Automatic Conversion of CityGML to IFC

MSc. Geomatics graduation project

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Gemeente Rotterdam

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Presentation Outline

- Motivation
- Goal
- Applications
- Research Question
- Requirements
- Methodology
- User accessibility
- Conclusions

Motivation

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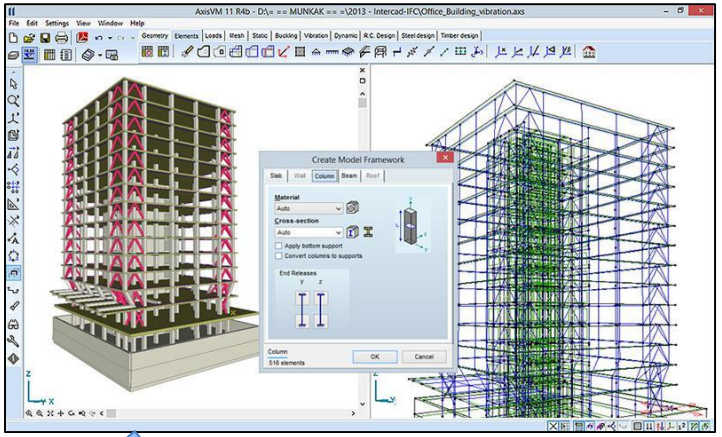
MOTIVATION

3D CityModels



BIM

?

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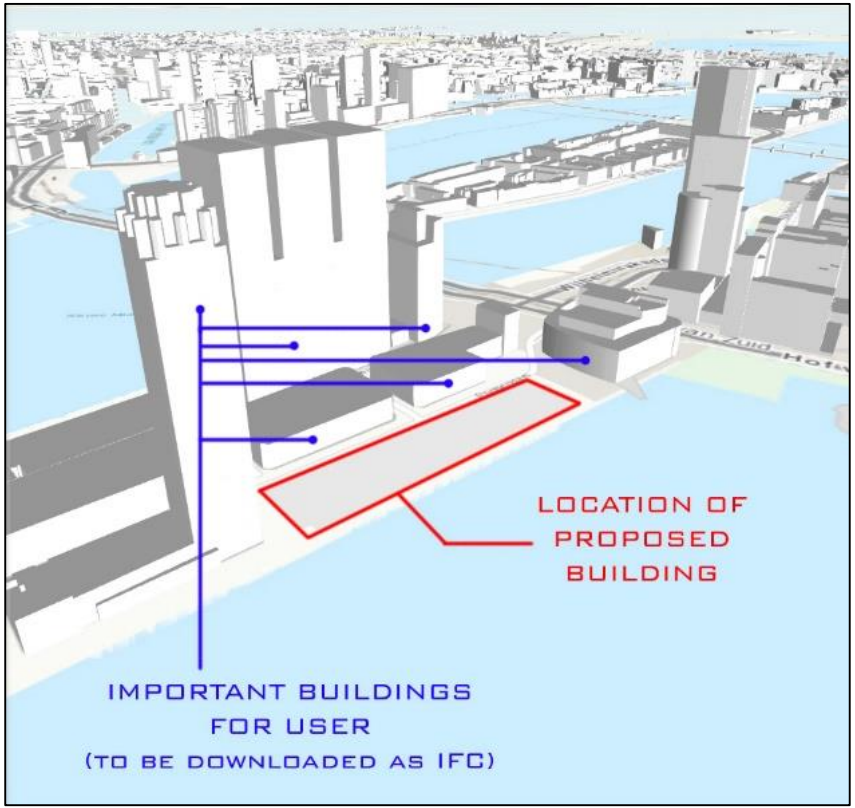
MOTIVATION



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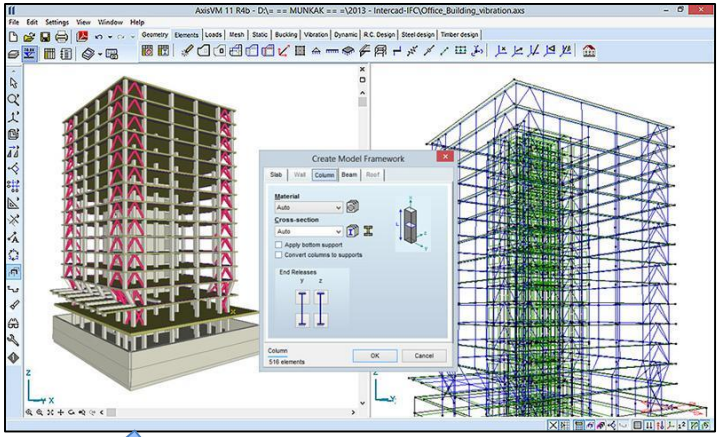
GOAL



CityGML

?

IFC2x3 CV2.0

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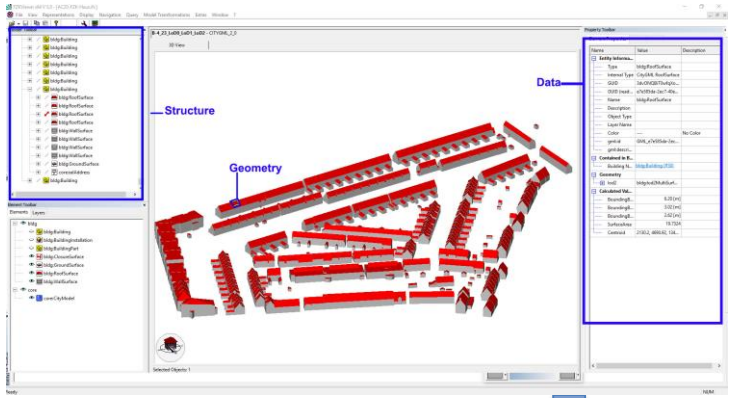
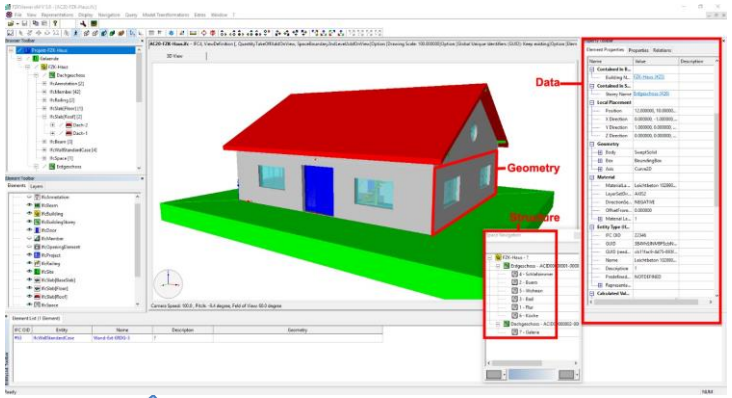
GOAL





CityGML

?

IFC2x3 CV2.0

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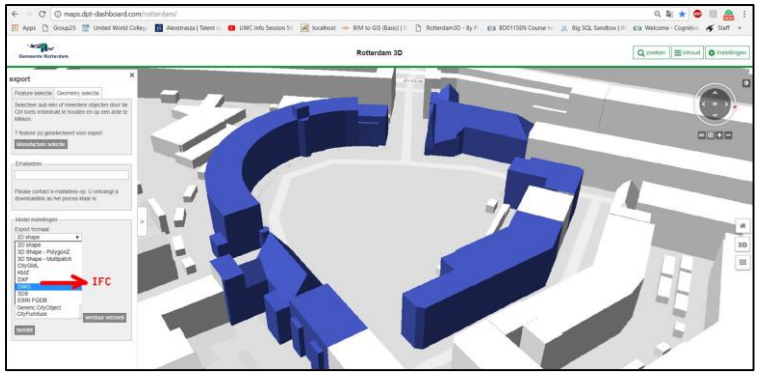
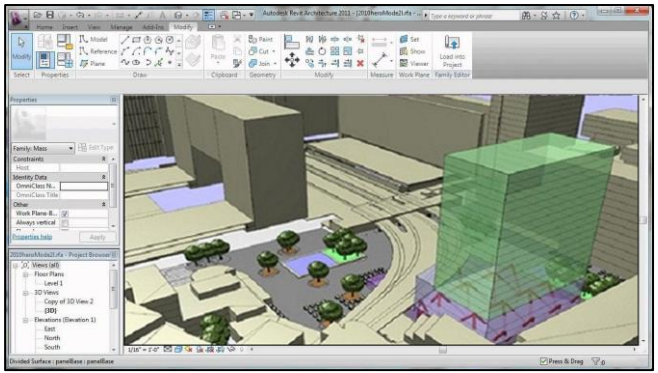
GOAL





