used within STEP to formally define the semantics of the data.



2

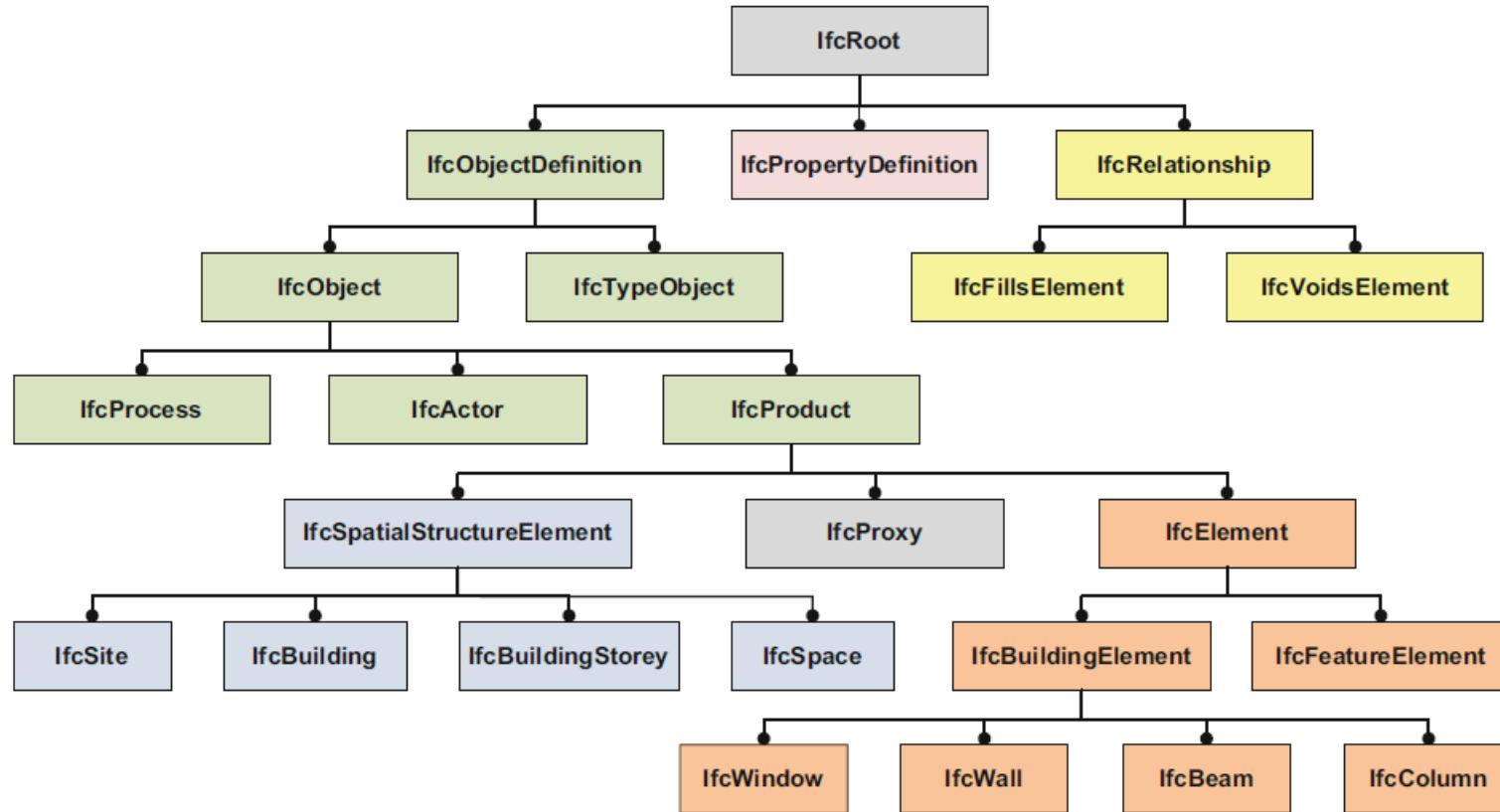
# IFC DATA MODEL





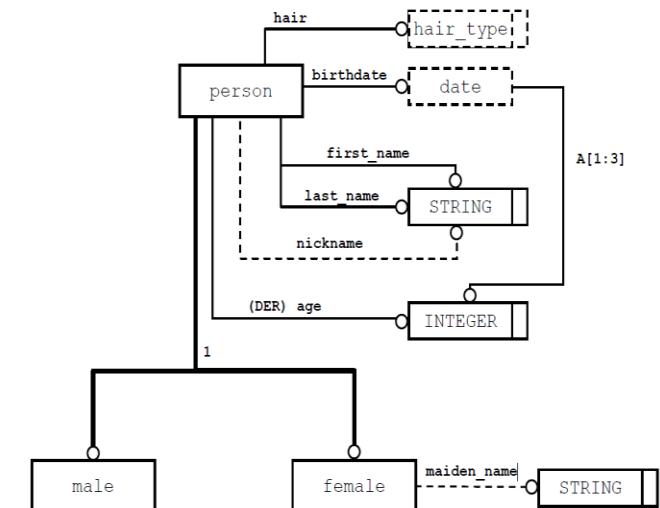
# Inheritance Hierarchy

- ▶ Inheritance hierarchy plays a crucial role in the IFC.
- ▶ It defines specialization and generalization relationships and therefore which attributes of which classes can be inherited by other classes.



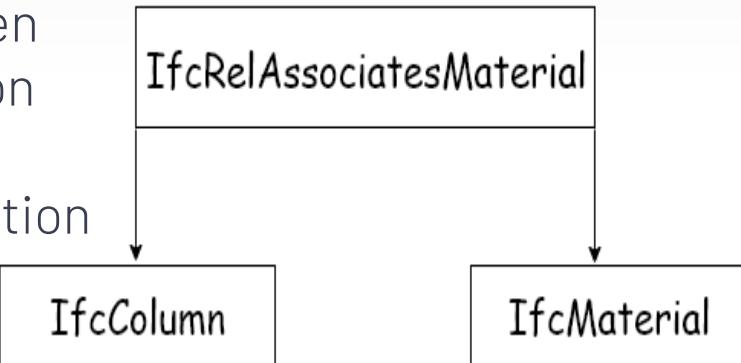
# Explicit vs Inverse Attributes

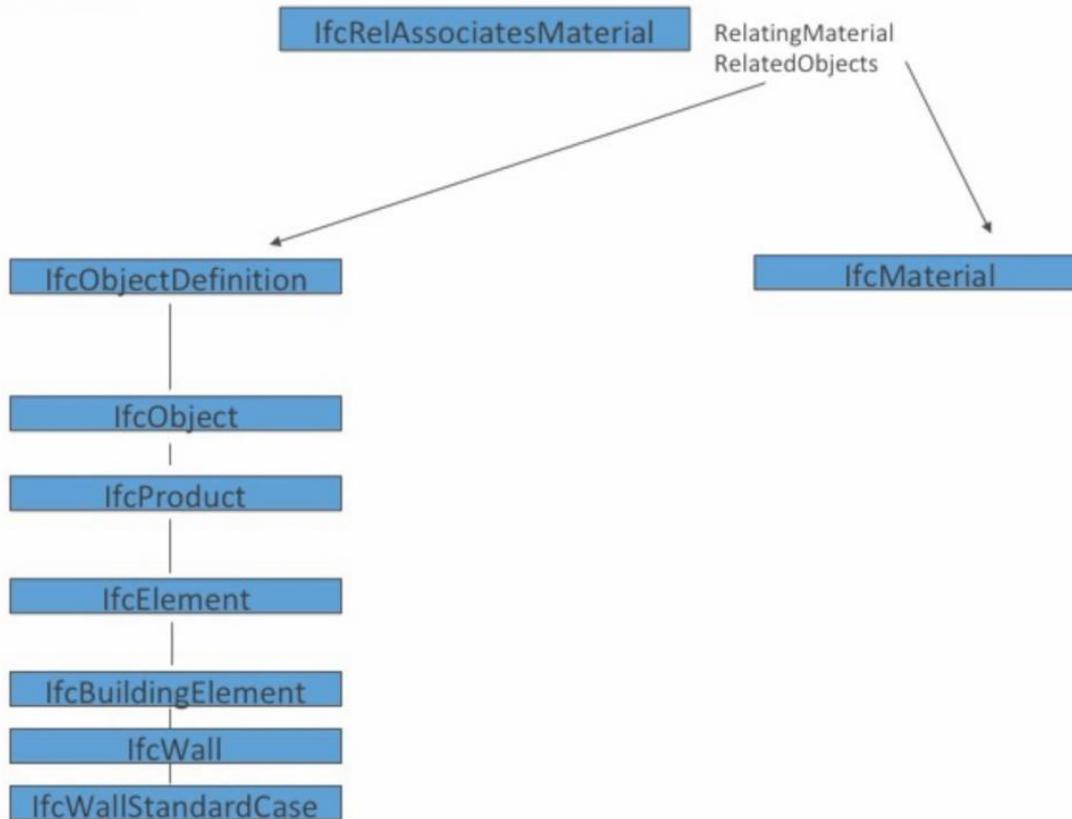
- ▶ Explicit Attributes: They are defined in class.
- ▶ Inverse Attributes: They are not defined in the class but there is an intermediary object that define the relationship (Objectified Relationships).



# Objectified Relationships

- ▶ Semantically relevant relationships between objects are not formed by direct association but instead with the help of a special intermediary object that represent the relation it self
- ▶ This object must be a subtype from IfcRelationship.







# Viewers

- ▶ xBIM WeXplorer



# Viewers

- ▶ BIMVision



BIMVision

The screenshot shows the BIM Vision 2.22 application interface. The top menu bar includes FILE, VIEW, OBJECTS, ADVANCED, MEASUREMENT, CHANGES, and PLUGINS. The main workspace displays a 3D model of a vertical column highlighted in green. To the right, the IFC Structure panel shows the hierarchical structure of the model, and the Properties panel displays specific element properties.

**IFC Structure:**

Act	Type	Name
✓	Project	simple column.sdb
✓	Site	Default Site
✓	Building	Default Building
✓	Building Storey	BASE LEVEL
✓	Columns	
✓	Standard Column	1
	Material layer	4000Psi
	Building Storey	TOP LEVEL

**Properties:**

Name	Value	Unit
Element Specific		
Guid	0wV79AGjEgB4RhGUfg\$	
IfcEntity	IfcColumnStandardCase	
Name	1	
Profile		
ProfileName	40*50	
XDim	0.5	m
YDim	0.4	m

```

ISO-10303-21;
HEADER;
FILE_DESCRIPTION (('ViewDefinition [CoordinationView]'), '2;1');
FILE_NAME ('simple column.ifc','2019-12-07T13:42:19',('Abdelrahman Fathy'),('None'),'20.2.0','SAP2000','None');

FILE_SCHEMA(('IFC4'));
ENDSEC;

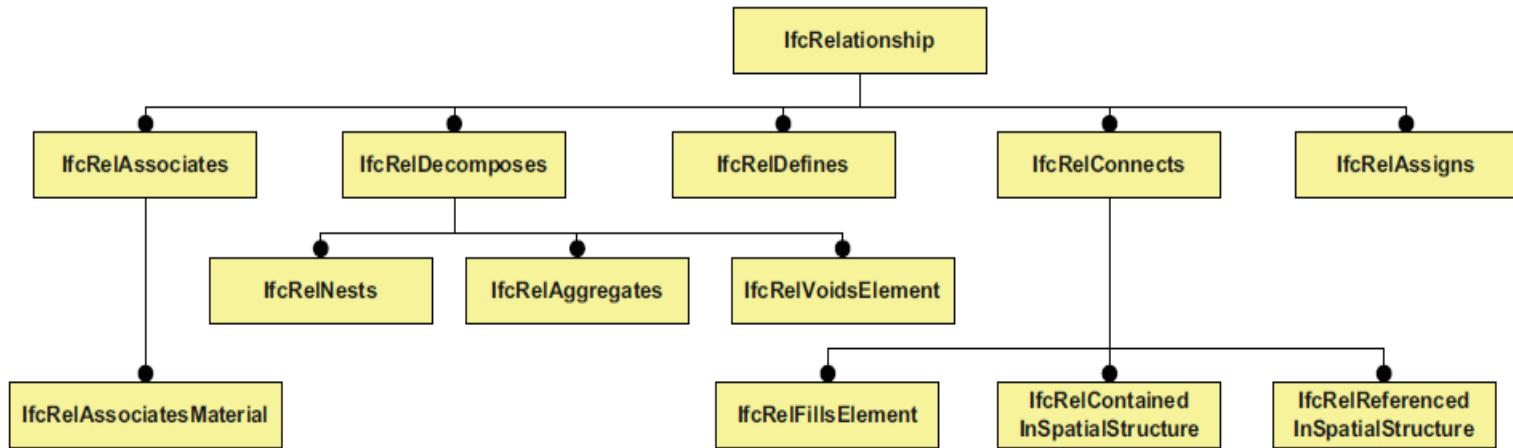
DATA;
#1=IFCRELAGGREGATES('0BmYvFAKrFJwNTQIJfueHK',#3,$,$,#4,(#5));
#2=IFCRELAGGREGATES('1CqpbJelb1eQaieEpvfiZ0',#3,$,$,#5,(#6));
#3=IFCOWNERHISTORY(#7,#8,$,.NOCHANGE.,1575726139,$,$,1575726139);
#4=IFCPROJECT('2SZgn8gvH0PRDXgioiQIF4',#3,'simple column.sdb',$,$,$,$,(#9),#10);
#5=IFCSITE('11yp47o25EvPXh1a84L2Xe',#3,'Default Site',$,$,$,$,.ELEMENT.,$,$,$,$,$);
#6=IFCBUILDING('3W9yodYb98tec0f94WuVFQ',#3,'Default Building',$,$,$,$,.ELEMENT.,$,$,$);
#7=IFCPERSONANDORGANIZATION(#11,#12,$);
#8=IFCAPPLICATION(#13,'20.2.0','SAP2000','SAP2000');
#9=IFCGEOMETRICREPRESENTATIONCONTEXT('Project World','Model',3,$,#14,$);
#10=IFCUNITASSIGNMENT((#15,#16,#17,#18,#19,#20,#21,#22,#23,#24,#25,#26,#27,#28,#29,#30,#31,#32,#33));
#11=IFCPERSON('Abdelrahman Fathy',$,'Nameless',$,$,$,$,$);
#12=IFCORGANIZATION($,'None',$,(#34),$);
#13=IFCORGANIZATION($,'Computers & Structures, Inc.',$, (#35),$);
#14=IFCAxis2Placement3D(#36,#37,#38);
#15=IFCSIUNIT(*,.LENGTHUNIT.,$,METRE.);
#16=IFCSIUNIT(*,.AREAUNIT.,$,.SQUARE_METRE.);
#17=IFCSIUNIT(*,.VOLUMEUNIT.,$,.CUBIC_METRE.);
#18=IFCDERIVEDUNIT((#39),.SECTIONMODULUSUNIT.,$);
#19=IFCDERIVEDUNIT((#40),.MOMENTOFINERTIAUNIT.,$);
#20=IFCSIUNIT(*,.PLANEANGLEUNIT.,$,RADIANT.);
#21=IFCSIUNIT(*,.TIMEUNIT.,$,SECOND.);
#22=IFCSIUNIT(*,.MASSUNIT.,.KILO.,.GRAM.);
#23=IFCDERIVEDUNIT((#41,#42),.MASSDENSITYUNIT.,$);
#24=IFCSIUNIT(*,.FORCEUNIT.,$,NEWTON.);
#25=IFCDERIVEDUNIT((#43,#44),.TORQUEUNIT.,$);
#26=IFCSIUNIT(*,.PRESSUREUNIT.,$,PASCAL.);
#27=IFCDERIVEDUNIT((#45,#46),.LINEARFORCEUNIT.,$);