CityGML

Export

IFC2x3 CV2.0

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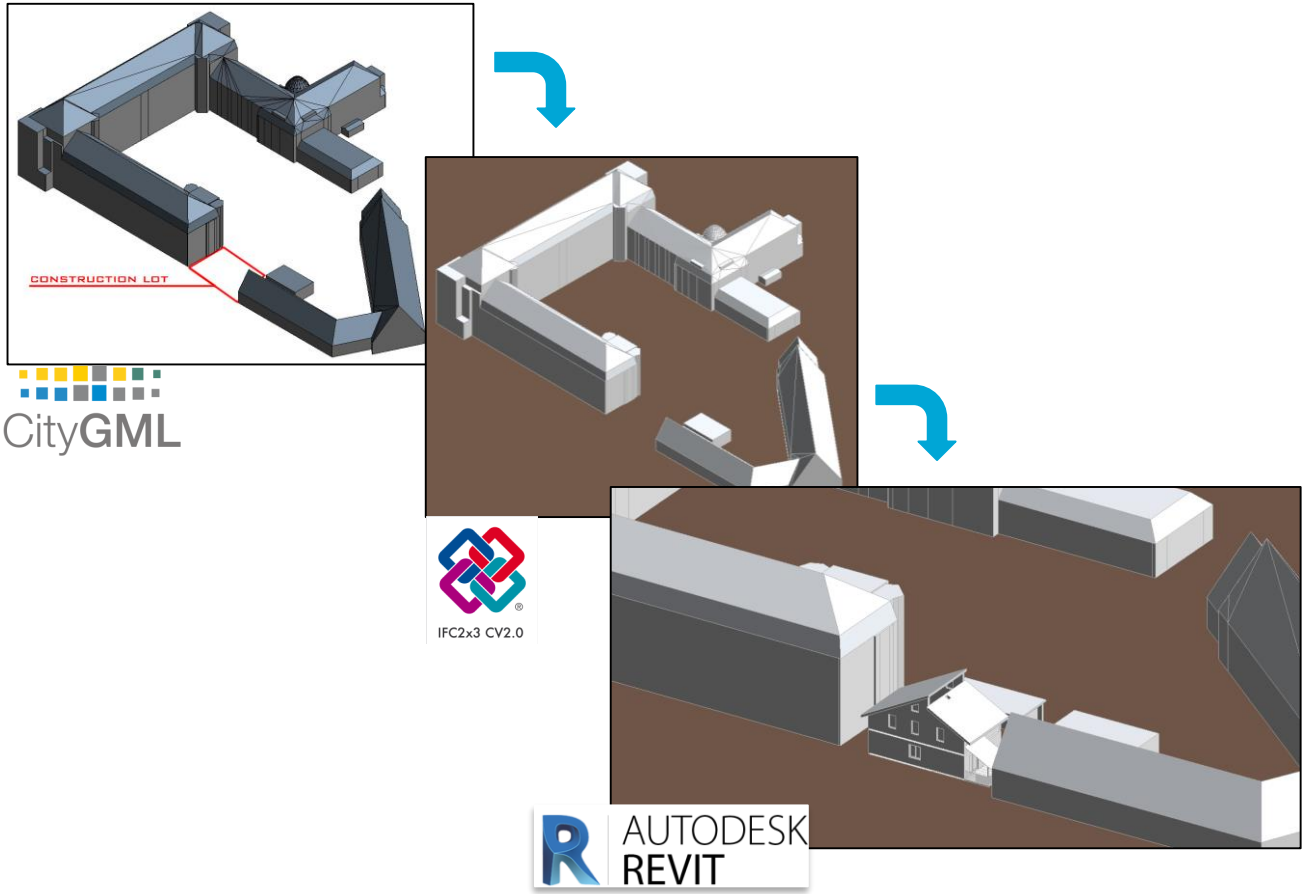
APPLICATIONS



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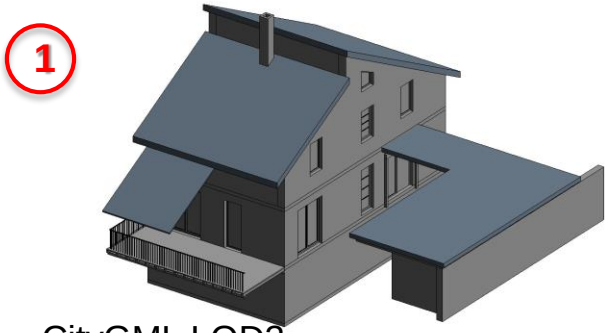
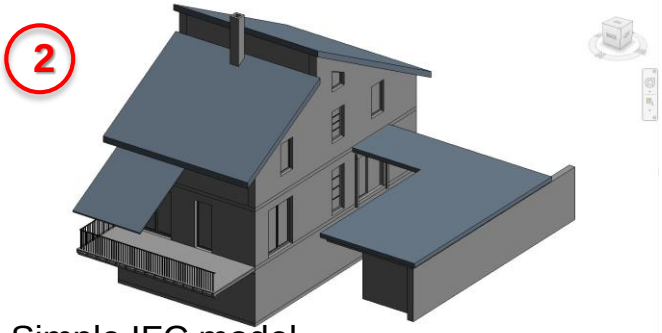
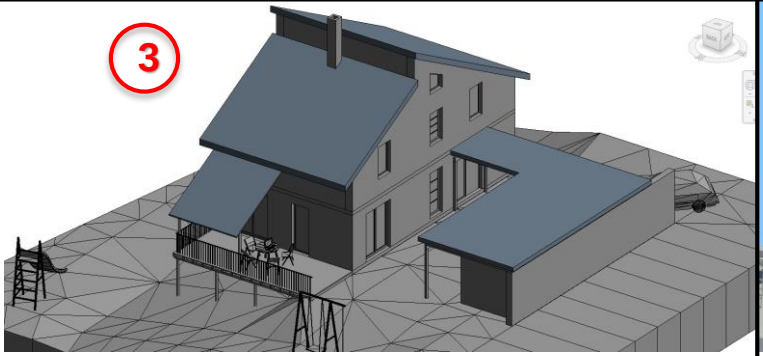
POSSIBLE APPLICATIONS



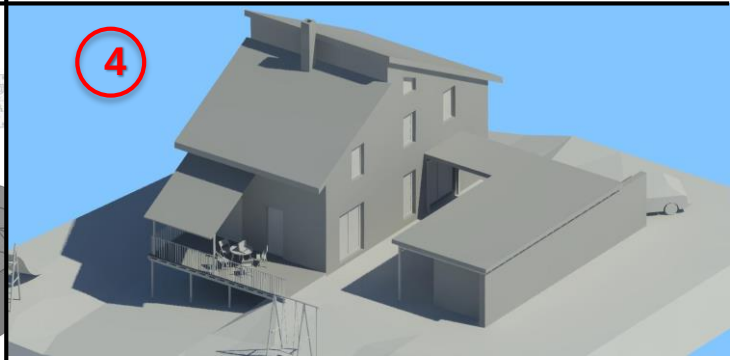
CityGML LOD3



Simple IFC model



Complete IFC model



Complete BIM model

Providing BIM models for buildings

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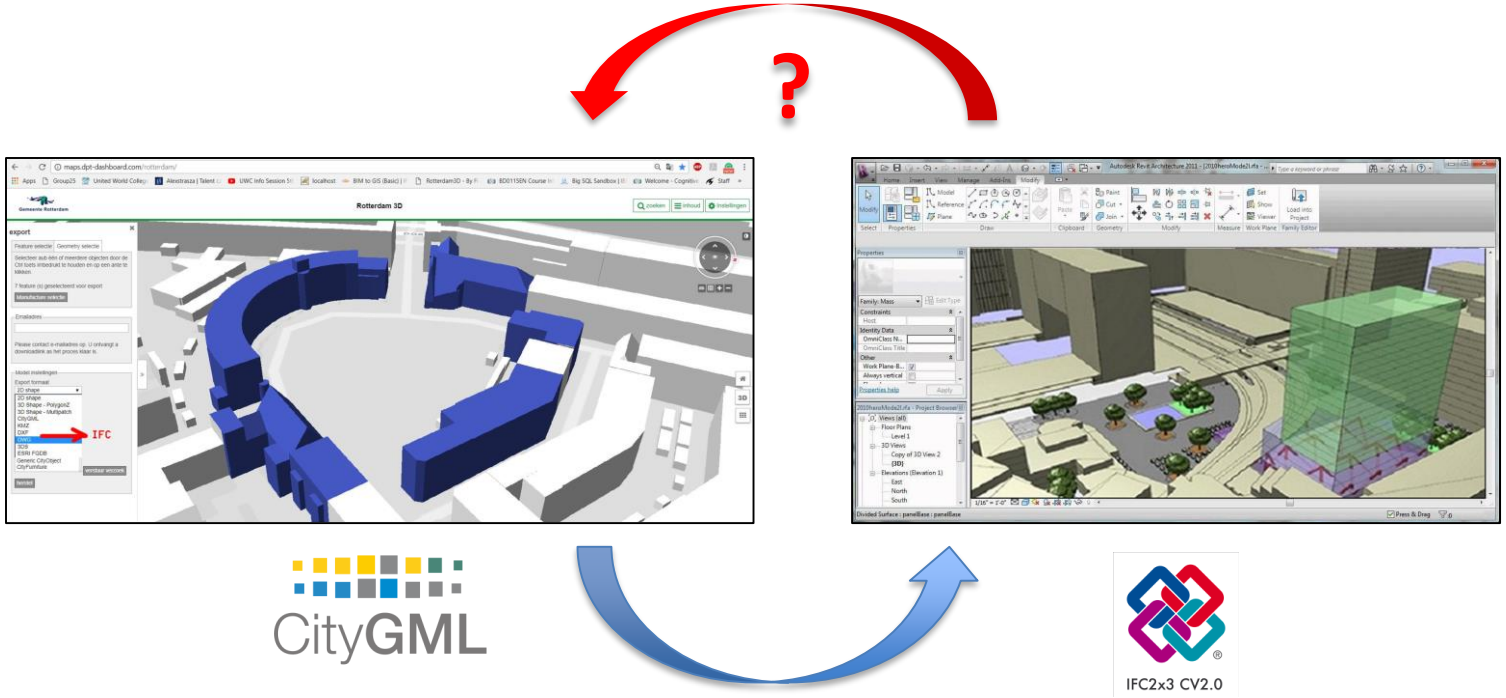
POSSIBLE APPLICATIONS



Reverse conversion from BIM to CityGML

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RESEARCH QUESTION

HOW TO MAKE 3D CITYMODELS ACCESSIBLE IN DESIGN & CONSTRUCTION SOFTWARE?

- *Requirements?*
- *Semantics?*
- *Geometry?*
- *Spatial referencing?*
- *Topology?*
- *Accessibility?*

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REQUIREMENTS

Semantics, Geometry, Coordinates, Topology, Encoding.

1. *Compare*

2. *Convert*

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REQUIREMENTS SEMANTICS

Semantics, Geometry, Coordinates, Topology, Encoding.

CityGML

Google Earth

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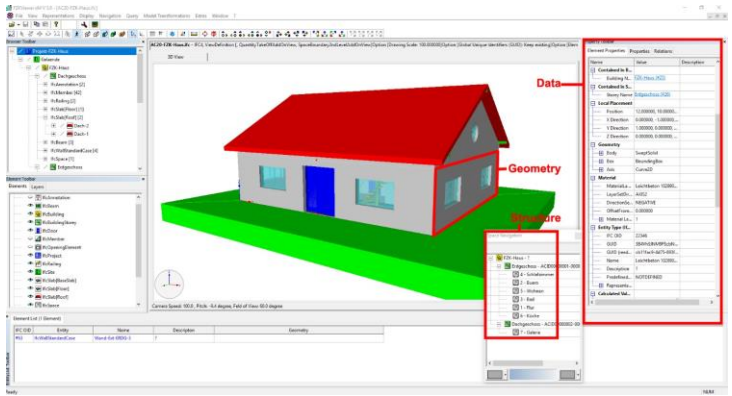
REQUIREMENTS SEMANTICS

Semantics, Geometry, Coordinates, Topology, Encoding.