```

```

<IfcProject id="i4" GlobalId="2SZgN8gvH0PRDXgioQIF4" Name="simple column.sdb">
  <OwnerHistory id="i3" xsi:type="IfcOwnerHistory" ChangeAction="nochange" LastModifiedDate="1575726139" CreationDate="1575726139">
    <OwningUser id="i7" xsi:type="IfcPersonAndOrganization">
      <ThePerson id="i11" xsi:type="IfcPerson" Identification="Abdelrahman Fathy" GivenName="Nameless" MiddleNames="" PrefixTitles="" SuffixTitles="" />
      <TheOrganization id="i12" xsi:type="IfcOrganization" Name="None">
        <OwningApplication id="i8" xsi:type="IfcApplication" Version="20.2.0" ApplicationFullName="SAP2000" ApplicationIdentifier="SAP2000">
          <ApplicationDeveloper id="i13" xsi:type="IfcOrganization" Name="Computers & Structures, Inc.">
            <IsDecomposedBy>
              <IfcRelAggregates id="i1" pos="0" GlobalId="0BmYvFAKrFJwWTQIJfueHK">
                <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                <RelatedObjects>
                  <IfcSite id="i5" pos="0" GlobalId="1lyp47oz5EvPXhla84L2Xe" Name="Default Site" CompositionType="element">
                    <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                    <IsDecomposedBy>
                      <IfcRelAggregates id="i2" pos="0" GlobalId="1CqpbJelbieQaieEpvfiz0">
                        <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                        <RelatedObjects>
                          <IfcBuilding id="i6" pos="0" GlobalId="3W9yodvb98teC0f94WuVFQ" Name="Default Building" CompositionType="element">
                            <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                            <IsDecomposedBy>
                              <IfcRelAggregates id="i88" pos="0" GlobalId="39YN68PPH9Nxmx6hEV8Zu$R">
                                <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                                <RelatedObjects>
                                  <IfcBuildingStorey id="i89" pos="0" GlobalId="2qHP66QLr7DRQVwSEZv2XC" Name="BASE LEVEL" CompositionType="element" Elevation="0">
                                    <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                                    <ContainsElements>
                                      <IfcRelContainedInSpatialStructure id="i87" pos="0" GlobalId="0NozKVk$n30Amy1PDqY00I">
                                        <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                                        <RelatedElements>
                                          <IfcColumnStandardCase id="i57" pos="0" GlobalId="0wXv79AGjEgB4lRhGUfg$h" Name="1">
                                            <RepresentationContexts>
                                              <UnitsInContext id="i10" xsi:type="IfcUnitAssignment">
                                                <IfcRelAssociatesMaterial id="i59" GlobalId="00F5rEUOTC5RQzixcEqqPs">
                                                  <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                                                  <RelatedObjects>
                                                    <IfcColumnStandardCase ref="i57" pos="0" xsi:nil="true" />
                                                  <RelatingMaterial>
                                                    <IfcMaterialProfileSetUsage id="i70" CardinalPoint="10">
                                                      <ForProfileSet id="i74" xsi:type="IfcMaterialProfileSet">
                                                        <MaterialProfiles>
                                                          <IfcMaterialProfile id="i80" pos="0">
                                                            <Material id="i69" xsi:type="IfcMaterial" Name="4000Psi">
                                                              <Profile ref="i81" xsi:type="IfcRectangleProfileDef" xsi:nil="true" />
                                                            </Material>
                                                          </IfcMaterialProfile>
                                                        </MaterialProfiles>
                                                      </ForProfileSet>
                                                    </RelatingMaterial>
                                                  </RelatedObjects>
                                                </OwnerHistory>
                                              </UnitsInContext>
                                            </RepresentationContexts>
                                          </IfcColumnStandardCase>
                                        </RelatedElements>
                                      </IfcRelContainedInSpatialStructure>
                                    </ContainsElements>
                                  </IfcBuildingStorey>
                                </RelatedObjects>
                              </IfcRelAggregates>
                            </IsDecomposedBy>
                          </IfcBuilding>
                        </RelatedObjects>
                      </IfcRelAggregates>
                    </IsDecomposedBy>
                  </IfcSite>
                </RelatedObjects>
              </IfcRelAggregates>
            </IsDecomposedBy>
          </ApplicationDeveloper>
        </OwningApplication>
      </TheOrganization>
    </OwningUser>
  </OwnerHistory>
  <IsDecomposedBy>
    <IfcRelAggregates id="i1" pos="0" GlobalId="0BmYvFAKrFJwWTQIJfueHK">
      <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
      <RelatedObjects>
        <IfcSite id="i5" pos="0" GlobalId="1lyp47oz5EvPXhla84L2Xe" Name="Default Site" CompositionType="element">
          <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
          <IsDecomposedBy>
            <IfcRelAggregates id="i2" pos="0" GlobalId="1CqpbJelbieQaieEpvfiz0">
              <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
              <RelatedObjects>
                <IfcBuilding id="i6" pos="0" GlobalId="3W9yodvb98teC0f94WuVFQ" Name="Default Building" CompositionType="element">
                  <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                  <IsDecomposedBy>
                    <IfcRelAggregates id="i88" pos="0" GlobalId="39YN68PPH9Nxmx6hEV8Zu$R">
                      <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                      <RelatedObjects>
                        <IfcBuildingStorey id="i89" pos="0" GlobalId="2qHP66QLr7DRQVwSEZv2XC" Name="BASE LEVEL" CompositionType="element" Elevation="0">
                          <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                          <ContainsElements>
                            <IfcRelContainedInSpatialStructure id="i87" pos="0" GlobalId="0NozKVk$n30Amy1PDqY00I">
                              <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                              <RelatedElements>
                                <IfcColumnStandardCase id="i57" pos="0" GlobalId="0wXv79AGjEgB4lRhGUfg$h" Name="1">
                                  <RepresentationContexts>
                                    <UnitsInContext id="i10" xsi:type="IfcUnitAssignment">
                                      <IfcRelAssociatesMaterial id="i59" GlobalId="00F5rEUOTC5RQzixcEqqPs">
                                        <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
                                        <RelatedObjects>
                                          <IfcColumnStandardCase ref="i57" pos="0" xsi:nil="true" />
                                        </RelatedObjects>
                                      </OwnerHistory>
                                    </UnitsInContext>
                                  </RepresentationContexts>
                                </IfcColumnStandardCase>
                              </RelatedElements>
                            </IfcRelContainedInSpatialStructure>
                          </ContainsElements>
                        </IfcBuildingStorey>
                      </RelatedObjects>
                    </IfcRelAggregates>
                  </IsDecomposedBy>
                </IfcBuilding>
              </RelatedObjects>
            </IfcRelAggregates>
          </IsDecomposedBy>
        </IfcSite>
      </RelatedObjects>
    </IfcRelAggregates>
  </IsDecomposedBy>
</IfcProject>

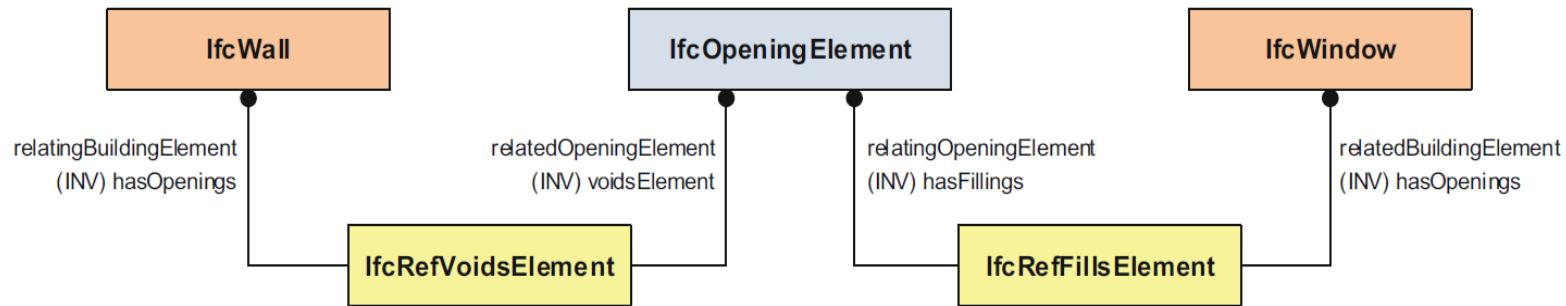
```



**Fig. 5.8** The inheritance hierarchy of relationship classes in the IFC data model

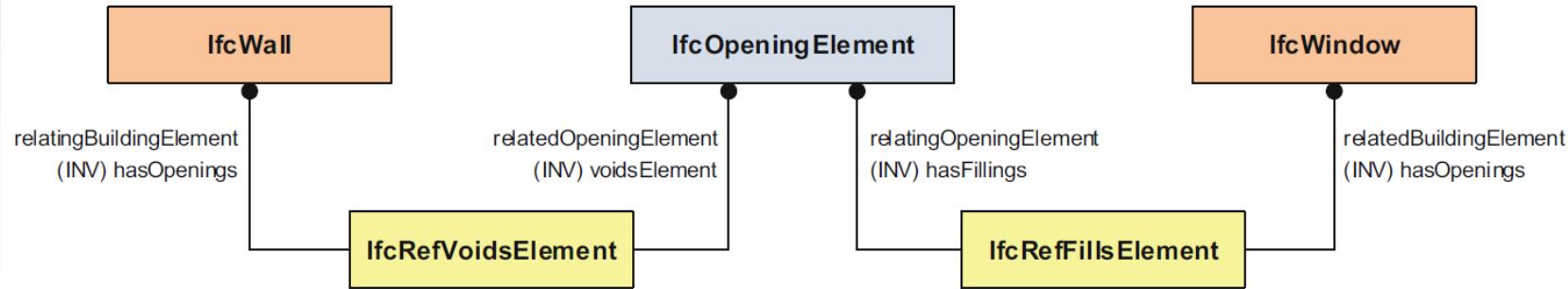
RelatingBuildingElement  
RelatedOpeningElement

IfcElement (ENTITY)  
IfcFeatureElementSubtraction (ENTITY)



RelatingOpeningElement  
RelatedBuildingElement

IfcOpeningElement (ENTITY)  
IfcElement (ENTITY)

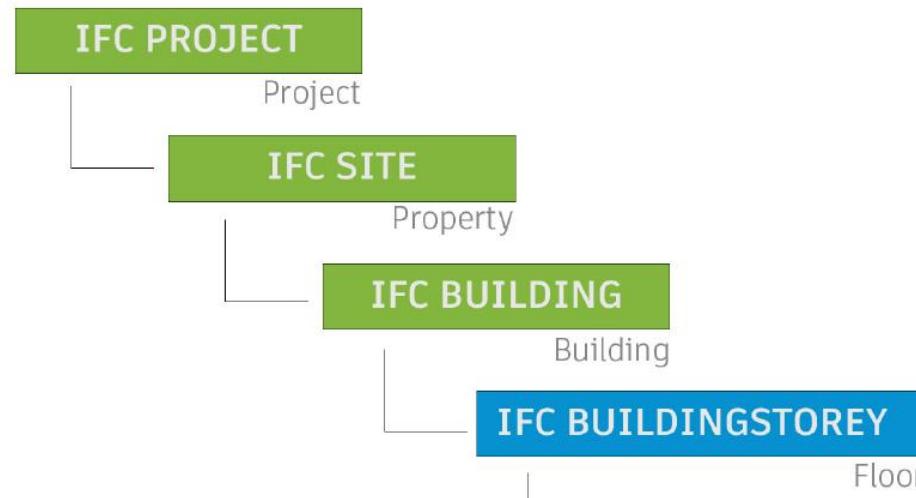


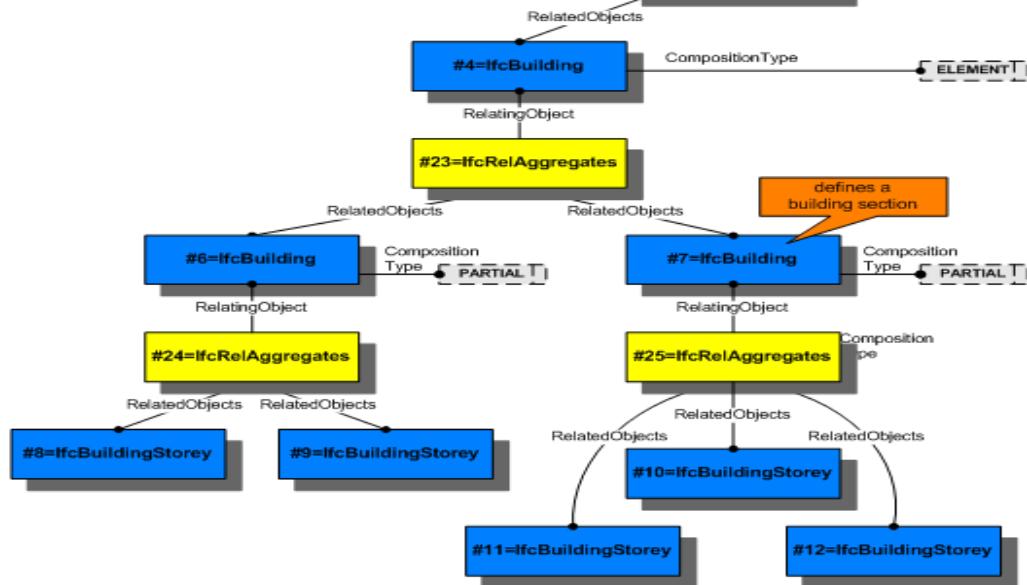
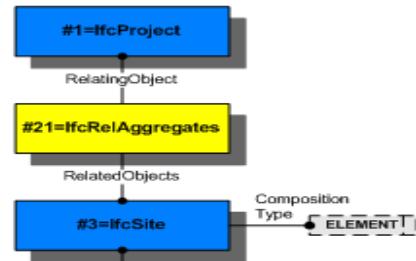
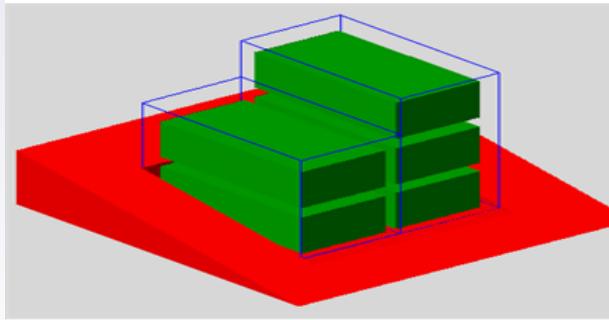
```

Wall:Generic - 200mm" Tag="419040" PredefinedType="notdefined">
  <IfcWall id="i1907" pos="14" GlobalId="2mLNpcXnrEAPAzAytZ6Pst" Name="Basic Wall:Generic - 200mm:419171" ObjectType="Basic
  Wall:Generic - 200mm" Tag="419171" PredefinedType="notdefined">
    <OwnerHistory ref="i42" xsi:type="IfcOwnerHistory" xsi:nil="true" />
    <IsTypedBy ref="i2135" xsi:type="IfcRelDefinesByType" xsi:nil="true" />
    +<IsDefinedBy>
    +<ObjectPlacement id="i1826" xsi:type="IfcLocalPlacement">
    +<Representation id="i1903" xsi:type="IfcProductDefinitionShape">
      -<HasOpenings>
        -<IfcRelVoidsElement id="i2176" pos="0" GlobalId="00Rpet9pT25QyuRTa$Doe8">
          <OwnerHistory ref="i42" xsi:type="IfcOwnerHistory" xsi:nil="true" />
          <RelatedOpeningElement id="i2171" xsi:type="IfcOpeningElement" GlobalId="2Q3hsNhdH59wd6I3iIsG0_" Name="Basic Wall:Generic -
            200mm:419171" ObjectType="Opening" PredefinedType="opening">
            <OwnerHistory ref="i42" xsi:type="IfcOwnerHistory" xsi:nil="true" />
            +<ObjectPlacement id="i2169" xsi:type="IfcLocalPlacement">
            +<Representation id="i2163" xsi:type="IfcProductDefinitionShape">
              +<IfcBuildingStorey id="i142" pos="1" GlobalId="1bDZ8MOUv31Bf3IwrvfYvg" Name="02-First Floor" ObjectType="Level:8mm Head" LongName="02-First
                Floor" Description="Floor 2" PredefinedType="level" />
  
```

# Spatial Aggregate Hierarchy

**IFC TREE-VIEW** - The IFC tree structure



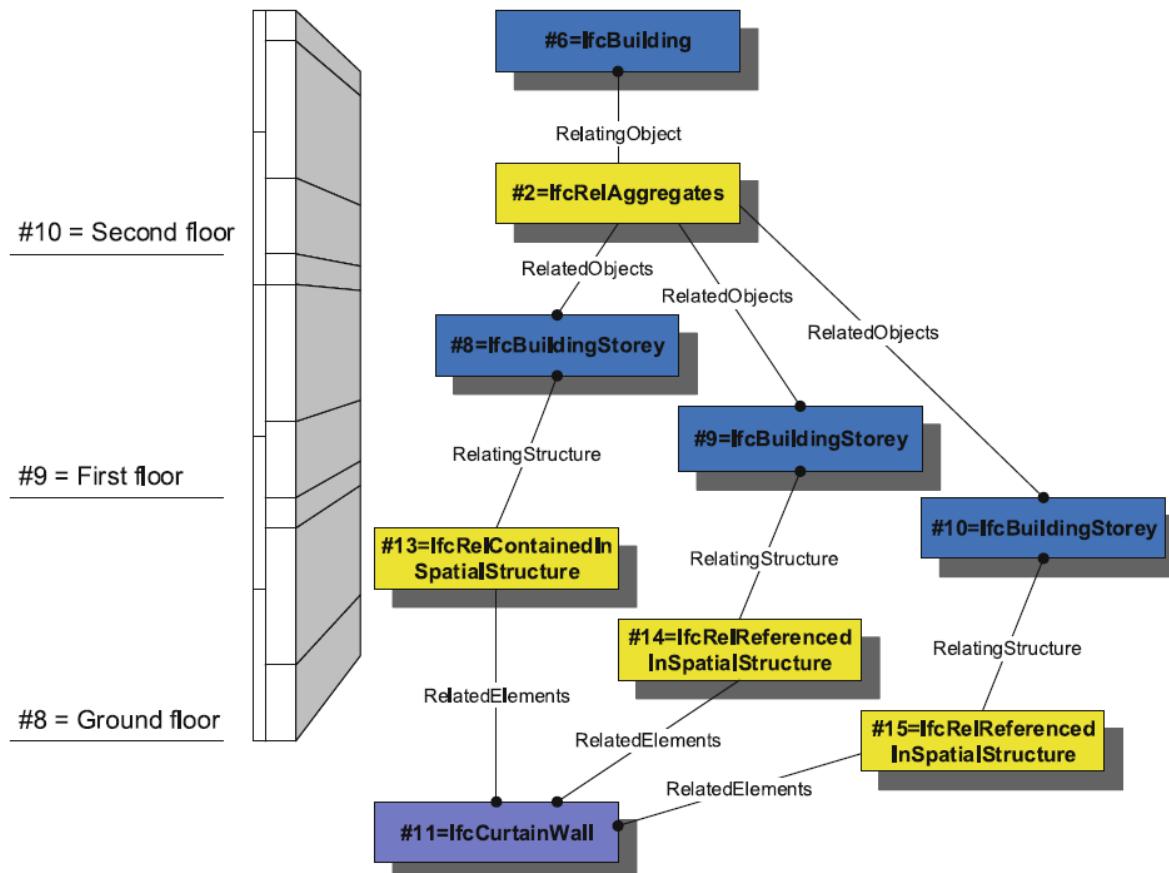


Note: in order to maintain the hierarchical form of the schema Inverse attribute “isDecomposedBy” is used.

```

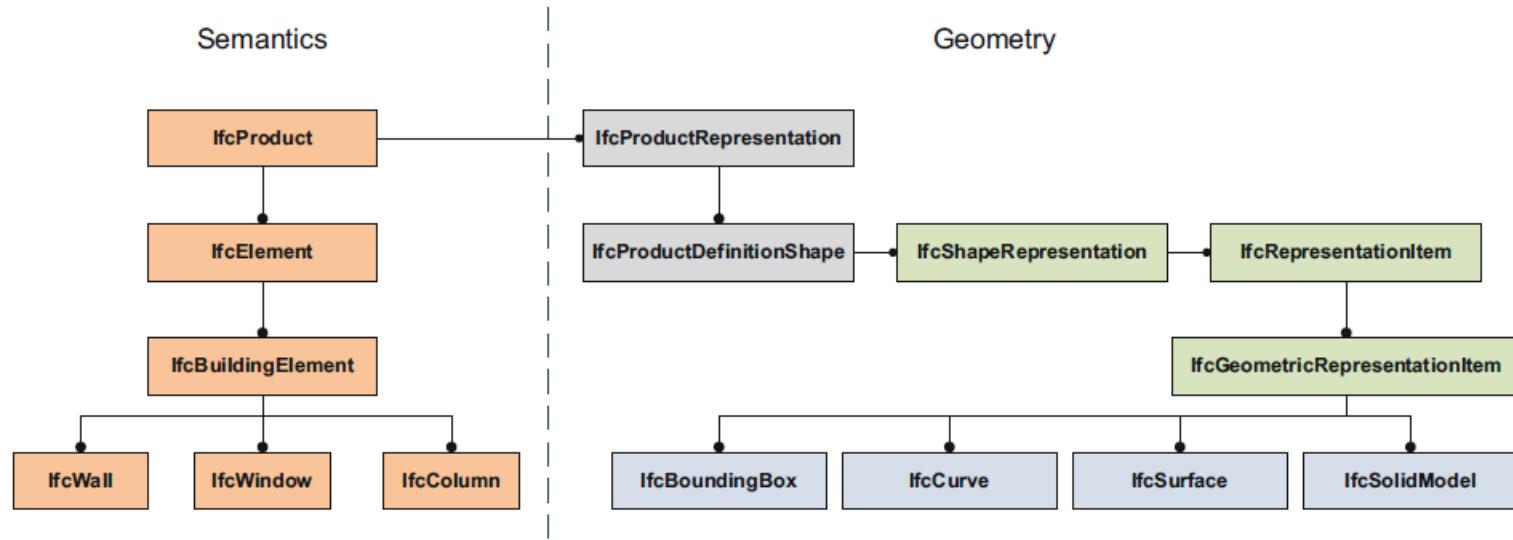
- <IfcProject id="i4" GlobalId="25ZgN8gvH0PRDXgioiQIF4" Name="simple column.sdb">
+ <OwnerHistory id="i3" xsi:type="IfcOwnerHistory" ChangeAction="nochange" LastModifiedDate="1575726139" CreationDate="1575726139">
- <IsDecomposedBy>
  - <IfcRelAggregates id="i1" pos="0" GlobalId="0BmYvFAKrFJwWTQIJfueHK">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <RelatedObjects>
  - <IfcSite id="i5" pos="0" GlobalId="11yp47oz5EvPXh1a84L2Xe" Name="Default Site" CompositionType="element">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <IsDecomposedBy>
  - <IfcRelAggregates id="i2" pos="0" GlobalId="1CqpbJelb1eQaieEpvfiz0">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <RelatedObjects>
  - <IfcBuilding id="i6" pos="0" GlobalId="3W9yodYb98teC0f94WuVFQ" Name="Default Building" CompositionType="element">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <IsDecomposedBy>
  - <IfcRelAggregates id="i88" pos="0" GlobalId="39YN68PPH9Wxm6hEV8Zu$R">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <RelatedObjects>
  - <IfcBuildingStorey id="i89" pos="0" GlobalId="2qHP66QLr7DRQVwSEZv2XC" Name="BASE LEVEL" CompositionType="element" Elevation="0">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <ContainsElements>
  - <IfcRelContainedInSpatialStructure id="i87" pos="0" GlobalId="0NozKVk$n30AmylPDqY00I">
    - <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
- <RelatedElements>
  - <IfcColumnStandardCase id="i57" pos="0" GlobalId="0wXv79AGjEgB4lRhGUfg$h" Name="1">
+ <IfcBuildingStorey id="i90" pos="1" GlobalId="2GQdkZ_Pv6kvNpgL92dqGN" Name="TOP LEVEL" CompositionType="element" Elevation="3">
+ <RepresentationContexts>
+ <UnitsInContext id="i10" xsi:type="IfcUnitAssignment">
- <IfcRelAssociatesMaterial id="i59" GlobalId="09F5rEU0TC5RQziXcEqqPs">

```



# Geometric Representation

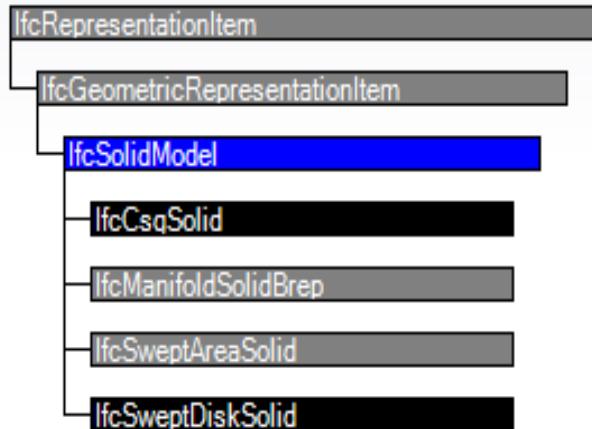
- ▶ The IFC data model makes a strict division between the semantic description and its geometric representation.
- ▶ Each semantic description can be linked to one or more geometric representation.
- ▶ The ability to link distinct geometric representations with an object addresses , the need for distinct geometric representations for distinct application scenarios.



**Fig. 5.14** The IFC data model makes a strict division between the semantic structure and geometric description. This affords the flexibility to link one or more geometric representations with a semantic object

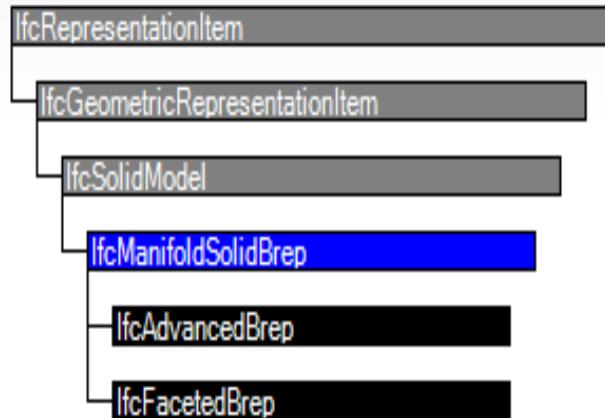
# Solid Modeling

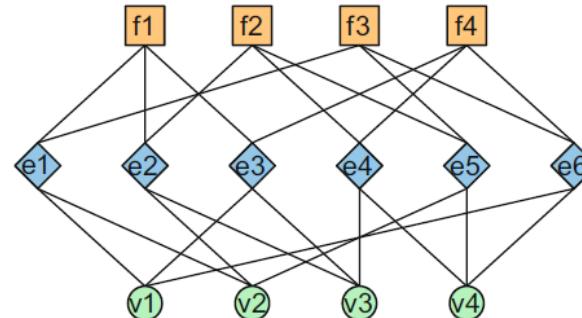
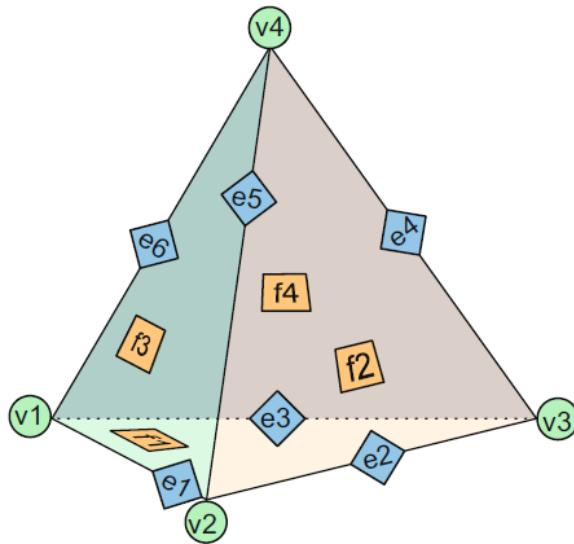
- ▶ Explicit Modeling: “Brep”.
- ▶ Implicit Modeling (Procedural Approach):  
Employs a sequence of construction steps.  
“Csg” & “Extrusion and Rotation method”.



# Brep (Boundary Representation)

- ▶ IfcFactedBep: is used to model flat simple solid objects.
- ▶ IfcFactedBrepWithVoids: a subtype of IfcFactedBep is used to model flat solid objects with voids.



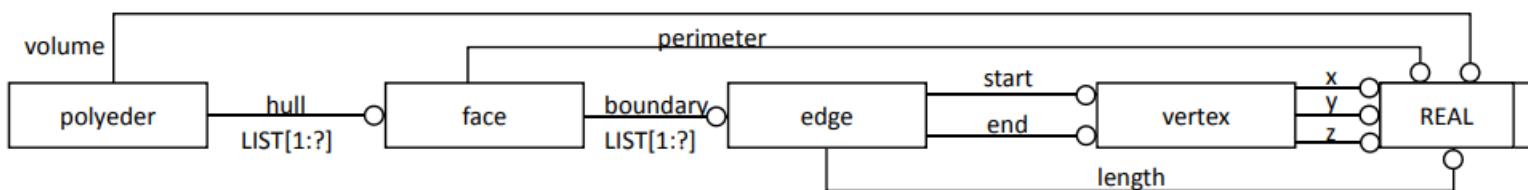


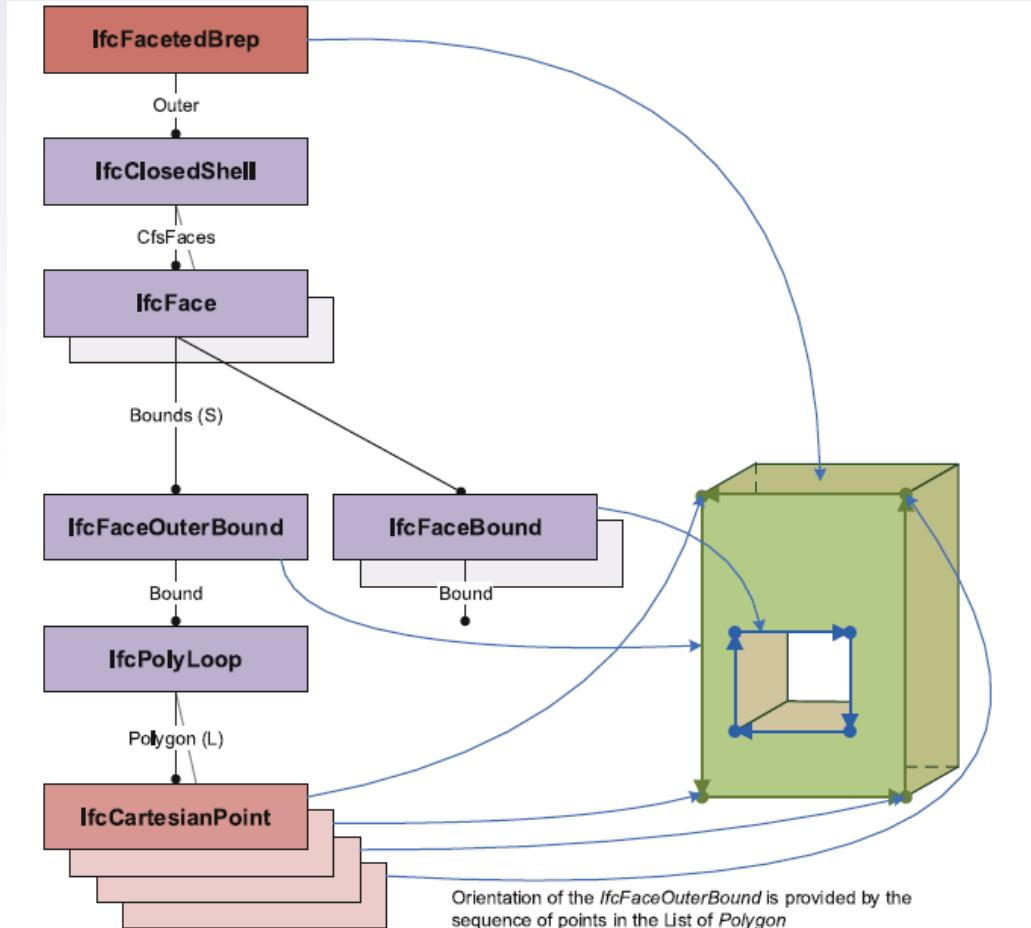
solid	faces
1	1,2,3,4

face	edges
1	1, 2, 3
2	2, 4, 5
3	1, 5, 6
4	3, 4, 6

vertex	coordinates
1	2, 0, 0
2	0, 0, 0
3	3, 0, 0
4	1, 1, 3

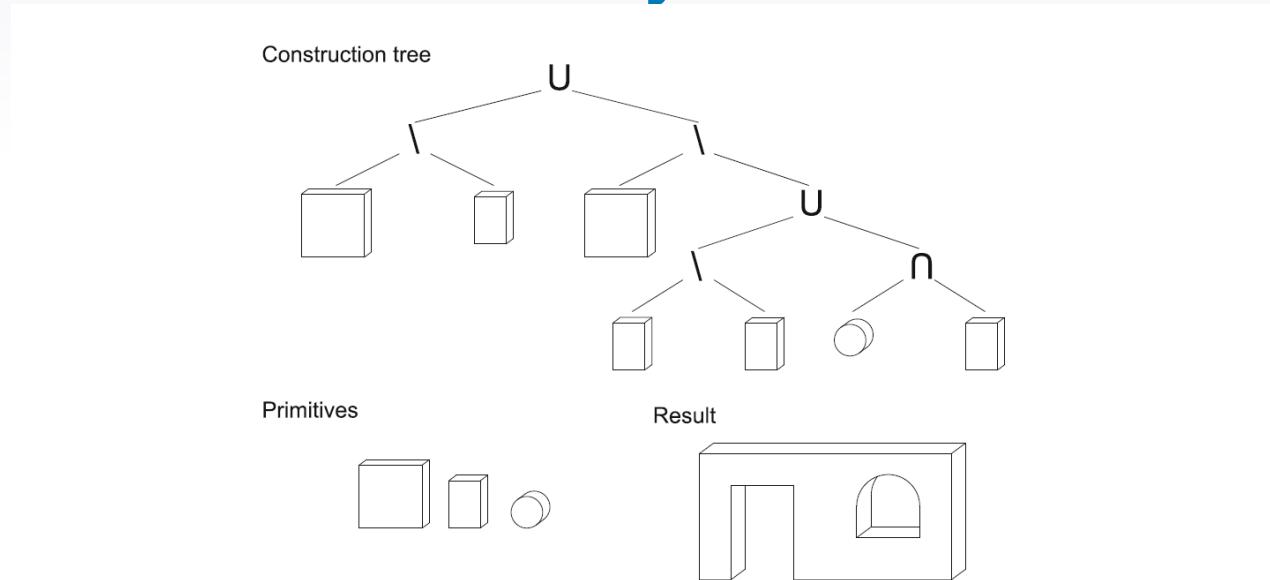
edge	vertices
1	1, 2
2	2, 3
3	3, 1
4	3, 4
5	2, 4
6	1, 4





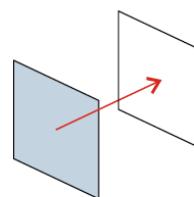
**Fig. 5.18** Data structure for representing solids with flat surfaces and straight edges. (Source: IFC Documentation. ©buildingSMART, reprinted with permission)