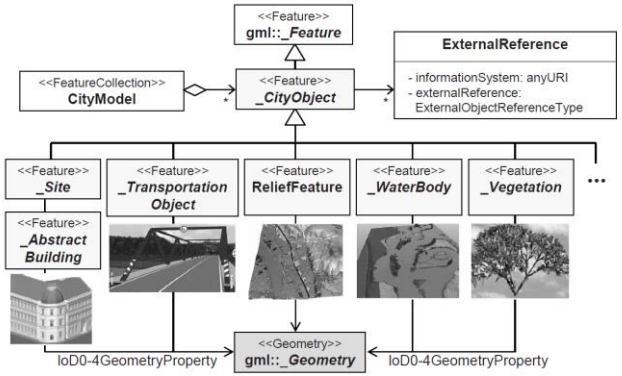
CityGML



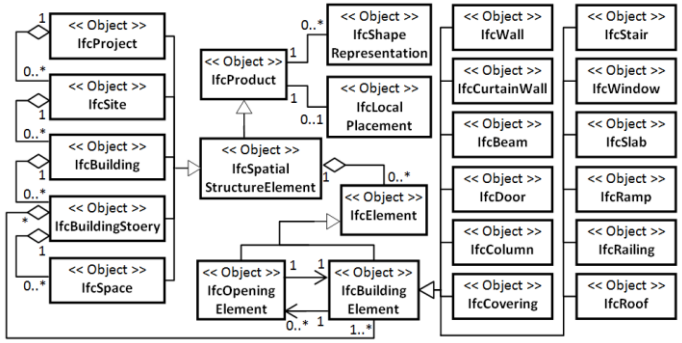
IFC2x3 CV2.0

REQUIREMENTS SEMANTICS

Semantics, Geometry, Coordinates, Topology, Encoding.



CityGML



IFC2x3 CV2.0

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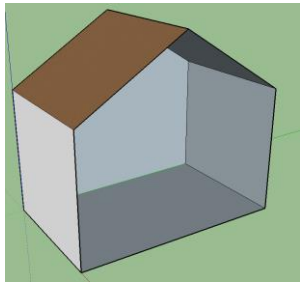
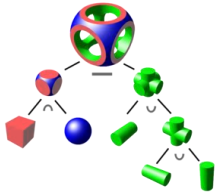
REQUIREMENTS GEOMETRY

Semantics, **Geometry**, Coordinates, Topology, Encoding.

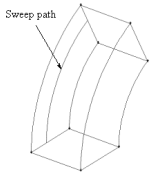
2D Face



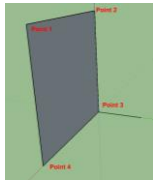
CityGML



CSG



SweptSolid



2D Face

IFC2x3 CV2.0

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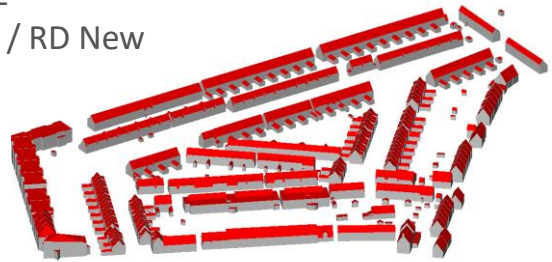
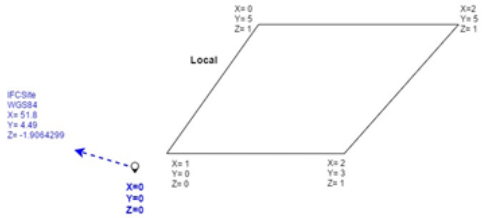
REQUIREMENTS COORDINATES

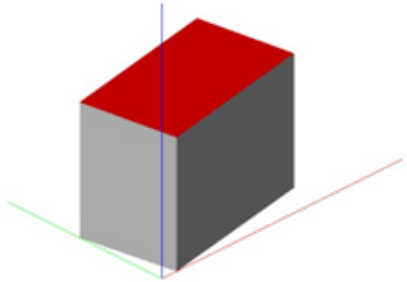
Semantics, Geometry, **Coordinates**, Topology, Encoding.

EPSG:28992
Amersfoort / RD New



CityGML





IFC2x3 CV2.0

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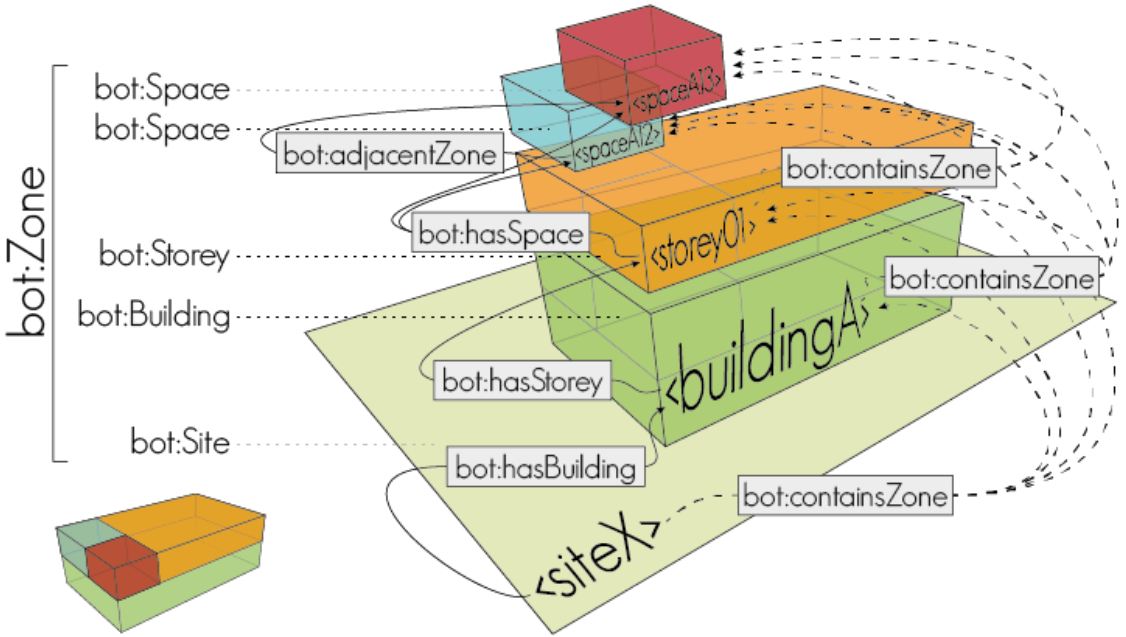
REQUIREMENTS TOPOLOGY

Semantics, Geometry, Coordinates, **Topology**, Encoding.



Source: ("Building Topology Ontology," 2019)

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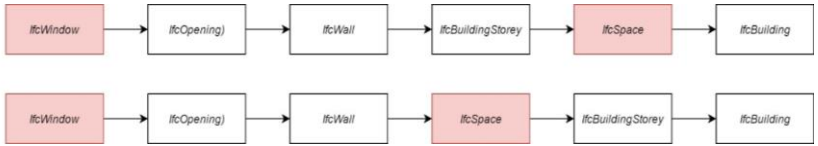
CityGML



IFC2x3 CV2.0

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REQUIREMENTS ENCODING

Semantics, Geometry, Coordinates, Topology, **Encoding**.

```
<gml:surfaceMember>
  <gml:Polygon gml:id="RCID_48dca1c6-42da-4372-8cb3-d843360f0e8d">
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        433789.030000000030000000 -1.082890000005110000 94779.960000000006000000 433786.510000000010000000
        -1.078269999999440100 94781.589999999997000000 433787.580000000020000000 -1.053760000000389900</gml:posList>
      </gml:LinearRing>
    </gml:exterior>
  </gml:Polygon>
</gml:surfaceMember>
<gml:surfaceMember>
```

CityGML

```
#1001  = IFCSITE ( '2bff34a3f1794bfb8f9906' , #102, 'Rotterdam', 'Description of Default
Site Rotterdam', 'LandUse', $, $, $, .ELEMENT., (4.512861440132937, 51.890110757113355,
13.254666879514) , (4.507494742156529, 51.88753047616053, -1.48868000000364) , $, $, $);
#1002  = IFCBUILDING ( 'b8c94e3a6c894311b7a421' , #102, 'bldg:Building', $, $, $, $, $,
$, $, $);
#1003  = IFCCARTESIANPOINT (( 343.8474259610084, 194.21844858600525, 10.56160203065271 ))
#1004  = IFCCARTESIANPOINT (( 338.82559265939926, 190.9169114730321, 10.56160203065271 ))
#1005  = IFCCARTESIANPOINT (( 341.070000000007, 187.48000000003958, 5.02410203065271 ));
#1006  = IFCCARTESIANPOINT (( 346.1000000000058, 190.77000000001863, 5.02410203065271 ));
#1007  = IFCCARTESIANPOINT (( 343.8474259610084, 194.21844858600525, 10.56160203065271 ))
#1008  = IFCPOLYLOOP (( #1003,#1004,#1005,#1006,#1007 ));
#1009  = IFCFACEOUTERBOUND ( #1008 , .T.);
#1010  = IFCFACE (( #1009 ));
#1011  = IFCOPENSHELL (( #1010 ));
#1012  = IFCSHELLBASEDSURFACEMODEL (( #1011 ));
#1013  = IFCSHAPEREPRESENTATION ($,'Body','SurfaceModel',( #1012 ));
#1014  = IFCPRODUCTDEFINITIONSHAPE ($, $, ( #1013 ));
#1015  = IFCSLAB ( 'fb6e546348854cac81718d' , $,'RoofSlab',' ',$,$, #1014 ,$,.ROOF.);
```

IFC2x3 CV2.0

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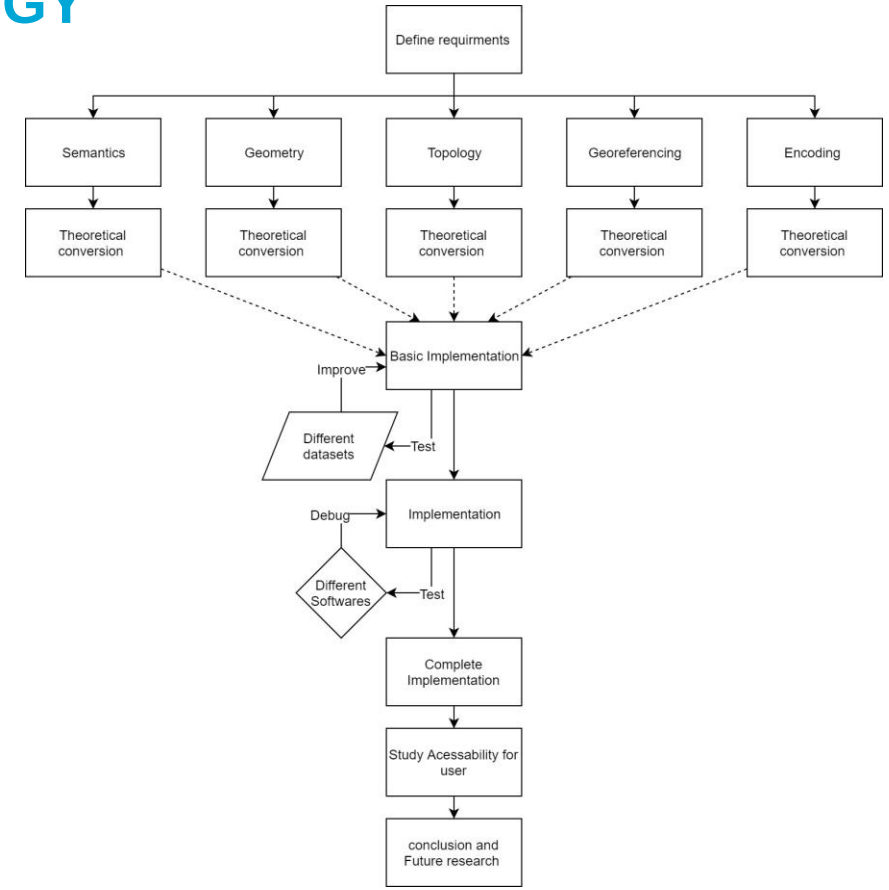
METHODOLOGY



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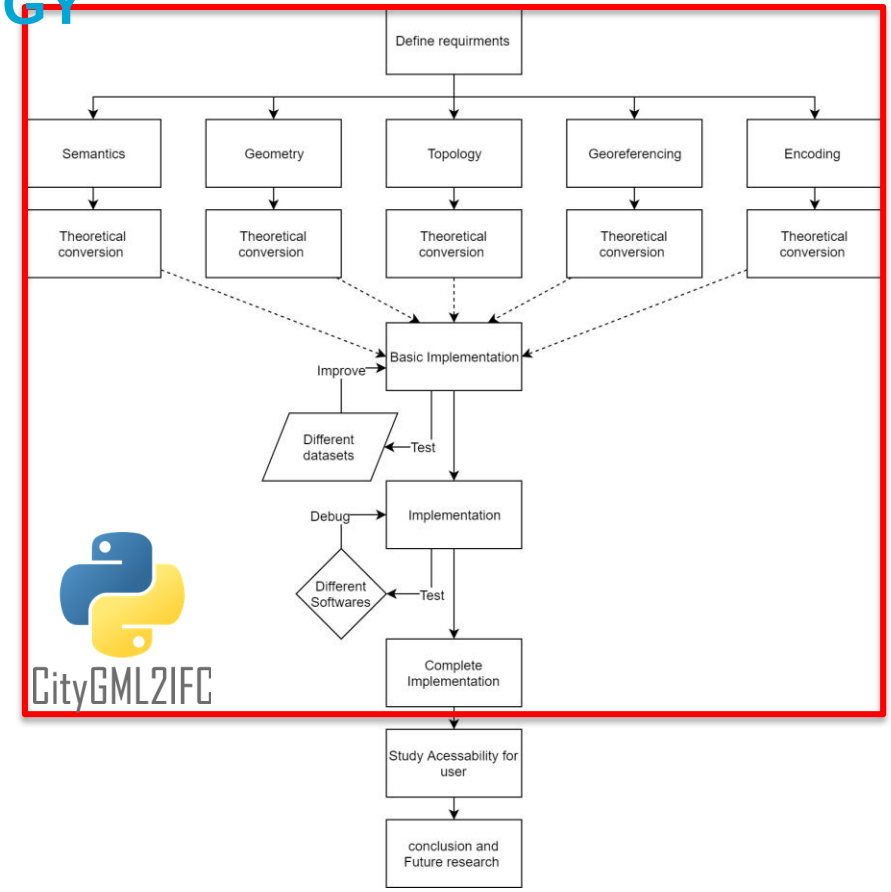
METHODOLOGY



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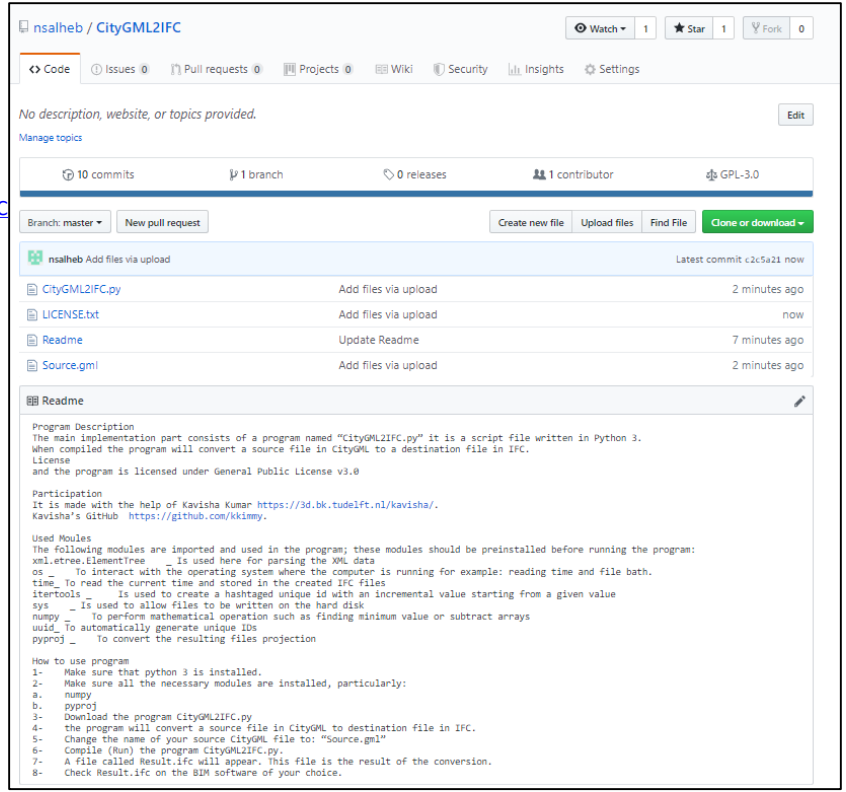
METHODOLOGY CITYGML2IFC

CityGML2IFC

https://github.com/nsalheb/CityGML2IFC



nsalheb / CityGML2IFC

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10 commits | 1 branch | 0 releases | 1 contributor | GPL-3.0

Branch: master | New pull request | Create new file | Upload files | Find File | Clone or download

nsalheb Add files via upload — Latest commit c2c5a21 now

CityGML2IFC.py	Add files via upload	2 minutes ago
LICENSE.txt	Add files via upload	now
Readme	Update Readme	7 minutes ago
Source.gml	Add files via upload	2 minutes ago

Readme

```
Program Description
The main implementation part consists of a program named "CityGML2IFC.py" it is a script file written in Python 3.
When compiled the program will convert a source file in CityGML to a destination file in IFC.
License
and the program is licensed under General Public License v3.0

Participation
It is made with the help of Kavisha Kumar https://3d.bk.tudelft.nl/kavisha/.
Kavisha's GitHub  https://github.com/kkimmy.

Used Moules
The following modules are imported and used in the program; these modules should be preinstalled before running the program:
xml.etree.ElementTree     _ Is used here for parsing the XML data
os _     To interact with the operating system where the computer is running for example: reading time and file bath.
time_ To read the current time and stored in the created IFC files
itertools _      Is used to create a hashtaged unique id with an incremental value starting from a given value
sys     _ Is used to allow files to be written on the hard disk
numpy _     To perform mathematical operation such as finding minimum value or subtract arrays
uuid_ To automatically generate unique IDs
pyproj _     To convert the resulting files projection

How to use program
1-    Make sure that python 3 is installed.
2-    Make sure all the necessary modules are installed, particularly:
a.    numpy
b.    pyproj
3-    Download the program CityGML2IFC.py
4-    the program will convert a source file in CityGML to destination file in IFC.
5-    Change the name of your source CityGML file to: "Source.gml"
6-    Compile (Run) the program CityGML2IFC.py.
7-    A file called Result.ifc will appear. This file is the result of the conversion.
8-    Check Result.ifc on the BIM software of your choice.
```

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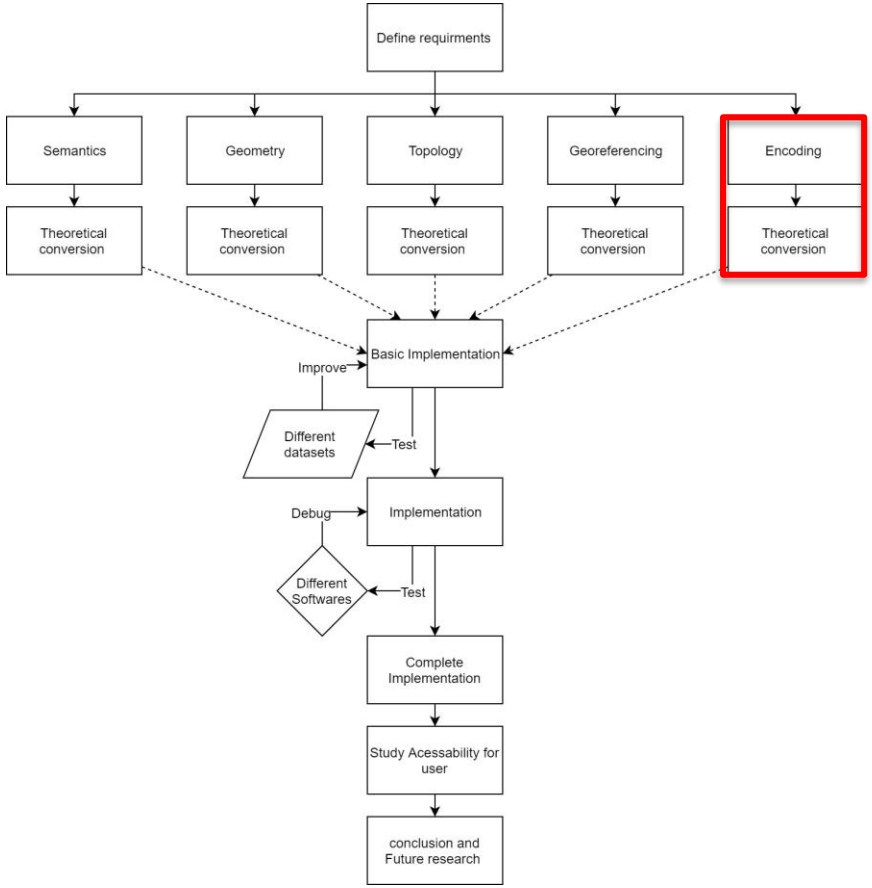
METHODOLOGY; ENCODING