# Csg (Constructive Solid Geometry)

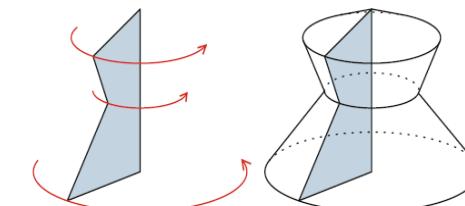
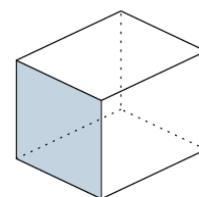


**Fig. 2.5** The CSG method is based on the combination of solids using the Boolean operators union, intersection and difference. (© S. Vilgertshofer, reprinted with permission)

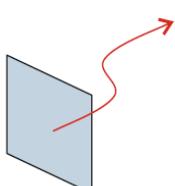
# Extrusion And Rotation Method



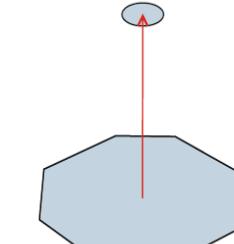
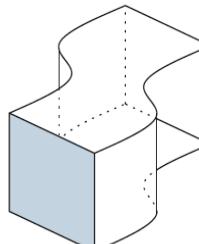
Extrusion



Rotation



Sweep



Lofting

```
<RelatedObjects>
  <IfcBuildingStorey id="i89" pos="0" GlobalId="2qHP66QLr7DRQVwSEZv2XC" Name="BASE LEVEL" CompositionType="element" Elevation="0">
    <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
  <ContainsElements>
    <IfcRelContainedInSpatialStructure id="i87" pos="0" GlobalId="0NozKVk$n30AmylPDqY00I">
      <OwnerHistory ref="i3" xsi:type="IfcOwnerHistory" xsi:nil="true" />
      <RelatedElements>
        <IfcColumnStandardCase id="i57" pos="0" GlobalId="0wXv79AGjEgB4lRhGUfg$h" Name="1">
          <OwnerHistory id="i60" xsi:type="IfcOwnerHistory" ChangeAction="modified" LastModifiedDate="1575726140" CreationDate="1575726140">
            <ObjectPlacement id="i61" xsi:type="IfcLocalPlacement">
              <RelativePlacement>
                <IfcAxis2Placement3D id="i71">
                  <Representation id="i62" xsi:type="IfcProductDefinitionShape">
                    <Representations>
                      <IfcShapeRepresentation id="i72" pos="0" RepresentationIdentifier="Body" RepresentationType="SweptSolid">
                        <ContextOfItems id="i9" xsi:type="IfcGeometricRepresentationContext" ContextIdentifier="Project World" ContextType="Model" CoordinateSpaceDimension="3">
                          <WorldCoordinateSystem>
                            <IfcAxis2Placement3D id="i14">
                              <Location id="i36" xsi:type="IfcCartesianPoint" Coordinates="0 0 0" />
                              <Axis id="i37" xsi:type="IfcDirection" DirectionRatios="0 0 1" />
                              <RefDirection id="i38" xsi:type="IfcDirection" DirectionRatios="1 0 0" />
                            <Items>
                              <IfcExtrudedAreaSolid id="i78" pos="0" Depth="3">
                                <SweptArea id="i81" xsi:type="IfcRectangleProfileDef" ProfileType="area" ProfileName="40*50" XDim="0.5" YDim="0.4" />
                                <Position ref="i14" xsi:type="IfcAxis2Placement3D" xsi:nil="true" />
                                <ExtrudedDirection ref="i37" xsi:type="IfcDirection" xsi:nil="true" />
                              <IfcShapeRepresentation id="i73" pos="1" RepresentationIdentifier="Axis" RepresentationType="Curve3D" />
                            </Items>
                          </WorldCoordinateSystem>
                        </ContextOfItems>
                      </IfcShapeRepresentation>
                    </Representations>
                  </Representation>
                </IfcAxis2Placement3D>
              </RelativePlacement>
            </ObjectPlacement>
          </IfcColumnStandardCase>
        </RelatedElements>
      </IfcRelContainedInSpatialStructure>
    </ContainsElements>
  </IfcBuildingStorey>
<IfcBuildingStorey id="i90" pos="1" GlobalId="2GQdkZ_Pv6kvNpgL92dqGN" Name="TOP LEVEL" CompositionType="element" Elevation="3">
```

# Relative Positioning

Fig. 5.25 The functioning of relative positioning using an *IfcAxis2Placement3D*

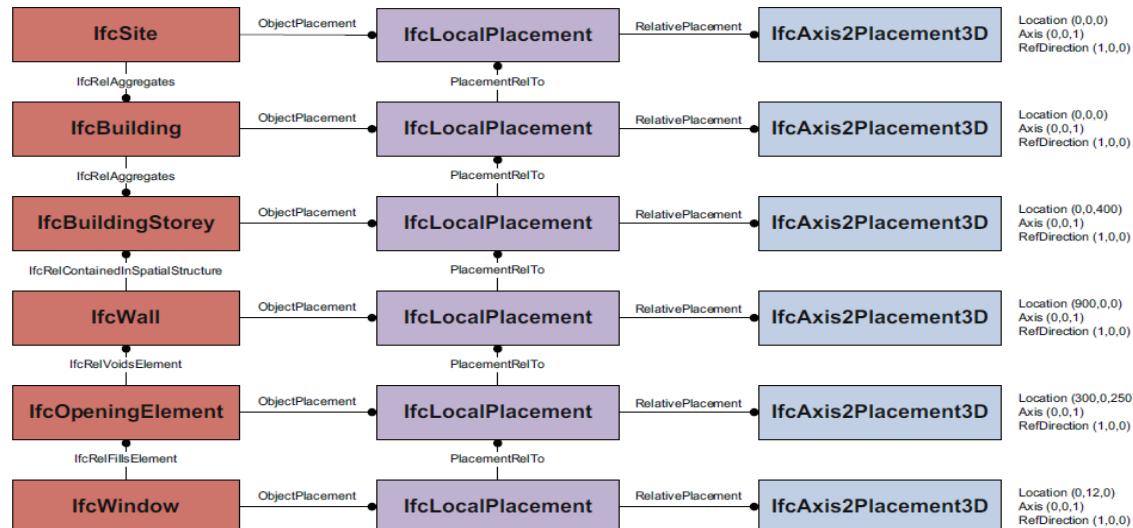


Fig. 5.26 Relationship between LocalPlacement and aggregation hierarchy of the building object

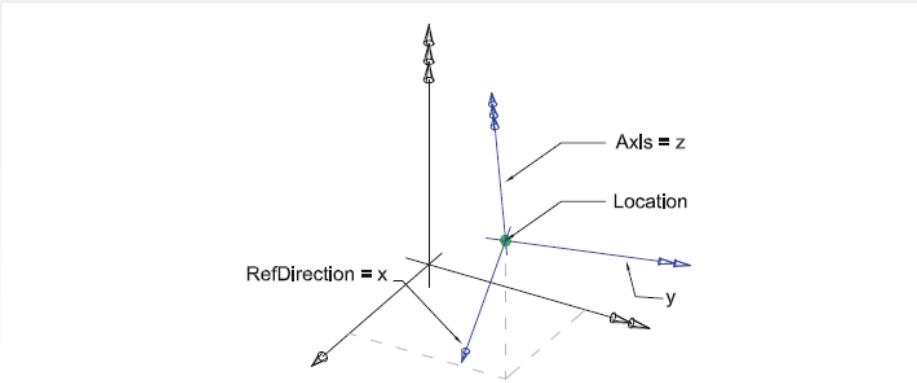
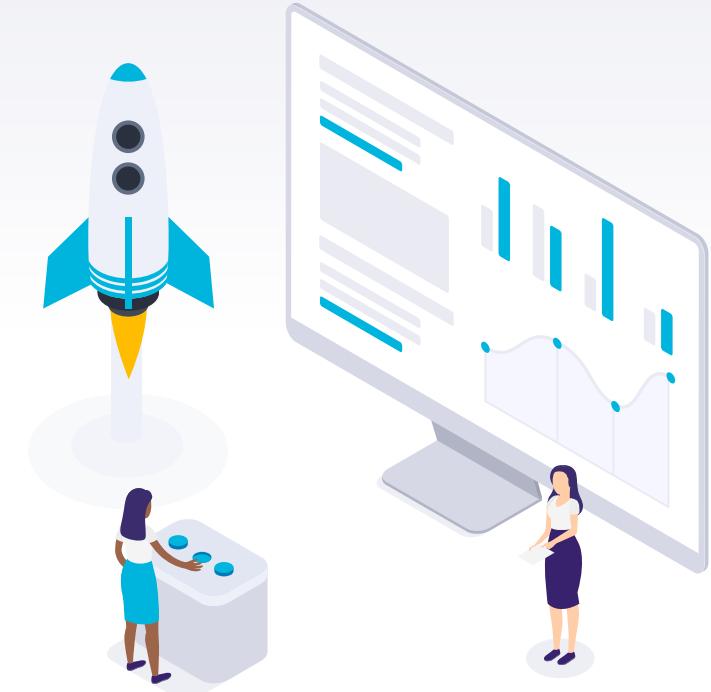


Fig. 5.25 The functioning of relative positioning using an *IfcAxis2Placement3D*

```
<ObjectPlacement id="i61" xsi:type="IfcLocalPlacement">
  <RelativePlacement>
    <IfcAxis2Placement3D id="i71">
      <Location id="i75" xsi:type="IfcCartesianPoint" Coordinates="6 18 0" />
      <Axis id="i76" xsi:type="IfcDirection" DirectionRatios="0 0 1" />
      <RefDirection id="i77" xsi:type="IfcDirection" DirectionRatios="0 -1 0" />
    </IfcAxis2Placement3D>
  </RelativePlacement>
</ObjectPlacement>
<IfcBuildingStorey id="i90" pos="1" GlobalId="2GQdkZ_Pv6kvNpgL92dqGN" Name="TOP LEVEL" CompositionType="element" Elevation="3">
</IfcBuildingStorey>
```

3

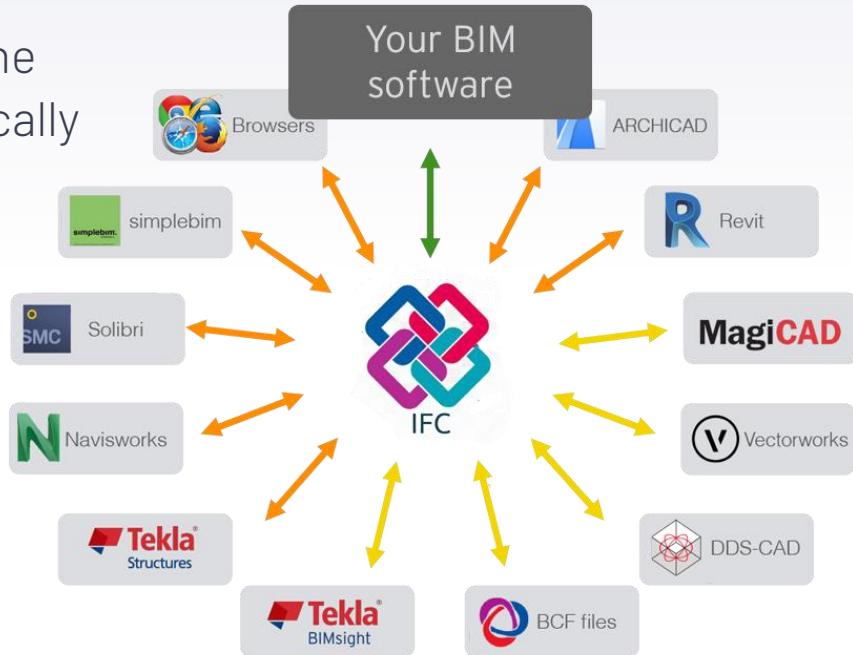
# ATTRIBUTES & PROPERTIES



# It's all about data

The importance of standardization is that the parameters of other software are automatically recognized and assigned correctly to your software.

- ▶ Data Mapping
- ▶ Attributes vs. Properties
- ▶ Property Sets
- ▶ Revit Implementation



# Data Mapping

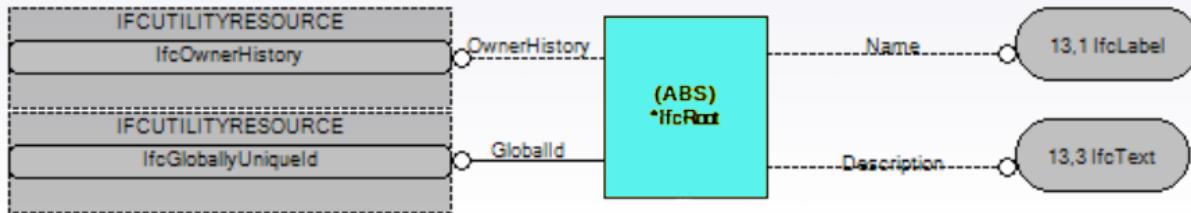
- ▶ To achieve the required levels of interoperability, a standardized way of data mapping and data containers has to be used.

**Direct exchange**

**3 doors**



# ATTRIBUTES



- Attributes are the basic metadata about an IFC entity and it where all other information about the entity can be attached.
- Attributes get inherited along the inheritance tree and as the object gets more actualized new attributes could be found in the object.

# ► Attributes can be defined in two categories:

## Entity Attributes

There is a direct relationship between the entity and the attribute.

## Inverse Attributes

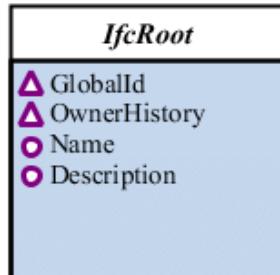
Means that the entity is referenced in some other entity direct attribute.

IfcObject			
5	ObjectType	IfcLabel	[0:1]
	<i>IsDeclaredBy</i>	IfcRelDefinesByObject @RelatedObjects	S[0:1]
	<i>Declares</i>	IfcRelDefinesByObject @RelatingObject	S[0:?]
	<i>IsTypedBy</i>	IfcRelDefinesByType @RelatedObjects	S[0:1]
	<i>IsDefinedBy</i>	IfcRelDefinesByProperties @RelatedObjects	S[0:?]

# Also, we could categorize them to:

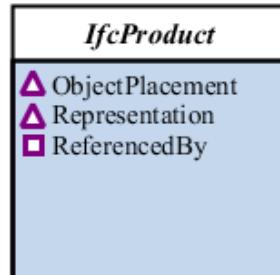
## Simple Attributes:

Indicates a simple data attribute like an integer or a string.



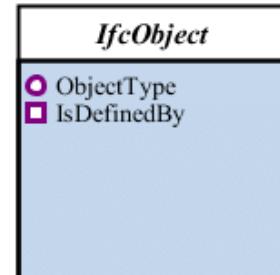
## Referenced Object Attributes:

An attribute that is a reference to another object.



## Relationship Attribute:

An attribute that is a reference to a relationship.



● Simple attributes

▲ Referenced object attributes

■ Relationship attributes



# Attributes in Revit

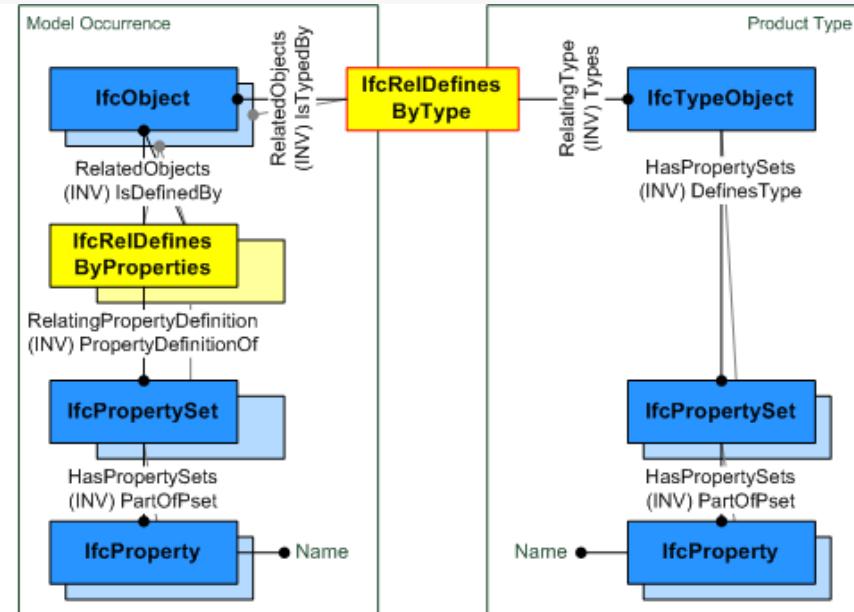
- ▶ Attributes are automatically exported if they are populated in Revit.
- ▶ Attributes could be override by making a parameter in Revit with the same name of the attribute.

# ► PROPERTIES

- We use properties to add more information to the entities than provided by the attributes.
- Properties are only found within a Property Set.

# Property Sets

- ▶ Property Sets are a collection of IfcProperty that could be attached to an entity through the relationship attribute IsDefinedBy if the object is occurrence or the attribute HasPropertySet if the object is a type.