METHODOLOGY; ENCODING

CityGML

IFC2x3 CV2.0

```
</bldg:Building>
        <bldg:boundedBy>
                <bldg:RoofSurface gml:id="08c133f1-e261-42e9-a962-2f028bf65c06">
                        <bldg:lod2MultiSurface>
                                <gml:MultiSurface srsName="EPSG:25833" srsDimension="3">
                                        <gml:surfaceMember>
                                                <gml:Polygon>
                                                        <gml:exterior>
                                                                <gml:LinearRing>
                                                                        <gml:posList>
-232826.945693134 5800258.80886523 9.574721626 -232825.395382719 5800250.33867422
9.574721626 -232819.31902886 5800251.44689201 9.574721626 -232820.85939135
5800259.91585694 9.574721626 -232826.945693134 5800258.80886523
9.574721626</gml:posList>
                                                                </gml:LinearRing>
                                                        </gml:exterior>
                                                </gml:Polygon>
                                        </gml:surfaceMember>
                                </gml:MultiSurface>
                        </bldg:lod2MultiSurface>
                </bldg:RoofSurface>
        </bldg:boundedBy>
</bldg:Building>
```

```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION(('ViewDefinition[CoordinationView_V2.0]'), '2;1');
FILE_NAME ( ' B-4_23_LoD0_LoD1_LoD2.gml ' , '2017-12-14T13:13:41' );
FILE_SCHEMA (('IFC2X3'));
ENDSEC;

DATA;
#101 = IFCORGANIZATION ($, 'MSC_Geomatics', 'TU_Delft', $, $);
#104 = IFCPERSON ($, 'Nebras_salheb', 'TU_Delft', $, $, $, $, $);
#103 = IFCPERSONANDORGANIZATION (#104, #101, $);
#105 = IFCAPPLICATION (#101, 'CityGML2IFC', 'CityGML2IFC', 'CityGML2IFC');
#102 = IFCOWNERHISTORY (#103, #105, .READWRITE., .NOCHANGE., $, $, 1528899117);
#109 = IFCCARTESIANPOINT ((0., 0., 0.));
#110 = IFCDIRECTION ((0., 0., 1.));
#111 = IFCDIRECTION ((1., 0., 0.));
#108 = IFCAXIS2PLACEMENT3D (#109, #110, #111);
#112 = IFCDIRECTION ((1., 0., 0.));
#107 = IFCGEOMETRICREPRESENTATIONCONTEXT ($, 'Model', 3, 1.E-005, #108, #112);
#114 = IFCSIUNIT (*, .LENGTHUNIT., $, .METRE.);
#113 = IFCUNITASSIGNMENT ((#114));
#115= IFCMATERIAL('K01-1');
#116= IFCMATERIAL('K01-2');
#117= IFCMATERIAL('K01-3');
#118= IFCMATERIAL('K01-4');
#119=IFCLOCALPLACEMENT($,#108);
 #1000  = IFCPROJECT ( '6073a79a6d58416cacb3db' , #102, 'core:CityModel', '', $, $, $, (#107), #113);
 #1001  = IFCSITE ( 'c08c4ca22cb3486e88a24b' , #102, 'Rotterdam', 'Description of Default Site
Rotterdam', 'LandUse', $, $, $, .ELEMENT., (4.512861440132937, 51.890110757113355,
13.254666879514) , (4.507494742156529, 51.88753047616053, -1.48868000000364) , $, $, $);
#1002  = IFCBUILDING ( '8d3be4110c5b4d7eb40455' , #102, 'bldg:Building', $, $, $, $, $, $, $, $);
#1003  = IFCCARTESIANPOINT (( 343.8474259610084, 194.21844858600525, 10.56160203065271 ));
#1004  = IFCCARTESIANPOINT (( 338.82559265939926, 190.9169114730321, 10.56160203065271 ));
#1005  = IFCCARTESIANPOINT (( 341.070000000007, 187.48000000003958, 5.02410203065271 ));
#1006  = IFCCARTESIANPOINT (( 346.1000000000058, 190.77000000001863, 5.02410203065271 ));
#1007  = IFCPOLYLOOP (( #1003,#1004,#1005,#1006 ));
#1008  = IFCFACEOUTERBOUND ( #1007 , .T.);
#1009  = IFCFACE (( #1008 ));
#1010  = IFCOPENSHELL (( #1009 ));
#1011  = IFCSHELLBASEDSURFACEMODEL (( #1010 ));
#1012  = IFCSHAPEREPRESENTATION ($,'Body','SurfaceModel',( #1011 ));
#1013  = IFCPRODUCTDEFINITIONSHAPE ($, $, ( #1012 ));
#1014  = IFCROOF ( '45b13a8fde104a58a6ffb8' , $,'RoofSlab',' ',$,$, #1013 ,$,.ROOF.);
```

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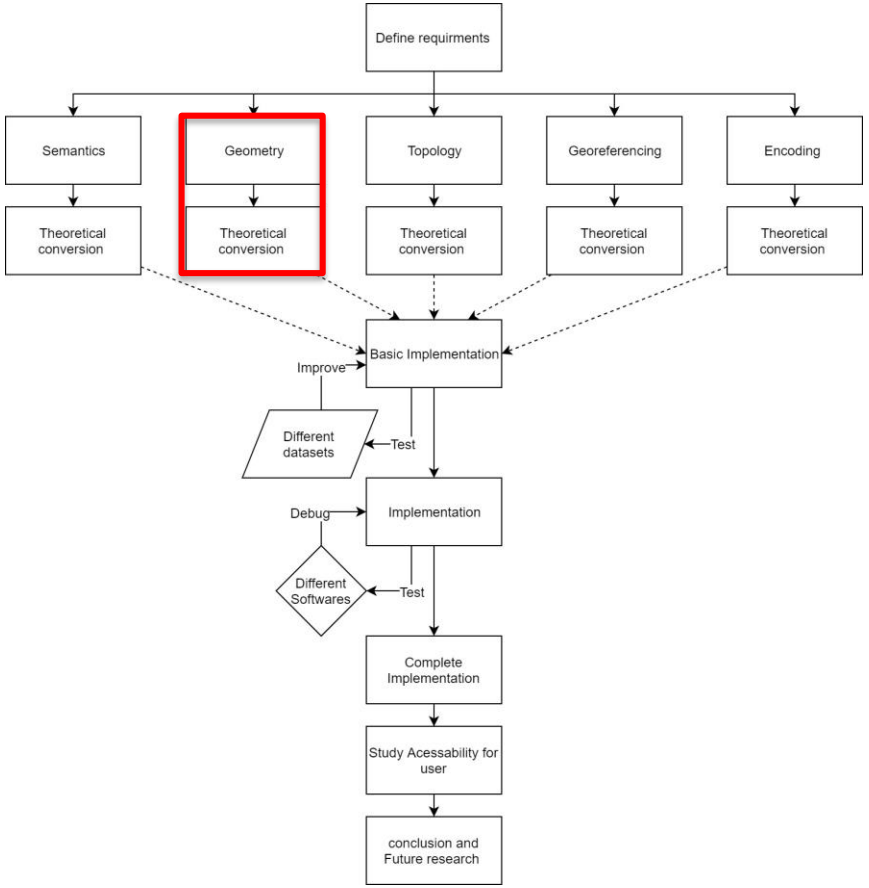

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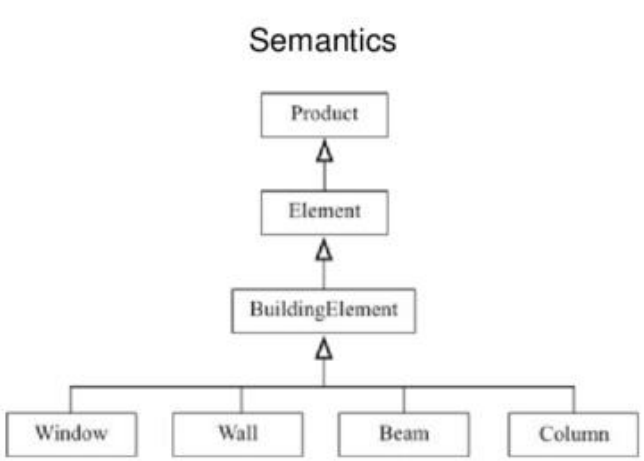

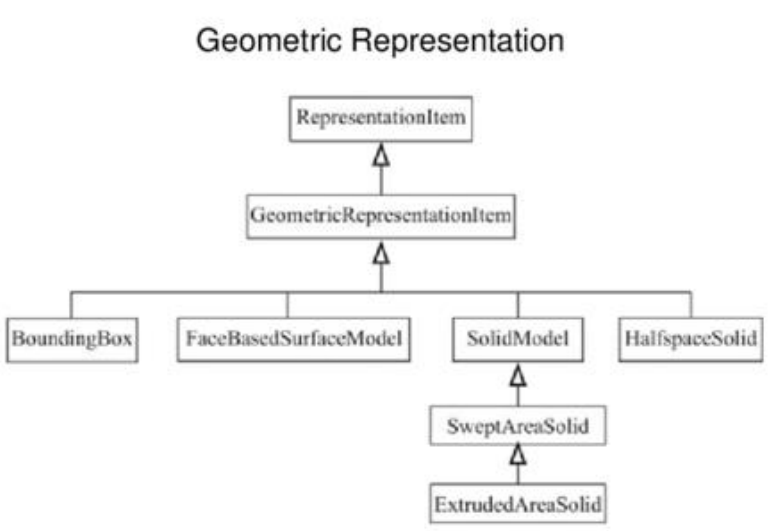

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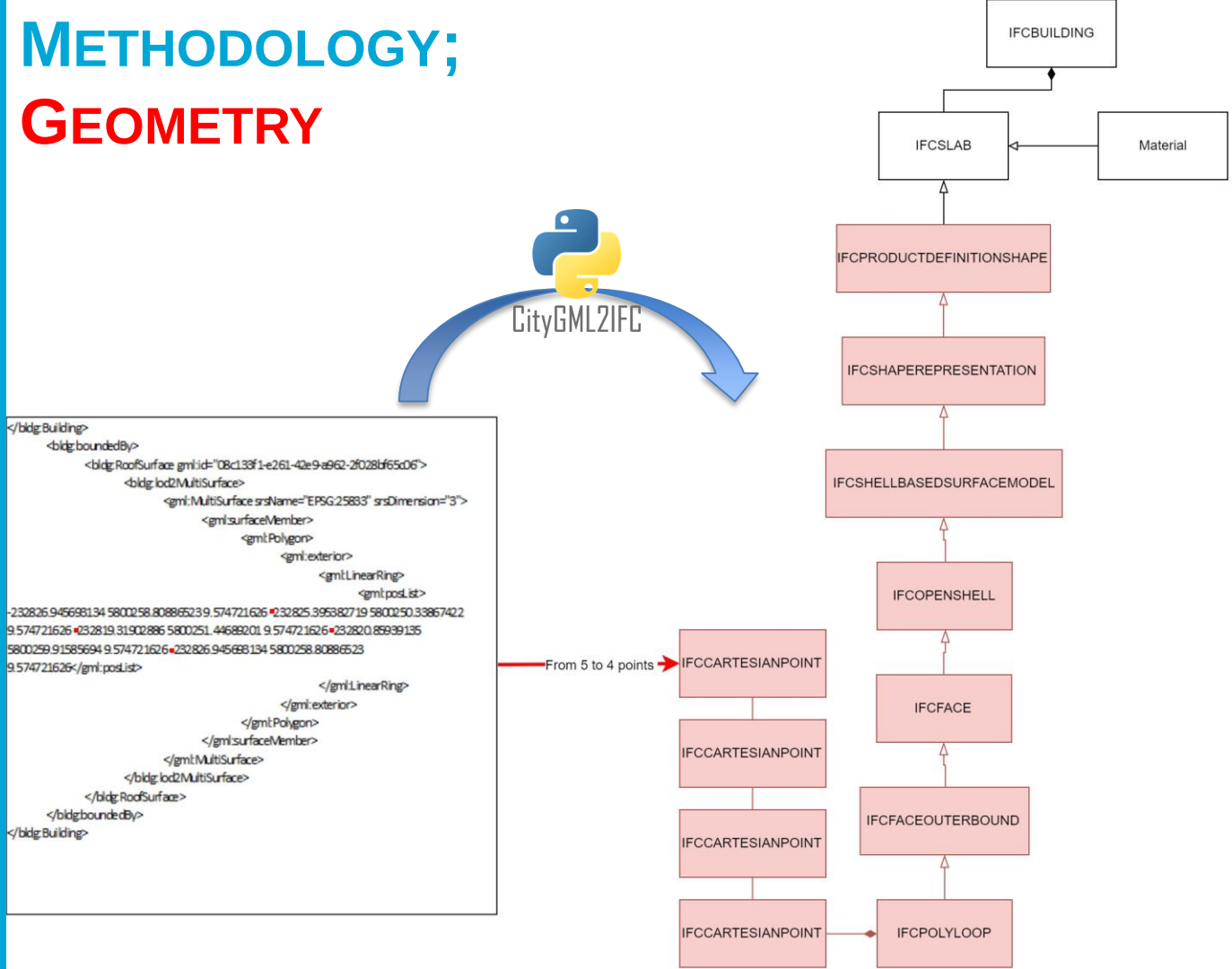

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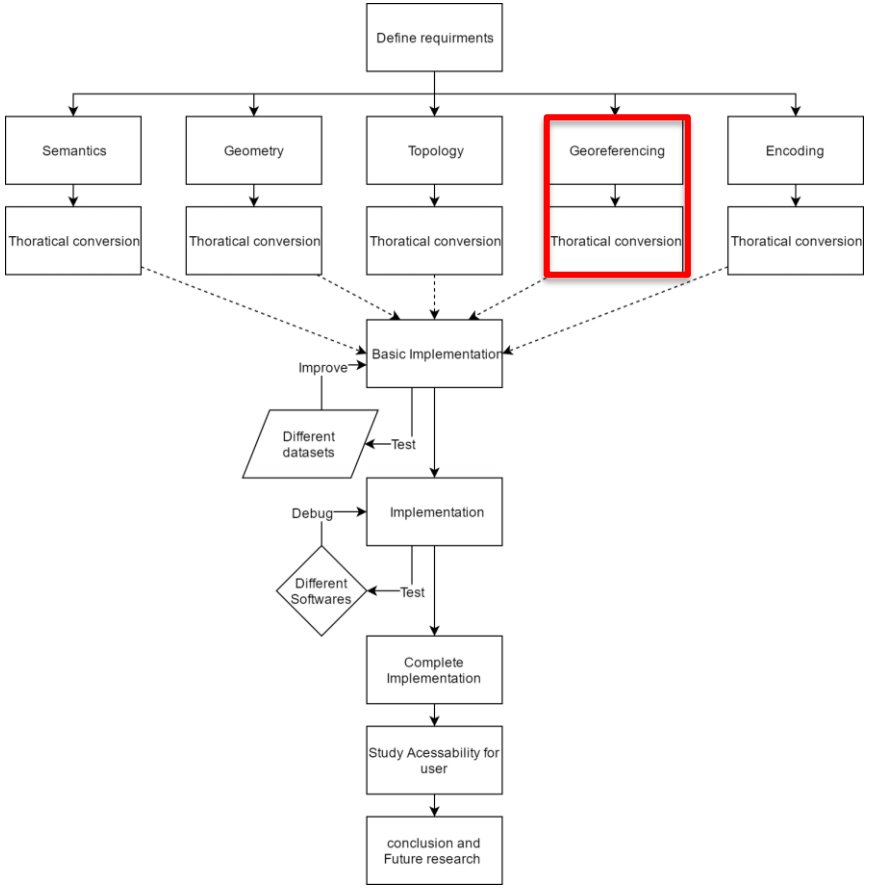
METHODOLOGY; COORDINATES



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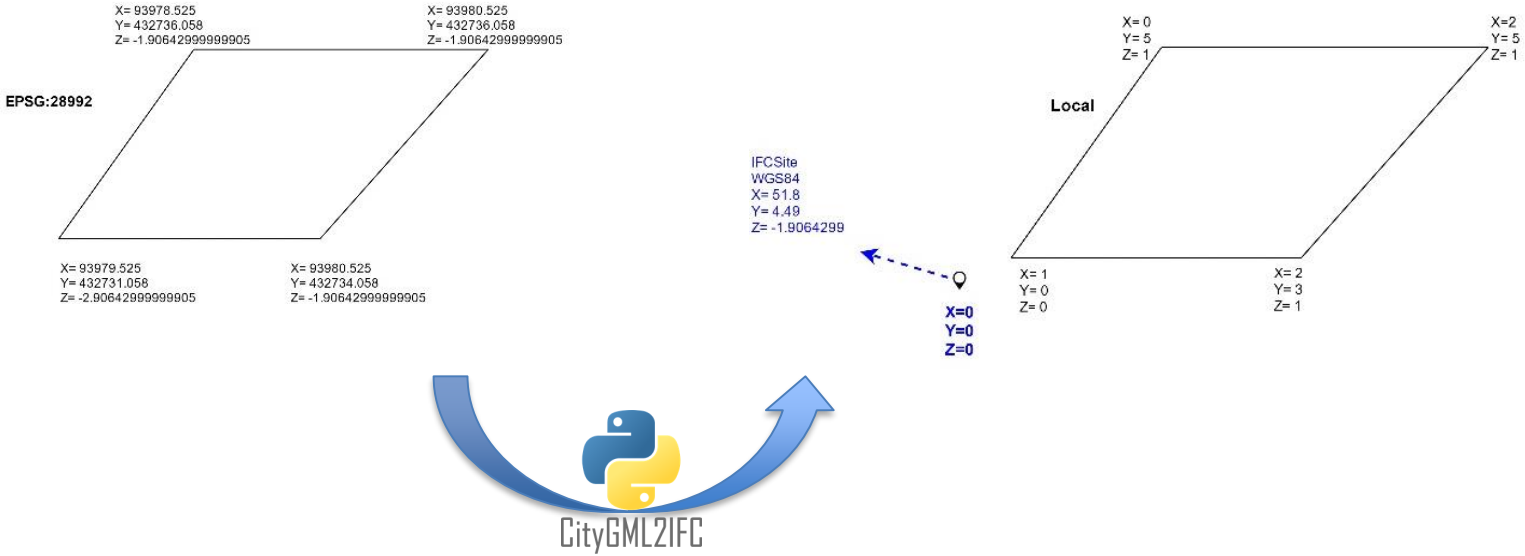