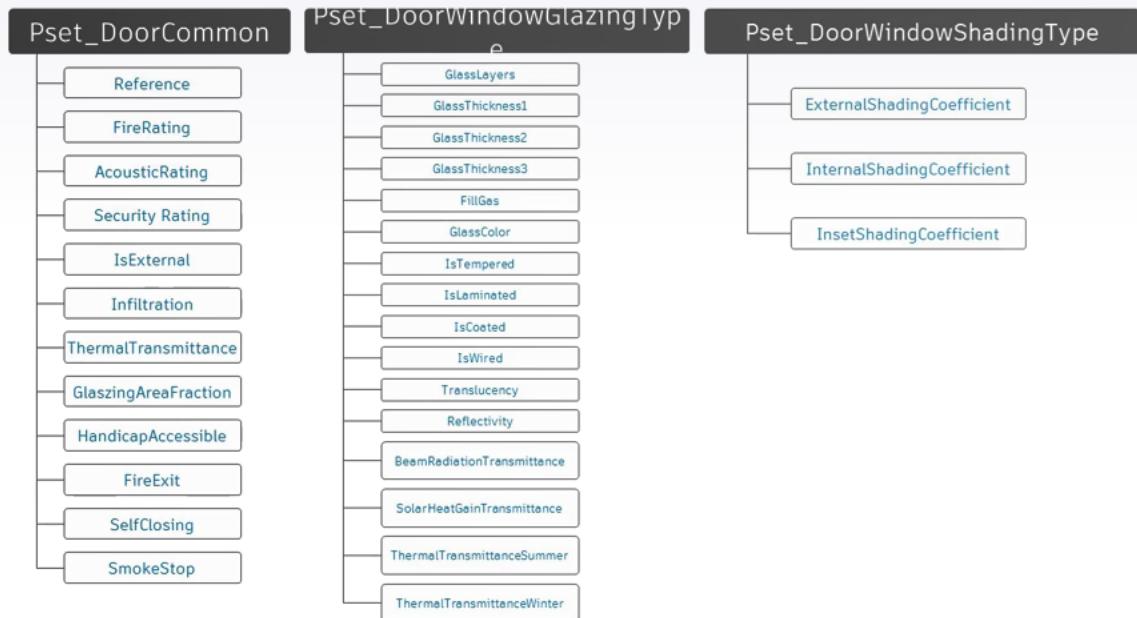


# Property Sets are classified into:

- ▶ IFC Schema Properties: Common Standard Property Sets (Psets)
- ▶ User Defined Property Sets

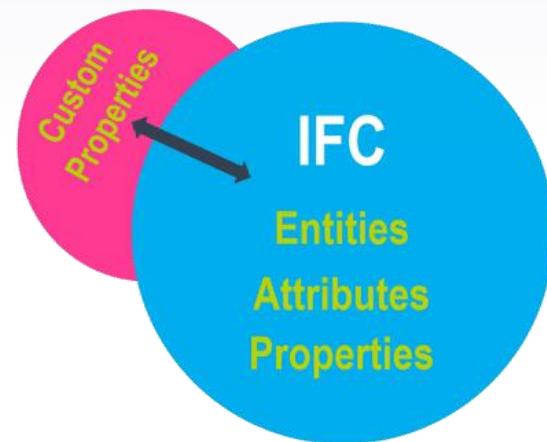
# IFC Common Property Sets:

- ▶ Most IFC classes have associated Psets containing properties specific to that class.



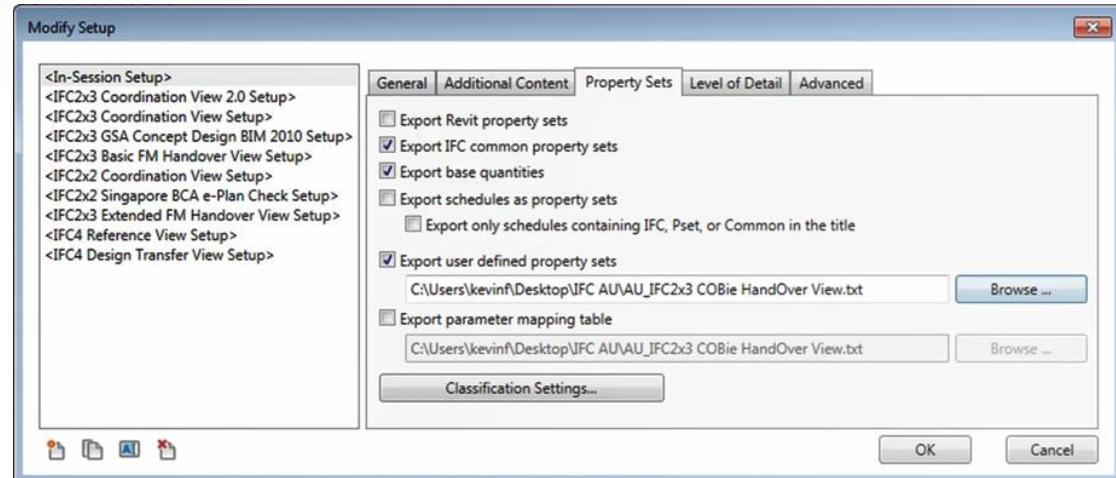
# User Defined Property Sets

- ▶ User defined or custom properties doesn't exist in the IFC schema but is defined by the user.



# Revit Implementation of the IFC Property Sets

- In the setup of the IFC exporter within Revit there are multiple options for the export.



# Exporting Common Psets

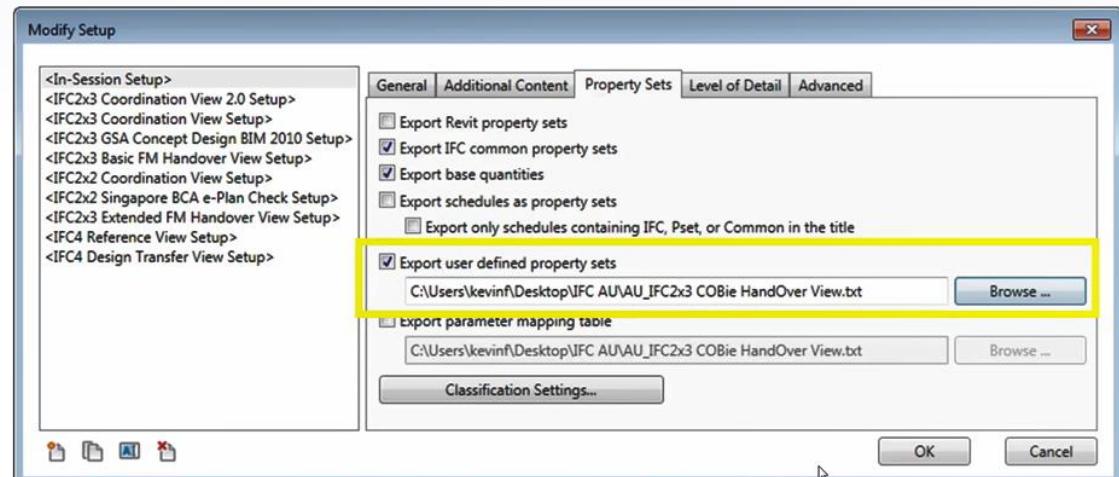
- ▶ Some of properties in the Common Psets correlates automatically to hard-wired Revit parameters.
- ▶ Some IFC properties don't.
- ▶ But mapping them is just by making a parameter with the same name of the properties.
- ▶ The hardwired parameters could be overridden.

GlassLayers	4
GlassColor	Contact Internorm
FireRating	n/a
FireExit	<input type="checkbox"/>
FillGas	Argon or Krypton
BeamRadiationTransmittance	0.000000
AcousticRating	36 dB
IfcExportAs	

Pset_DoorCommon		Pset_DoorWindowGlazingType
Property		Value
AcousticRating		36 dB
FireExit		False
FireRating		n/a
GlazingAreaFraction		0

# Exporting User Defined Psets

- ▶ Shared parameters in Revit need to be mapped manually to the User Defined Property Sets



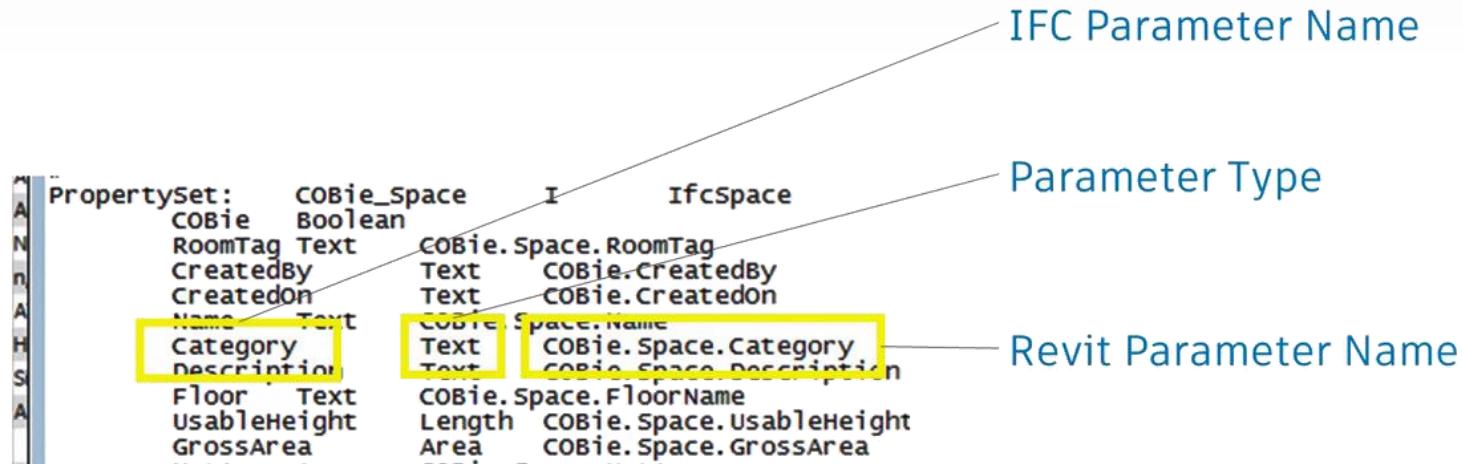
# Data Mapping files

- The first part is the Property Set Definition

		Pset Delimiter		Pset Name	
				(I)stance or (T)ype Parameter	
				Element Type	
A	PropertySet:	COBie_Space	I	IfcSpace	
N	cobie	Boolean			
R	RoomTag	Text	COBie_Space.RoomTag		
C	CreatedBy	Text	COBie_CreatedBy		
C	CreatedOn	Text	COBie_Createdon		
N	Name	Text	COBie_Space.Name		
H	Category	Text	COBie_Space.Category		
S	Description	Text	COBie_Space.Description		
A	Floor	Text	COBie_Space.FloorName		
A	UsableHeight	Length	COBie_Space.UsableHeight		
A	GrossArea	Area	COBie_Space.GrossArea		

# Data Mapping files

- Second part is the parameter definition



# Exporting Example

- A three text parameters were created and grouped under the Text group.

Name:	Type 1	Parameter	Value	Formula
<b>Text</b>				
CreatedByURL		CreatedByURL	www.revitiq.com	=
CreatedBy		CreatedBy	revitIQ	=
BIMObjectName		BIMObjectName	Abcdef	=
<b>Identity Data</b>				
Keynote		Keynote		=
Model		Model		=
Manufacturer		Manufacturer	Generic	=
Type Comments		Type Comments		=
URL		URL		=
Description		Description	Generic Object	=
Assembly Code		Assembly Code		=
Cost		Cost		=

# Export Revit Property Sets

Identification	Location	Quantities	Profile	Relations	Classification	Hyperlinks	Constraints	Dimensions							
Identity Data(Type)	Other	Other(Type)	Phasing	Pset_ManufacturerTypeInformation				Text(Type)							
Property		Value													
BIMObjectName		Abcdef													
CreatedBy		revitiQ													
CreatedByURL		www.revitiq.com													

# Export IFC Common Property Sets

Info							
Furniture.0.1							
Identification	Location	Quantities	Profile	Relations	Classification	Hyperlinks	Pset_ManufacturerTypeInformation
Property		Value					
Model		GenericChair					
Discipline		Architectural					
Name		GenericFamily:Type 1:1123037					
Phase		Project Status					
Type		Type 1					
Description							
Material							
Layer		I-FURN-____-OTLN					
System							
Geometry		Extrusion					
Application		Autodesk Revit 2016 (ENU)					
GUID		32VlpHVGnEj8E_pOLwJixU					
BATID		1123037					

# Export User Defined Property Sets

The image shows two windows demonstrating the export of user-defined property sets.

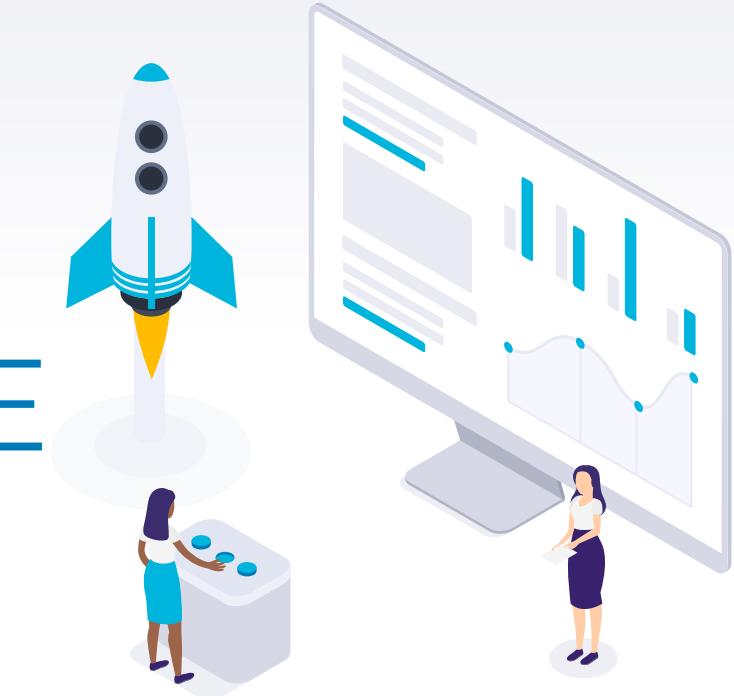
The top window is a Notepad titled "revitIQ\_ParameterSet - Notepad". It contains the following text:

```
#  
PropertySet: revitIQ.com T IfcElementType  
    Created by Text CreatedBy  
    Website Text CreatedByURL  
    Name Text BIMObjectName  
#
```

The bottom window is the Revit "Info" dialog for a selected element named "Furniture.0.1". The "Identification" tab is selected. The "Pset\_ManufacturerTypeInformation" tab is also visible. The properties listed are:

Property	Value
Created by	revitIQ
Name	Abcdef
Website	<a href="http://www.revitiq.com">www.revitiq.com</a>