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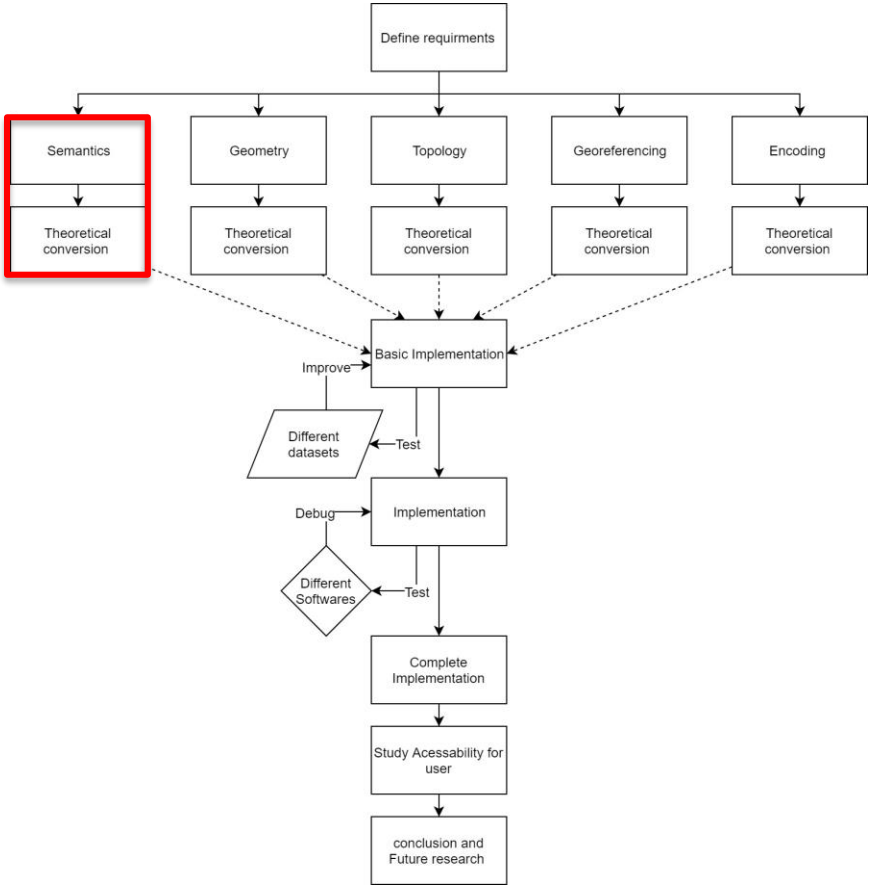

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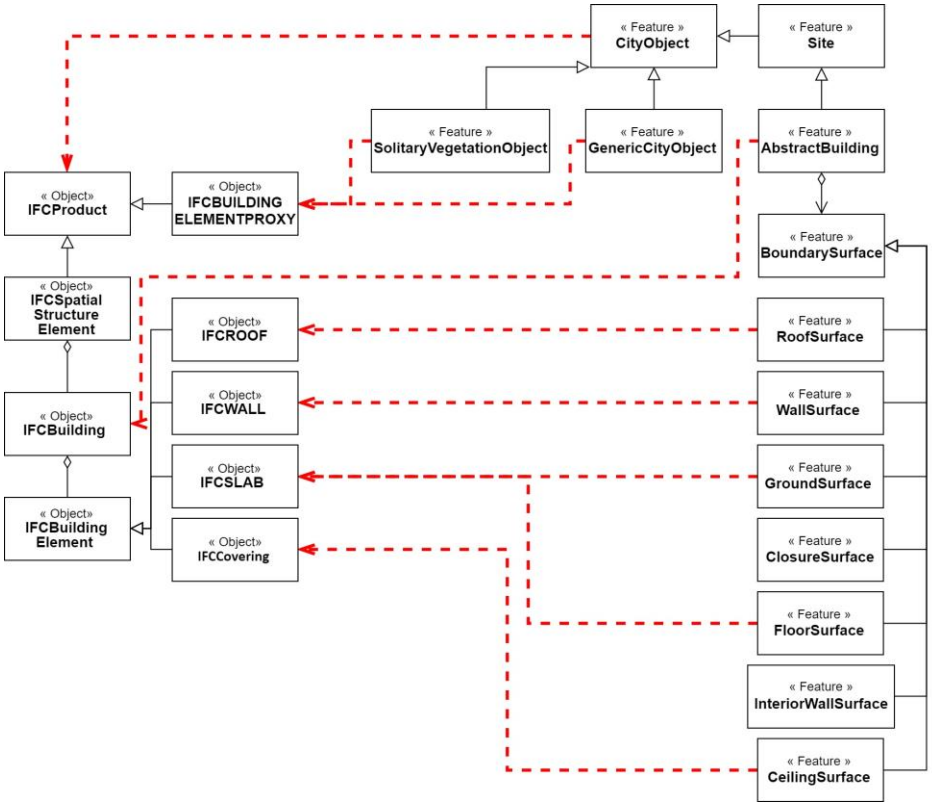

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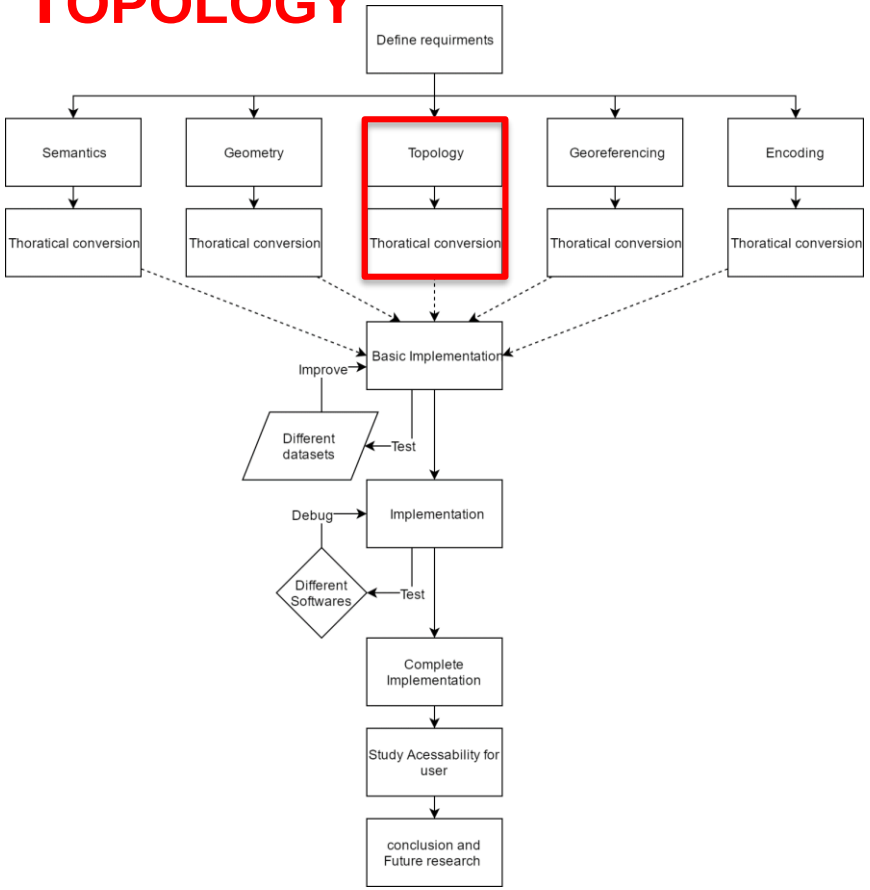

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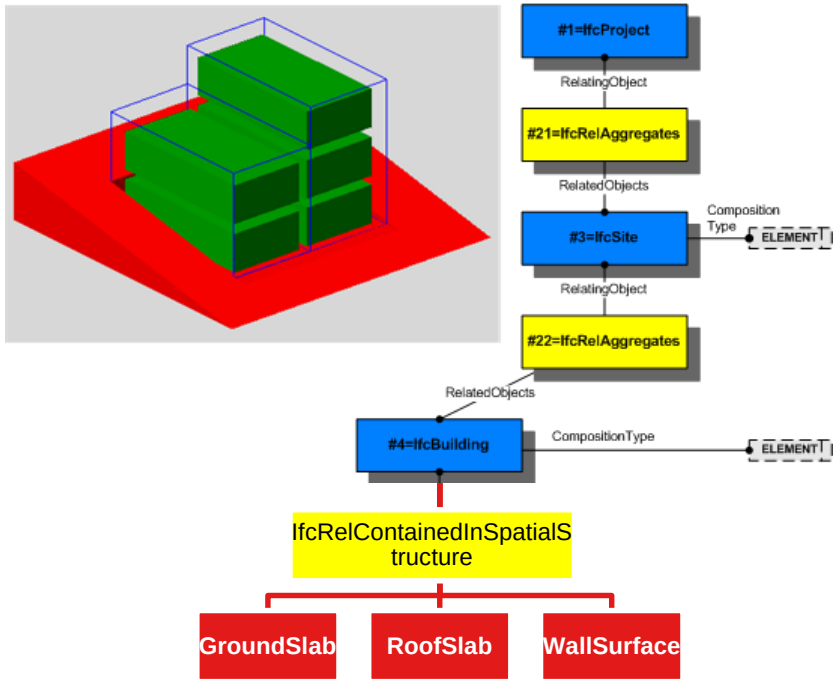

METHODOLOGY

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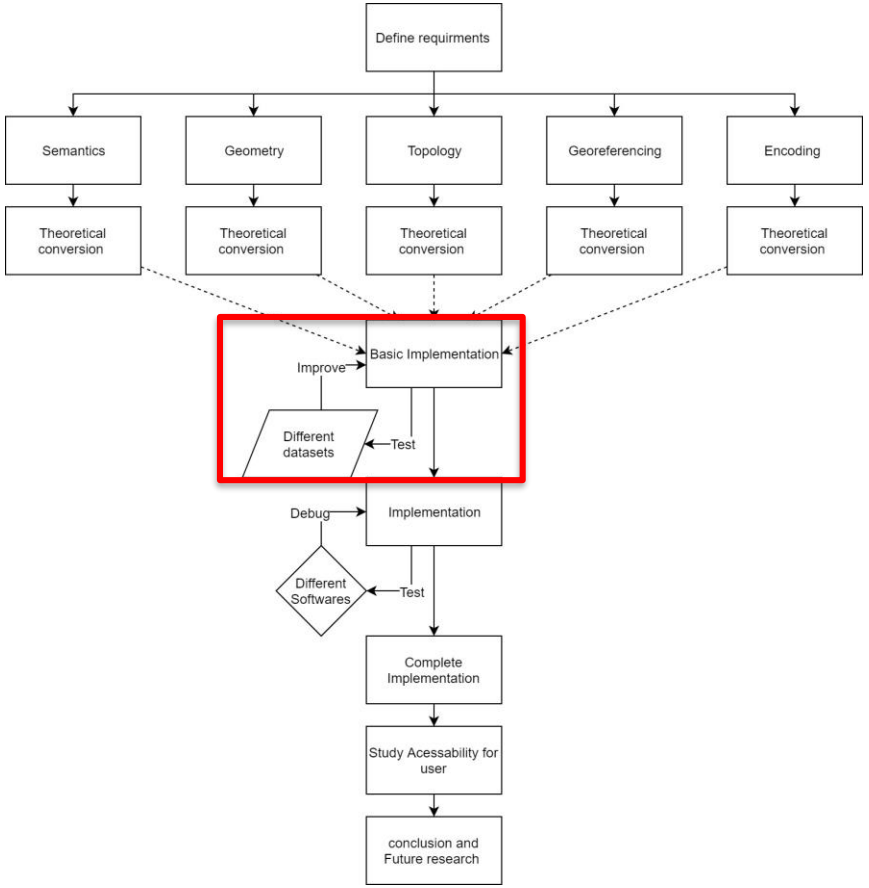