# IFC: THE NOW & THE FUTURE

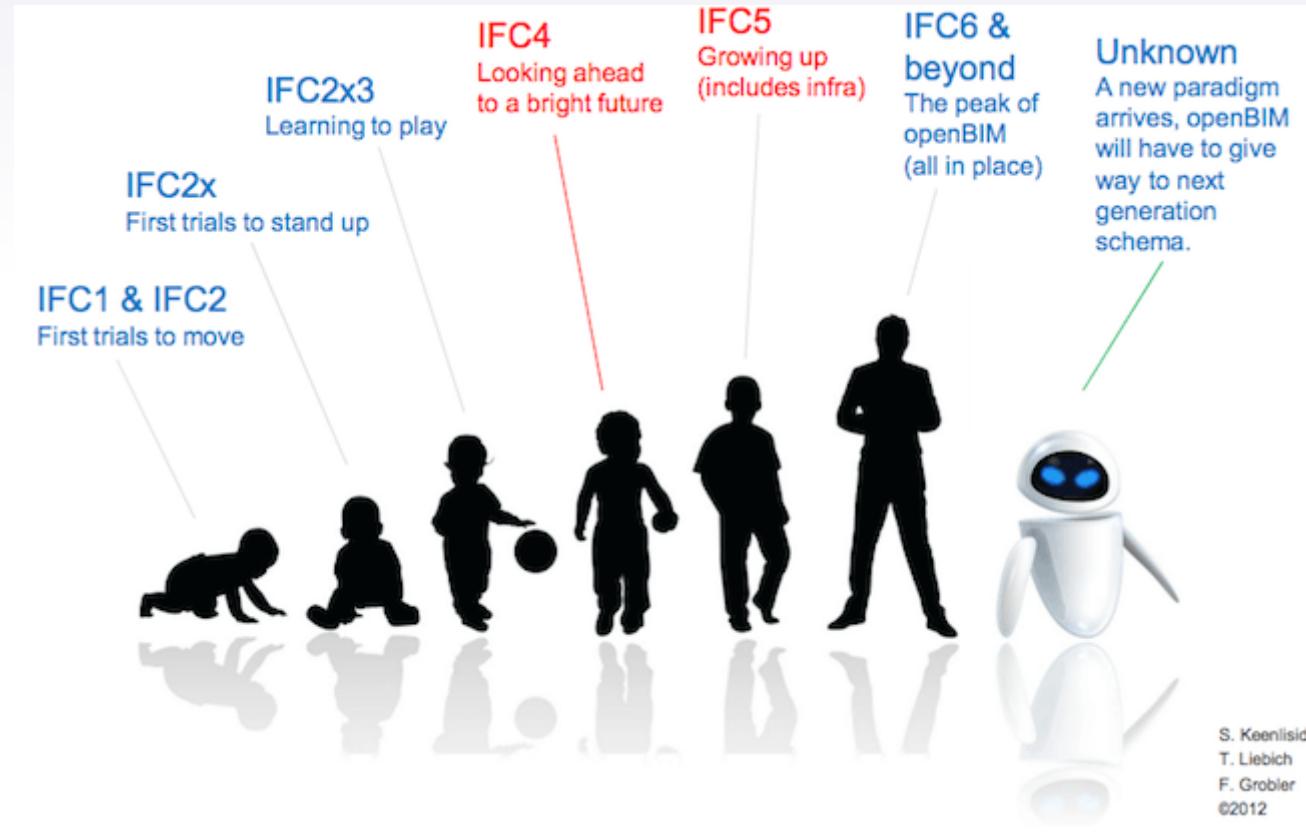


# Preview

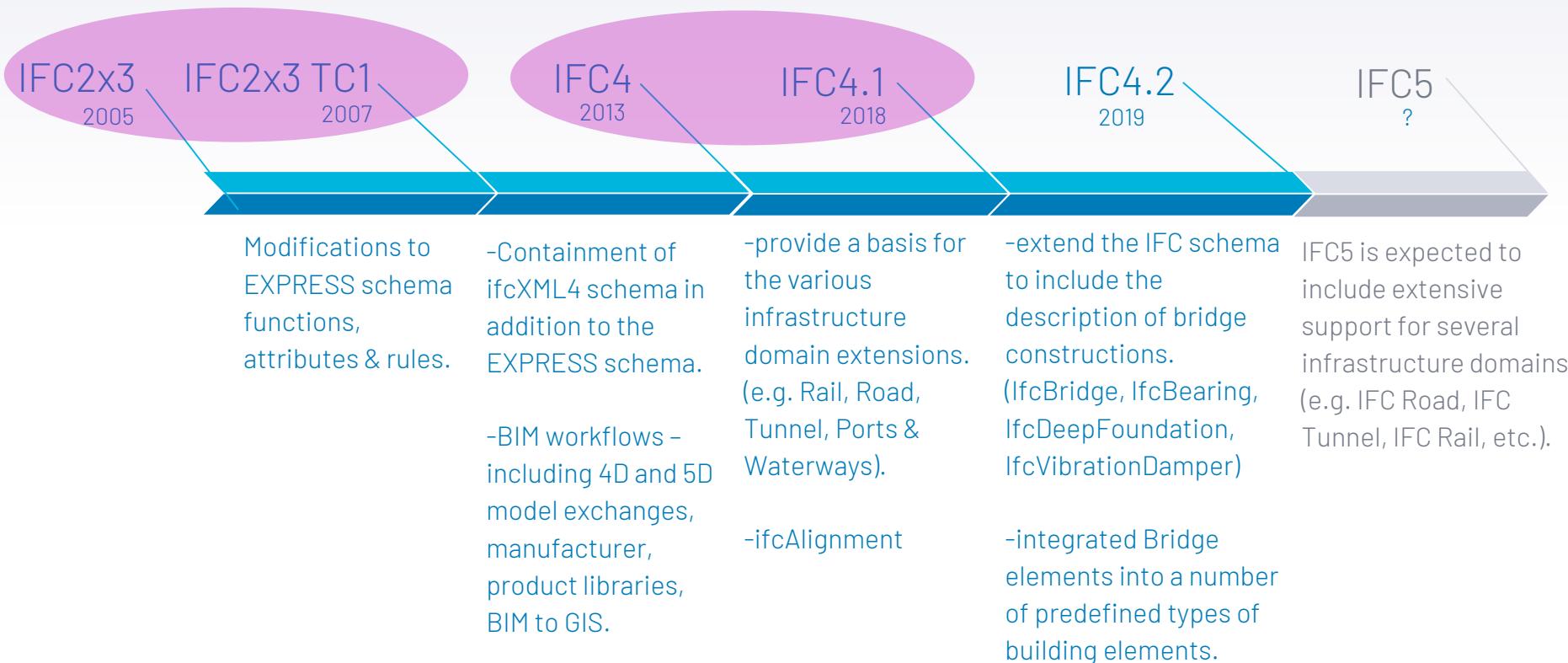
- ▶ Ifc Versions & Certification:
  - IFC versions evolution
  - IFC Certification
  - Case Study: ifcBridge addition to ifc4.
  - Ifc5.0 infrastructure & better GIS integration
- ▶ Ifc Formats
  - Common ones (ifc, ifcXML, ifcZIP)
  - Brief Case Study: ifcJSON format (precast element implementation)



# Ifc Versions Evolution



# Ifc Versions Evolution



# Ifc Certification

## Ifc2x3 Certification:

-Given for a software that supports a model view definition (MVD) called:

- **Coordination View (CV2.0)**

Main use is to support the exchange of information between the building services disciplines.

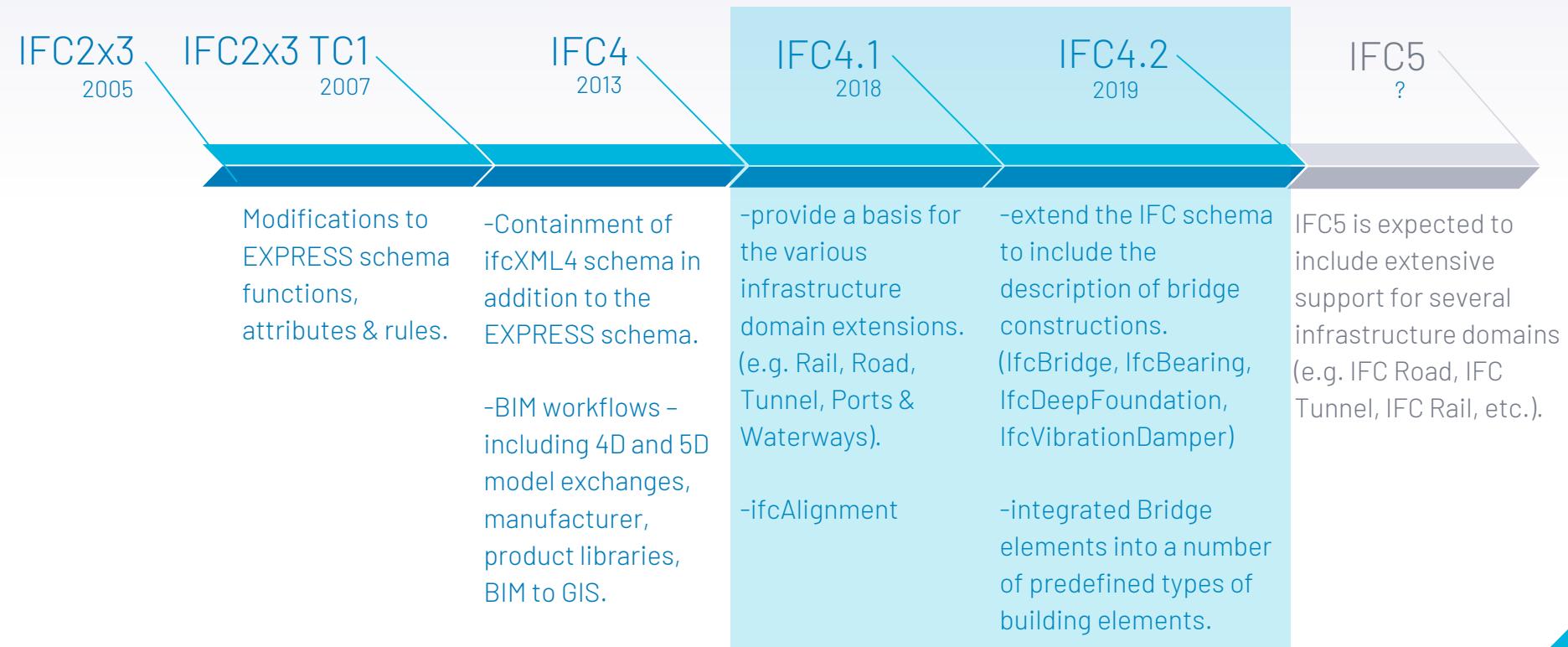
- Clash detection
- Consistency control
- Building code checking

## Ifc4 Certification:

Coordination View (CV2.0) is split to two views:

- 1) **IFC4 reference view RV**: enable the swift, accurate exchange of information between disciplines, with rapid export and import times and no need for rework.
- 2) **IFC design transfer view DTV**: allow the BIM model to be handed over to the next stage of editing, responsibility for the transferred model is likely to be taken over by the receiver.

# Ifc Versions Evolution

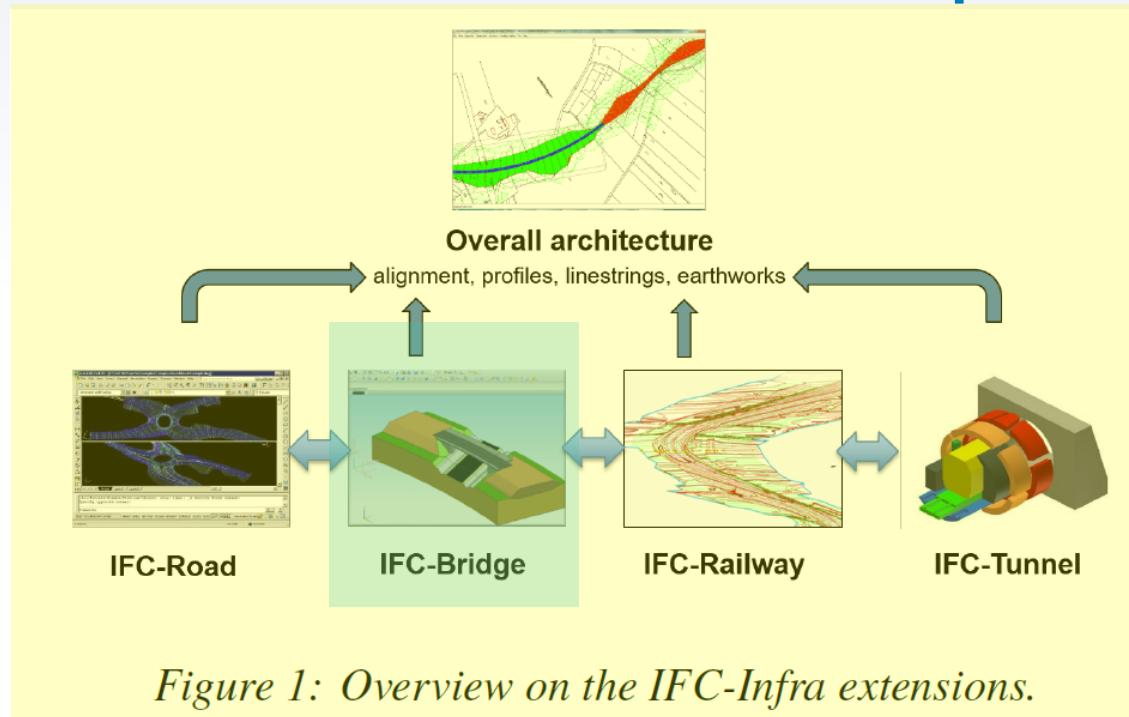


# ifcBridge Addition to IFC4.2

A high demand from international infrastructure stakeholders for extending IFC for bridges.

Infra Room as a fast-track project with a duration of 2 years.

It started in January 2017 and was completed in April 2019.



# ifcBridge Addition to IFC4.2

## 1) Rigorous Scope Definition, Why?

- The large extent of the existing IFC data model (IFC4.1 comprises 801 entities)
- The limited time and resources available for the developing the extensions.
- Lowering the effort for software implementation to enable a fast uptake of the standard.

# ifcBridge Addition to IFC4.2

## 1) Rigorous Scope; Bridge Types:

- Covered types:  
ex: Slab bridge, Girder bridge, Box-girder bridge...etc.
- Types that were not directly covered, but representable by the extension:  
ex: Truss bridge, Cable-Stayed Bridge, Suspension Bridge...etc.
- Material classification:  
ex: Steel, Concrete...etc.



# ifcBridge Addition to IFC4.2

## 2) Use Cases:

- Initial State Modeling
- Import of major road / railway parameters
- Technical Visualization
- Coordination / Collision Detection
- 4D Construction Sequence Modeling
- Progress Monitoring
- As-built vs. as-planned comparison
- Handover to asset management
- Handover to GIS for spatial analysis
- Design to design (reference model).
- Quantity Take-Off

# ifcBridge Addition to IFC4.2

## 3) Geometry:

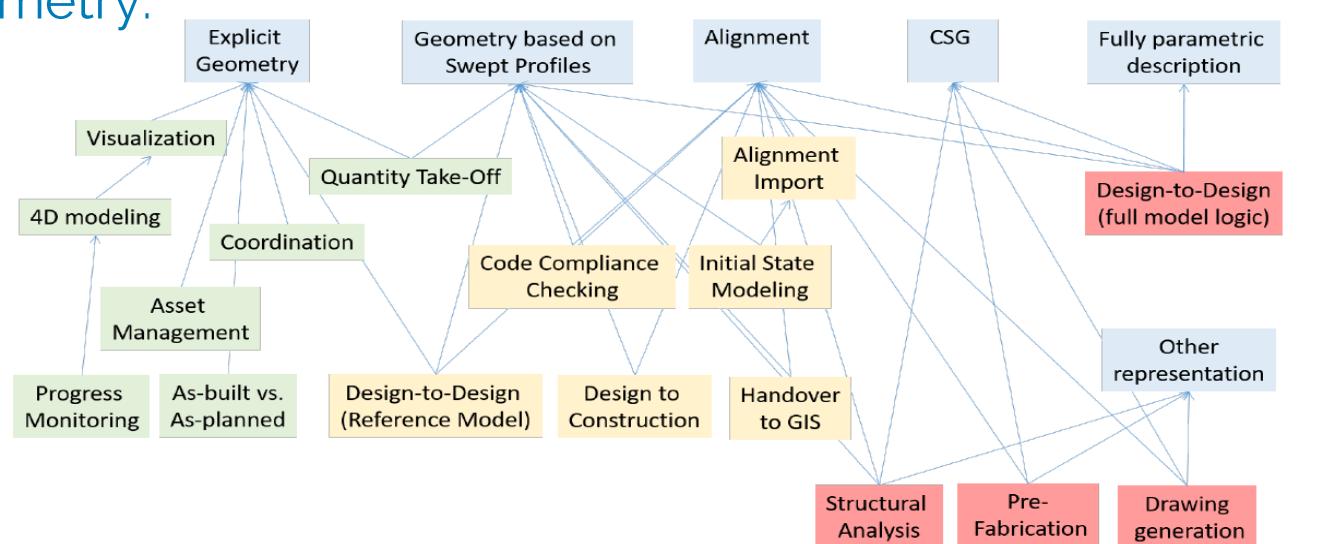
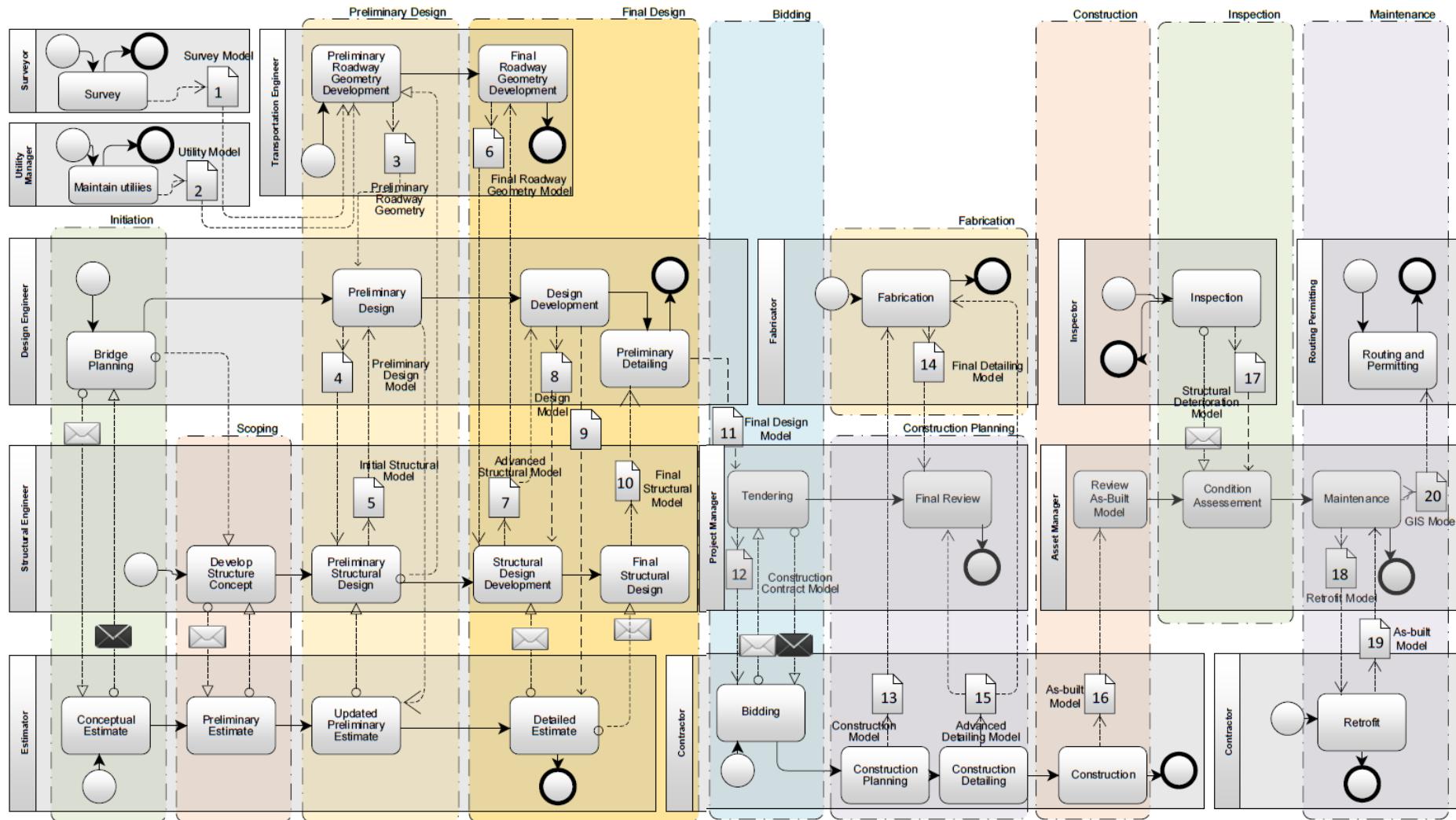


Figure 2: Dependence of the use cases on specific geometry representations.

# ► ifcBridge Addition to IFC4.2

## 4) Process Map:

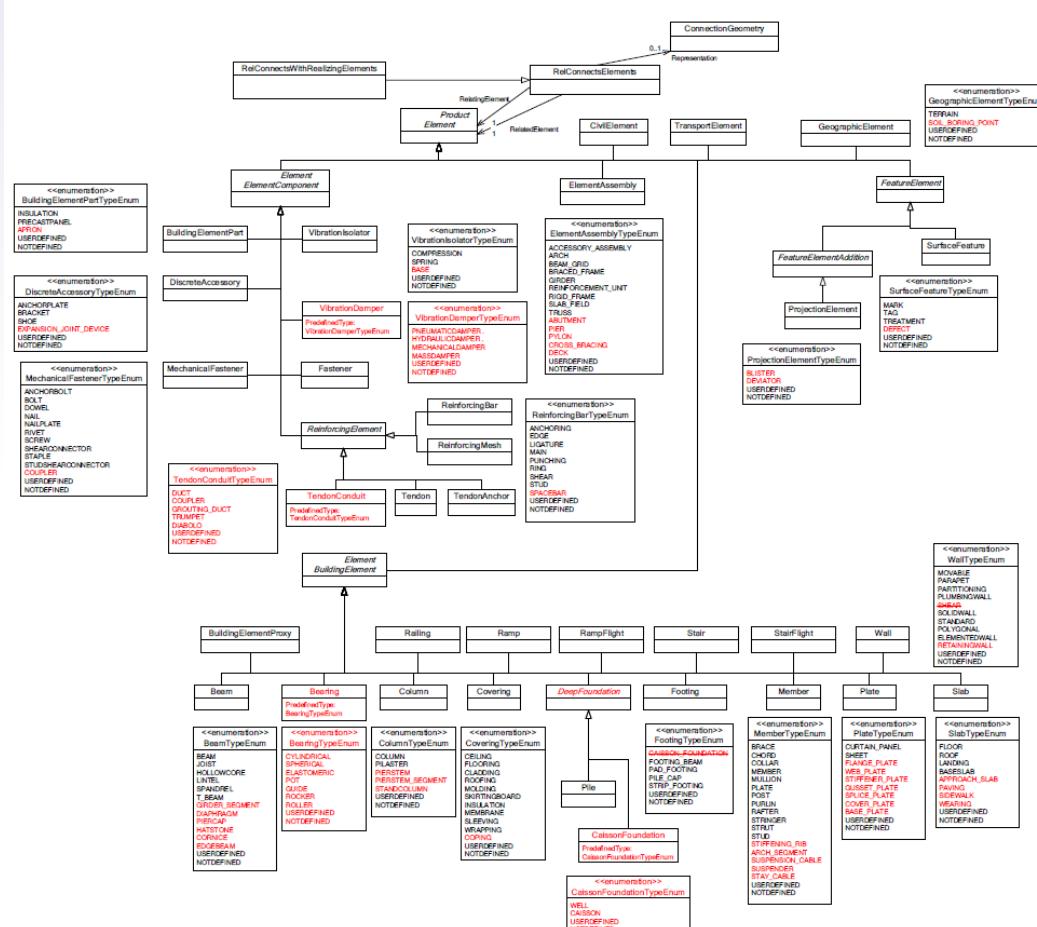
Map developed to clearly identify the exchange requirements and associate them with dedicated data exchange scenarios.



# ► ifcBridge Addition to IFC4.2

## 5) Taxonomy Analysis:

to identify concepts specific to bridge construction and to find commonly used English terms for them.



IfcBeam: <ul style="list-style-type: none"> <li>• GIRDER_SEGMENT</li> <li>• DIAPHRAGM</li> <li>• PIERCAP</li> <li>• HATSTONE</li> <li>• CORNICE</li> <li>• EDGEBEAM</li> </ul>	IfcColumn: <ul style="list-style-type: none"> <li>• PIERSTEM</li> <li>• PIERSTEM_SEGMENT</li> <li>• STANDCOLUMN</li> </ul>	IfcCovering: <ul style="list-style-type: none"> <li>• COPING</li> </ul>
IfcMember: <ul style="list-style-type: none"> <li>• STIFFENING_RIB</li> <li>• ARCH_SEGMENT</li> <li>• SUSPENSION_CABLE</li> <li>• SUSPENDER</li> <li>• STAY_CABLE</li> </ul>	IfcPlate: <ul style="list-style-type: none"> <li>• FLANGE_PLATE</li> <li>• WEB_PLATE</li> <li>• STIFFENER_PLATE</li> <li>• GUSSET_PLATE</li> <li>• SPLICE_PLATE</li> <li>• COVER_PLATE</li> <li>• BASE_PLATE</li> </ul>	IfcSlab: <ul style="list-style-type: none"> <li>• APPROACH_SLAB</li> <li>• PAVING</li> <li>• SIDEWALK</li> <li>• WEARING</li> </ul>
IfcWall: <ul style="list-style-type: none"> <li>• RETAININGWALL</li> </ul>	IfcElementAssembly: <ul style="list-style-type: none"> <li>• ABUTMENT</li> <li>• PIER</li> <li>• PYLON</li> <li>• CROSS_BRACING</li> <li>• DECK</li> </ul>	IfcVibrationIsolator: <ul style="list-style-type: none"> <li>• BASE</li> </ul>
IfcBuildingElementPart: <ul style="list-style-type: none"> <li>• APRON</li> </ul>	IfcDiscreteAccessory: <ul style="list-style-type: none"> <li>• EXPANSION_JOINT_DEVICE</li> </ul>	IfcMechanicalFastener: <ul style="list-style-type: none"> <li>• COUPLER</li> </ul>
IfcReinforcingBar: <ul style="list-style-type: none"> <li>• SPACEBAR</li> </ul>	IfcSurfaceFeature: <ul style="list-style-type: none"> <li>• DEFECT</li> </ul>	IfcProjectionElement: <ul style="list-style-type: none"> <li>• BLISTER</li> <li>• DEVIATOR</li> </ul>
IfcGeographicElement: <ul style="list-style-type: none"> <li>• SOIL_BORING_POINT</li> </ul>	IfcBuildingSystem: <ul style="list-style-type: none"> <li>• REINFORCING</li> <li>• PRESTRESSING</li> </ul>	

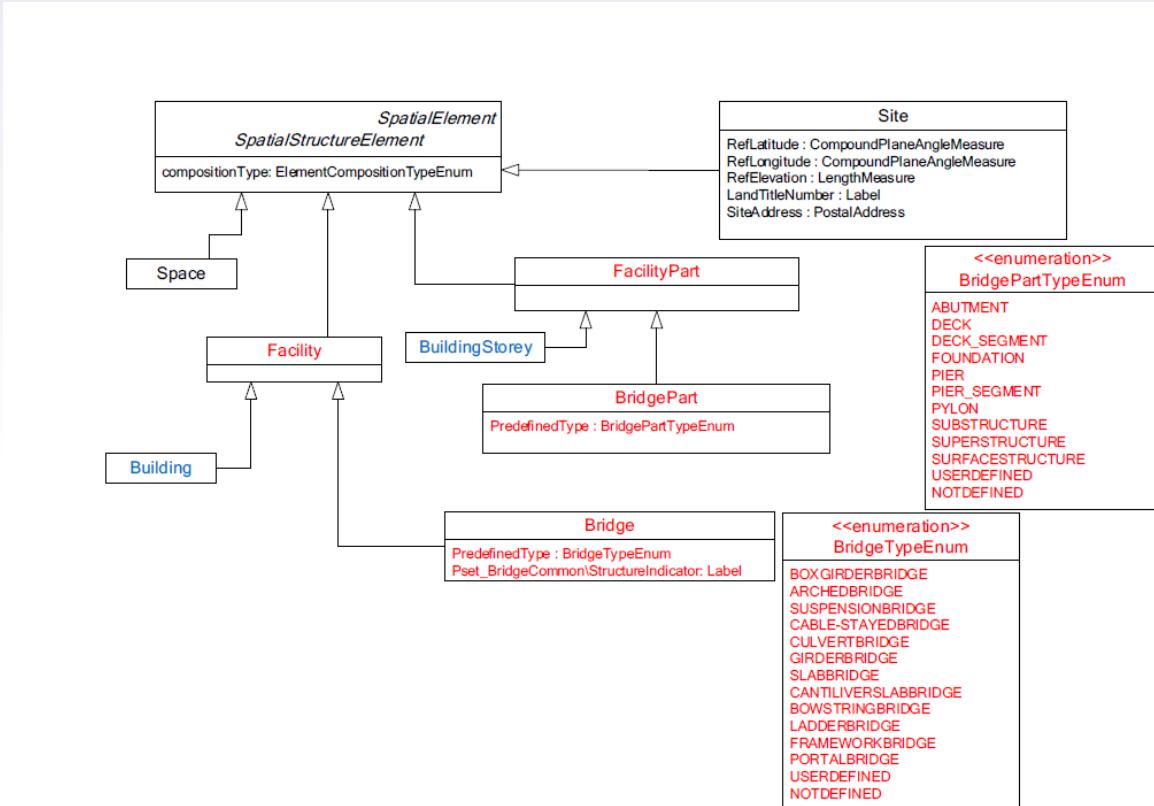
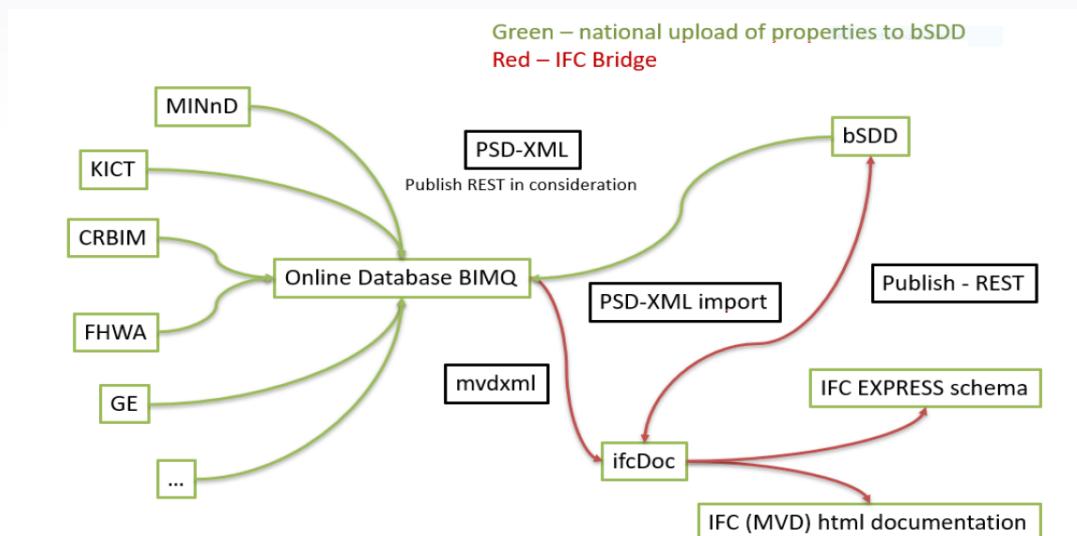


Figure 6: Extension of the spatial elements. New elements are marked in red.

# ifcBridge Addition to IFC4.2

## 6) Handling Of Properties:



FHWA-Federal Highway Administration (American)

CRBIM- Railway BIM Data (Chinese)

Figure 7: General approach taken by the IFC-Bridge project to defining and managing properties

# ► ifcBridge Addition to IFC4.2

## 7) Model View Definitions:

- Bridge Reference View (Bridge RV)
- Alignment-based Bridge Reference View (Bridge ARV)
- Bridge Design Transfer View (Bridge DTV)
- Bridge Asset Management Handover View (Bridge AMV)

# ifcBridge Addition to IFC4.2

## 8) Final Testing & Implementation:

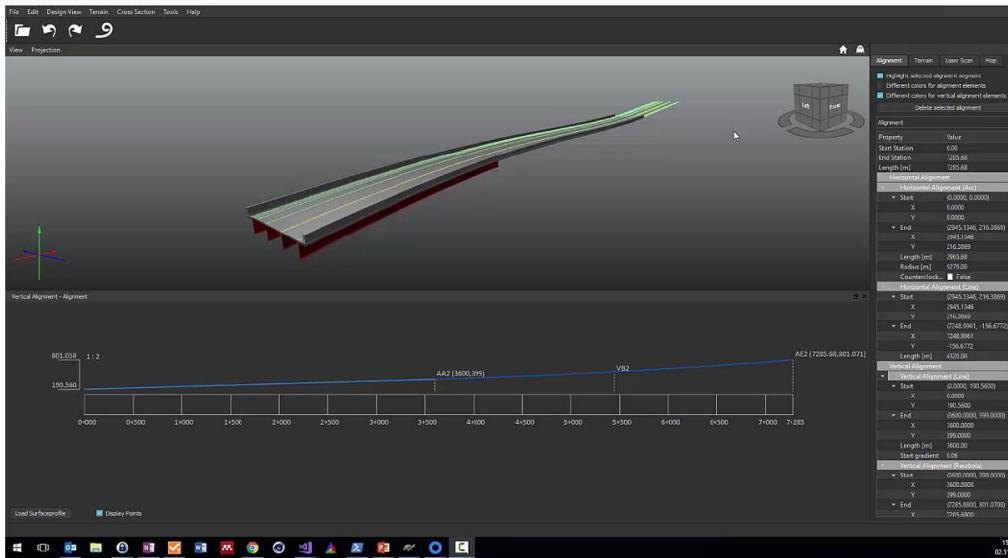
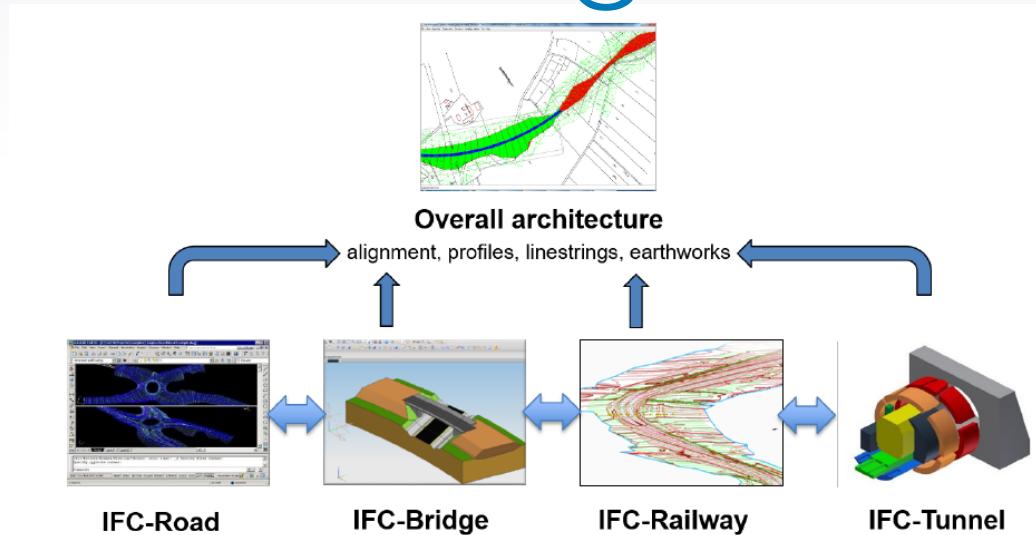


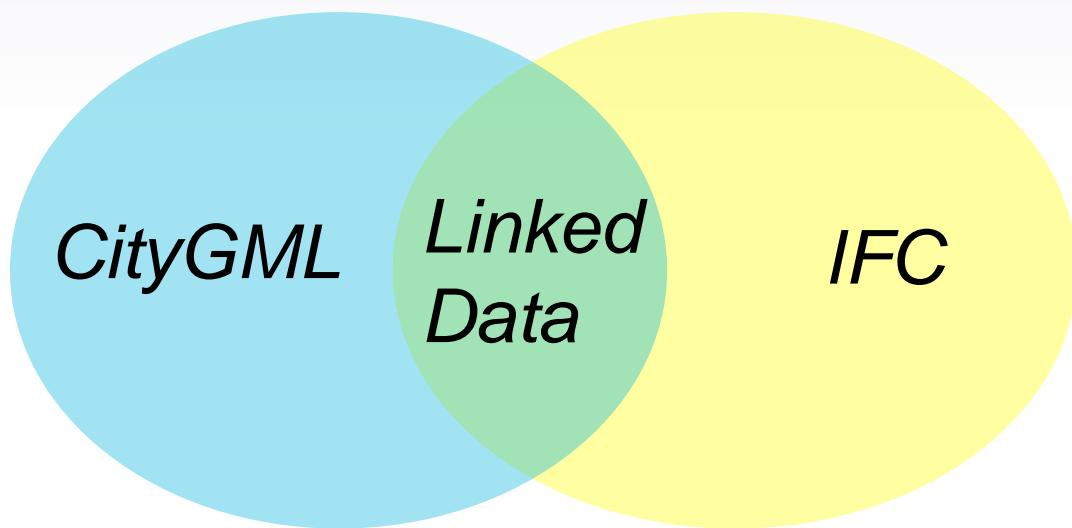
Figure 8: TUM Open Infra Platform visualizing bridge deck geometry created by alignment-based sweep

# Ifc5.0 Infrastructure & Better GIS Integration



*Figure 1: Overview on the IFC-Infra extensions.*

# ► Ifc5.0 Infrastructure & Better GIS Integration



The concept of *Linked Data* which allows the original data to coexist and provide coherence by establishing references between the corresponding entities of both standards; IFC & CityGML.

CityGML is an open data model and XML-based format for the storage and exchange of virtual 3D city models.

# Ifc New Candidate Formats

Some Research efforts found that **ifcJSON** format (based on JavaScript Object Notion) could preform better than **ifcXML** due to the following reasons:

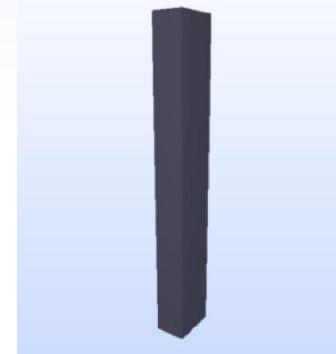
- ▶ XML requires extra libraries to retrieve data from DOM objects ,But JSON objects are analyzed as string arrays which can perform much faster.
- ▶ JSON data format supports high scalability and it creates more compact models than XML.
- ▶ JSON is a **key-value style** lightweight data exchange format which is independent of any programming language and unlike XML it is easy for **(1)** machines to parse and generate while it is also **(2)** human readable.

# Brief Case Study: Ifcjson Format (Precast Element Implementation)

ifcJSON4 schema and the ifcJSON document for this exchange model is described here for four data categories.

- 1) geometry data representation
- 2) object placement data
- 3) owner history data
- 4) Building element data that includes these three data categories.

Name	Concrete Column
<b>Profile Type</b>	Rectangle
<b>Geometry</b>	Extrusion
<b>X Dim</b>	0.45
<b>Y Dim</b>	0.30
<b>Length</b>	3.00
<b>Top Elevation</b>	3.00
<b>Bottom Elevation</b>	0.00
<b>Global X</b>	0.00
<b>Global Y</b>	0.00



# Brief Case Study: Ifcjson Format (Precast Element Implementation)

## 1) geometry data representation( IfcProductDefinitionShape, IfcExtrudedAreaSolid)

Table 15

IfcProductDefinitionShape in ifcJSON document (Left), ifcJSON4 schema representation for IfcProductDefinitionShape (Right).

ifcJSON document	ifcJSON4 Schema
<pre>{     "instanceId": 252,     "name": null,     "description": "DetailedProfile",     "representations": [         {             "instanceId": 111,             "contextOfItems": [                 {                     "instanceId": 67,                     "contextIdentifier": null,                     "contextType": "Model",                     "coordinateSpaceDimension": 3,                     "precision": 1.0,                     "worldCoordinateSystem": {                         "instanceId": 64,                         "location": {                             "instanceId": 6,                             "Coordinates": [0, 0, 0]                         },                         "axis": null,                         "refDirection": null                     },                     "trueNorth": {                         "instanceId": 65,                         "directionRatios": [2, 6.1, 1]                     }                 },                 "representationIdentifier": "Body",                 "representationType": "SweptSolid",                 "items": [{} // see Table 14 ]             ]         }     ] }</pre>	<pre>{     \$type: "object",     properties: {         instanceId: {             \$type: "integer"         },         name: {             \$type: "oneOf",             \$options: [                 {                     \$type: "null"                 },                 {                     \$type: "string",                     maxLength: 255                 }             ]         },         description: {             \$type: "type",             \$options: [                 {                     \$type: "string"                 },                 {                     \$type: "null"                 }             ]         },         representations: {             \$type: "array",             items: {                 \$type: "object",                 properties: {                     \$ref: "#/properties/IfcShapeRepresentation"                 }             }         }     } }</pre>

Table 14

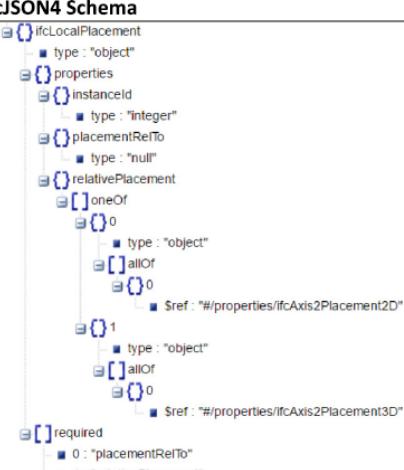
IfcExtrudedAreaSolid in ifcJSON document (Left), ifcJSON4 schema representation for IfcExtrudedAreaSolid (Right).

ifcJSON document	ifcJSON4 Schema
<pre>{     "instanceId": 110,     "sweptArea": {         "instanceId": 108,         "profileType": "AREA",         "profileName": null,         "position": {             "instanceId": 107,             "location": {                 "instanceId": 9,                 "coordinates": [0, 0],                 "refDirection": {                     "instanceId": 29,                     "directionRatios": [0, -1]                 }             },             "xDim": 0.45,             "yDim": 0.30         },         "position": {             "instanceId": 31,             "location": {                 "instanceId": 6,                 "coordinates": [0, 0, 0]             },             "axis": null,             "refDirection": null         },         "extrudedDirection": {             "instanceId": 19,             "directionRatios": [0, 0, 1]         },         "depth": 3.0     } }</pre>	<pre>{     \$type: "object",     properties: {         instanceId: {             \$type: "integer"         },         sweptArea: {             \$type: "object",             properties: {                 profileType: {                     \$type: "oneOf",                     \$options: [                         {                             \$type: "null"                         },                         {                             \$ref: "#/properties/IfcRectangleProfileDef"                         }                     ]                 },                 profileName: {                     \$type: "null"                 },                 position: {                     \$type: "oneOf",                     \$options: [                         {                             \$type: "null"                         },                         {                             \$ref: "#/properties/IfcAxis2Placement3D"                         }                     ]                 },                 extrudedDirection: {                     \$type: "object",                     properties: {                         directionRatios: {                             \$type: "array"                         }                     }                 }             }         },         depth: {             \$type: "number",             minimum: 0,             exclusiveMinimum: false         }     } }</pre>

# Brief Case Study: Ifcjson Format (Precast Element Implementation)

## 2) Object placement data (IfcLocalPlacement)

Table 17  
IfcLocalPlacement in ifcJSON document (Left), ifcJSON4 schema representation for IfcLocalPlacement (Right).

ifcJSON document	ifcJSON4 Schema
<pre>{     "ifcLocalPlacement": {         "instanceId": 257,         "placementRefTo": null,         "relativePlacement": {             "instanceId": 31,             "location": {                 "instanceId": 6,                 "coordinates": [0, 0, 0]             },             "axis": null,             "refDirection": null         }     } }</pre>	

# Brief Case Study: Ifcjson Format (Precast Element Implementation)

## 3) Owner data (IfcOwnerHistory)

Table 19  
IfcOwnerHistory in ifcJSON document (Left), ifcJSON4 schema representation for IfcOwnerHistory (Right).

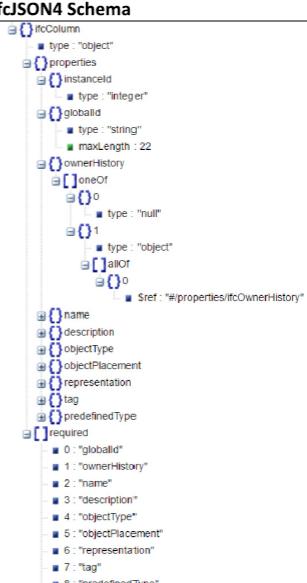
ifcJSON document	ifcJSON4 Schema
<pre>{     "instanceId": 41,     "owningUser": {         "instanceId": 3,         "thePerson": {             "instanceId": 1,             "identification": "KID",             "familyName": "Afsari",             "givenName": "Keresh",             "middleNames": null,             "prefixTitles": null,             "suffixTitles": null,             "roles": null,             "addresses": null         },         "theOrganization": {             "instanceId": 2,             "identification": "organization",             "name": "Organization name",             "description": "Org description",             "roles": null,             "addresses": null         },         "roles": null     },     "owningApplication": {         "instanceId": 5,         "applicationDeveloper": {             "instanceId": 2,             "identification": "organization",             "name": "Organization name",             "description": "Org description",             "roles": null,             "addresses": null         },         "version": "2016",         "applicationFullName": "Application",         "applicationIdentifier": "App identifier"     },     "state": null,     "changeAction": "NOCHANGE",     "lastModifiedDate": null,     "lastModifyingUser": null,     "lastModifyingApplication": null,     "creationDate": 1407386573 }</pre>	<pre> @ IfcOwnerHistory   type : "object"   properties:     instanceId:       type : "integer"     owningUser:       type : "object"       allOf:         0:           \$ref: "#/properties/ifcPersonAndOrganization"         1:           type : "object"           allOf:             0:               \$ref: "#/properties/ifcApplication"             1:               type : "object"               allOf:                 0:                   \$ref: "#/properties/ifcApplication"                 1:                   state:                     oneOf:                       0: changeAction                       1: lastModifiedDate                       2: lastModifyingUser                       3: creationDate                       required:                         0: owningUser                         1: owningApplication                         2: state                         3: changeAction                         4: lastModifiedDate                         5: lastModifyingUser                         6: lastModifyingApplication                         7: creationDate </pre>

# Brief Case Study: Ifcjson Format (Precast Element Implementation)

- 4) Building element data that includes these three data categories.

Table 21

IfcColumn in ifcJSON document (Left), ifcJSON4 schema representation for IfcColumn (Right).

ifcJSON document	ifcJSON4 Schema
<pre>{   "instanceId": 259,   "globalId": "3\$gxit421D9RMef03b0mxA",   "ownerHistory": { // see section 6.3.1},   "name": "Precast Concrete Column",   "description": null,   "objectType": "Column",   "objectPlacement": { // see section 6.2.1},   "representation": { // see section 6.1.1},   "tag": "267108",   "predefinedType": "COLUMN" }</pre>	 <pre> {   "\$schema": "http://json-schema.org/draft-07/schema#",   "title": "IfcColumn Schema",   "type": "object",   "properties": {     "type": {       "type": "object"     },     "globalId": {       "type": "string",       "maxLength": 22     },     "ownerHistory": {       "oneOf": [         {           "type": "null"         },         {           "type": "object",           "properties": {             "name": {               "type": "string"             },             "description": {               "type": "string"             },             "objectType": {               "type": "string"             },             "objectPlacement": {               "type": "string"             },             "representation": {               "type": "string"             },             "tag": {               "type": "string"             },             "predefinedType": {               "type": "string"             }           }         }       ]     }   },   "required": [     "globalId",     "ownerHistory",     "name",     "description",     "objectType",     "objectPlacement",     "representation",     "tag",     "predefinedType"   ] } </pre>

# Brief Case Study: Ifcjson Format (Precast Element Implementation)

- ▶ ifcJSON still has limitations & it's under development and provision by BuildingSMART.

The screenshot shows a section of the buildingSMART International website. At the top, there is a navigation bar with the buildingSMART International logo, Home, Community, Standards, Certification, and Resources. Below this, a yellow box highlights "Provisional/Candidate". A table row is shown with the following data:

JavaScript Object Notation (JSON)	.json	application/json	Yes	No	148%	JSON provides enhanced readability and benefits from a broad range of software tools.
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# References (IFC Overview)

- ▶ <https://bimconnect.org/en/software/what-is-ifc/>
- ▶ <https://technical.buildingsmart.org/standards/ifc>
- ▶ <https://bimconnect.org/en/software/the-bim-collaboration-format-bcf/>
- ▶ <https://helpcenter.graphisoft.com/user-guide/77194/>
- ▶ <https://www.magicad.com/en/feature/bcf-manager-2/>
- ▶ [https://www.bimpedia.eu/-/1004-bcf-\\_bim-collaboration-format](https://www.bimpedia.eu/-/1004-bcf-_bim-collaboration-format)
- ▶ <https://www.bimcollab.com/en/Resources/OpenBIM/BCF>
- ▶ <https://www.bim42.com/2015/02/bimcollab/>
- ▶ <https://bimconnect.org/en/wiki/working-with-ifc-and-model-view-definitions/>
- ▶ [https://en.wikipedia.org/wiki/Data\\_modeling](https://en.wikipedia.org/wiki/Data_modeling)
- ▶ [https://en.wikipedia.org/wiki/Modeling\\_language](https://en.wikipedia.org/wiki/Modeling_language)
- ▶ [https://en.wikipedia.org/wiki/EXPRESS\\_\(data\\_modeling\\_language\)](https://en.wikipedia.org/wiki/EXPRESS_(data_modeling_language))
- ▶ <http://deslab.mit.edu/DesignLab/dicpm/step.html>



# References (IFC Data Model)

- ▶ *Building Information Modeling Technology Foundations and Industry Practice (Chapter 5: Industry Foundation Classes, A standardized Data Model for the vendor neutral exchange of digital building models)* - Andre Bormann, Markus Konig, Christian Koch & Jakob Beets Eds.
- ▶ <https://www.steptools.com/stds/ifc/html/>
- ▶ <https://technical.buildingsmart.org/standards/ifc/>
- ▶ <http://docs.xbim.net/XbimWebUI/>



# References (Attributes & Properties)

- ▶ Revit IFC manual, Autodesk
- ▶ <https://bimblog.bondbryan.co.uk/>
- ▶ <https://revitiq.com/>
- ▶ <https://www.buildingsmart.org/standards/bsi-standards/standards-library/>



# References (The Now & The Future)

- ▶ THE IFC-BRIDGE PROJECT-André Borrmann1, et al- European Conference on Computing in Construction- July 2019
- ▶ Linking BIM and GIS models in infrastructure by example of IFC and CityGML- S. Vilgertshofer, et al-Technical University of Munich-2017
- ▶ JavaScript Object Notation (JSON) data serialization for IFC schema in web-based BIM data exchange-Afsari et al .Georgia Institute of Technology-2017
- ▶ <https://technical.buildingsmart.org/standards/ifc/ifc-schema-specifications/ifc-release-notes/>
- ▶ [http://docs.buildingsmartalliance.org/IFC4x2\\_Bridge/link/ifc2x3-to-ifc4.htm](http://docs.buildingsmartalliance.org/IFC4x2_Bridge/link/ifc2x3-to-ifc4.htm)
- ▶ <http://ifcinfra.com/>
- ▶ [https://www.dds-cad.net/services/news/detail/?tx\\_ttnews%5Btt\\_news%5D=97&cHash=dcc1fa16fb7b7372e9916d7991d45d60](https://www.dds-cad.net/services/news/detail/?tx_ttnews%5Btt_news%5D=97&cHash=dcc1fa16fb7b7372e9916d7991d45d60)

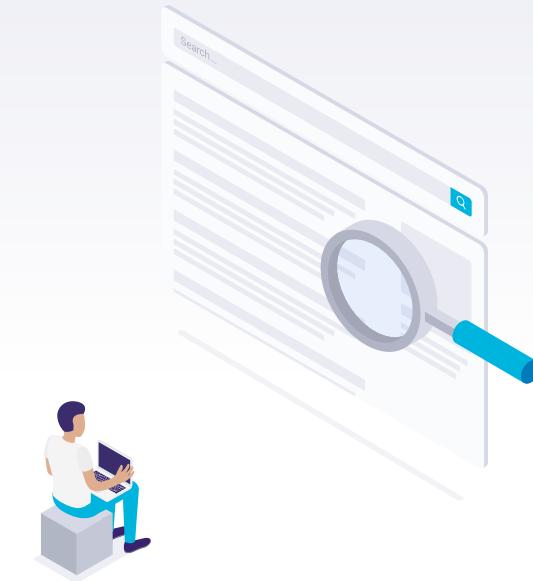


# THANKS!

Any questions? 😊

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and many more...