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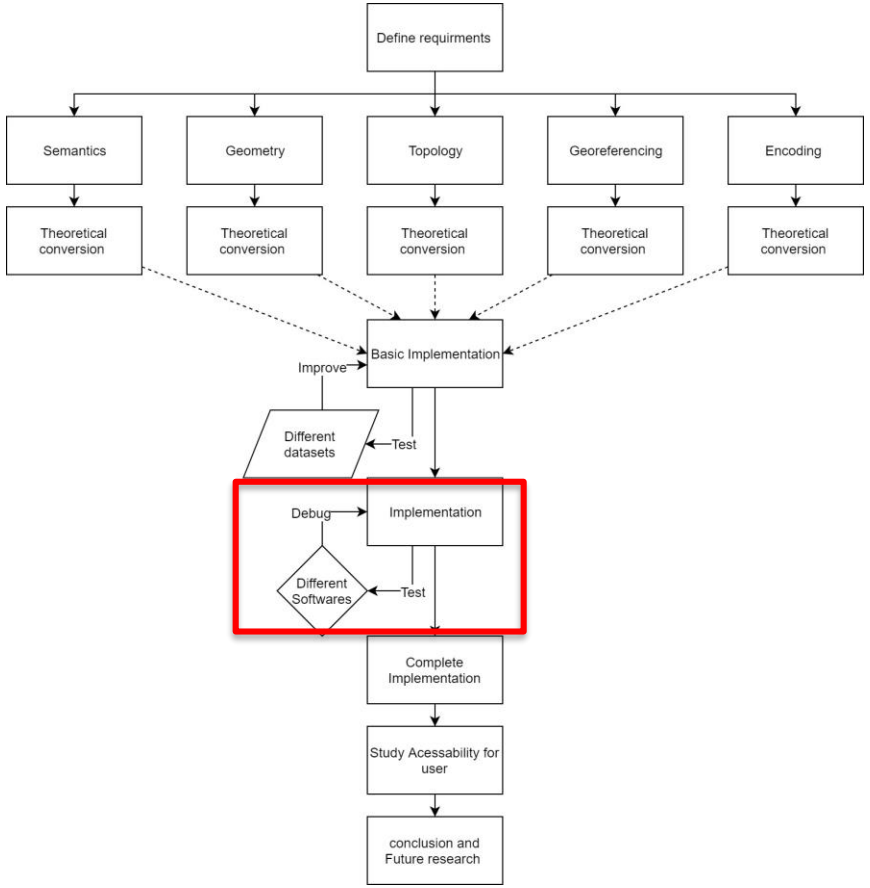
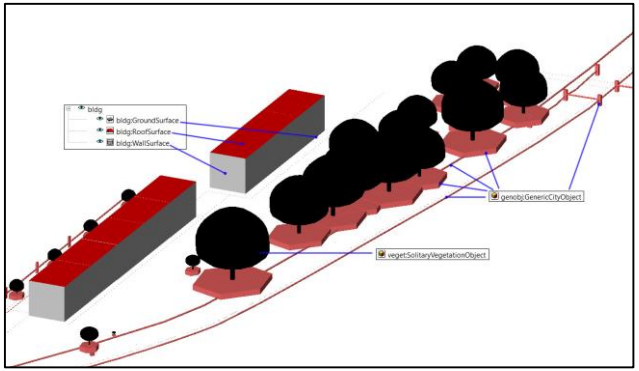


METHODOLOGY
VALIDATION (SOFTWARE)

KIT Karlsruher Institut für Technologie



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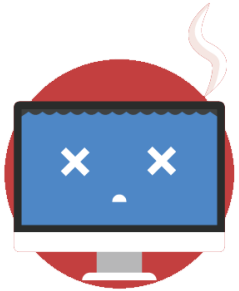
Areddo See what's BIM



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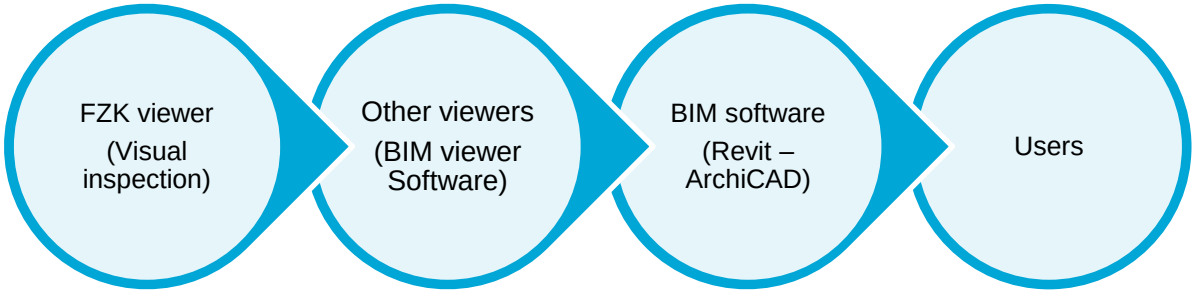

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Karlsruher Institut für Technologie

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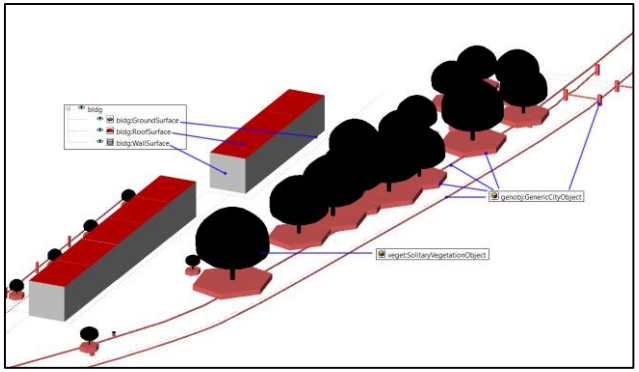
See what's BIM



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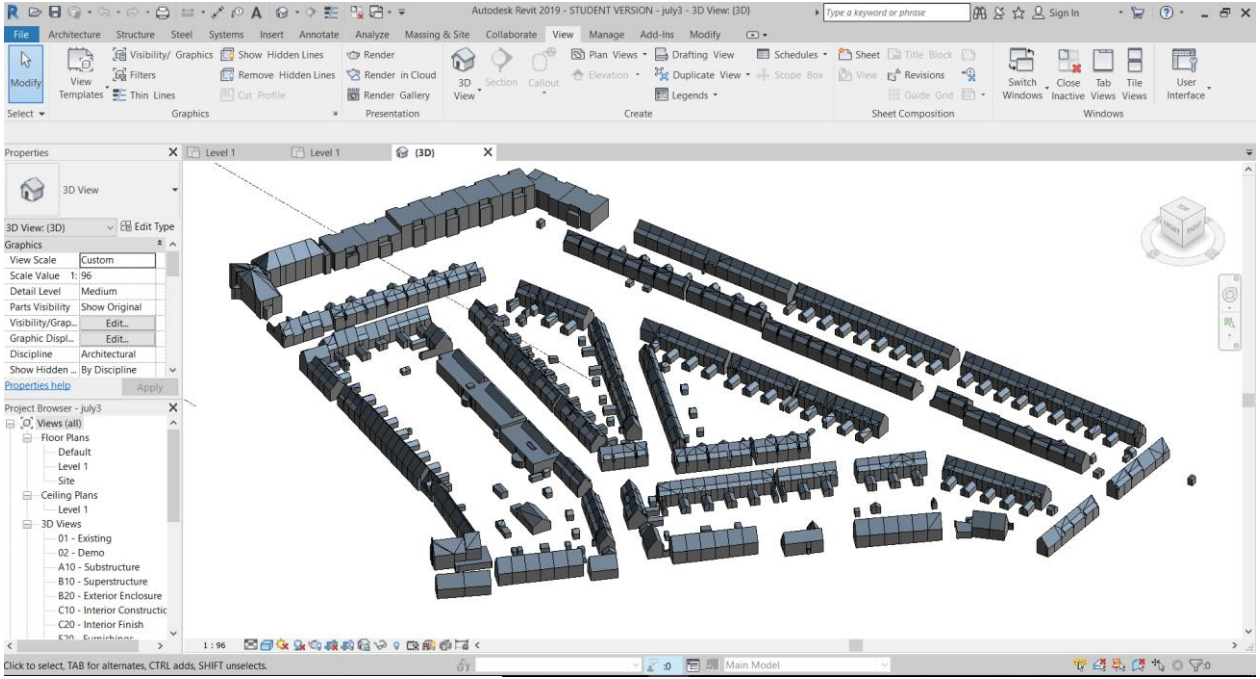

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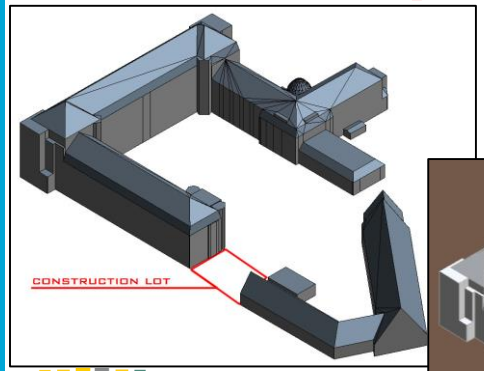
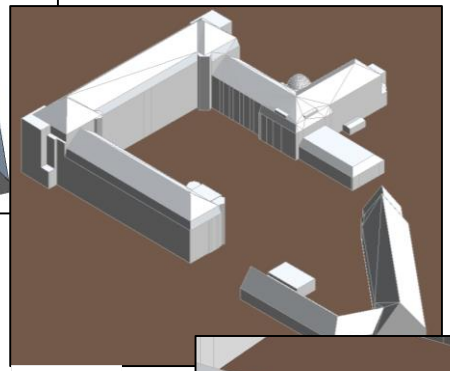
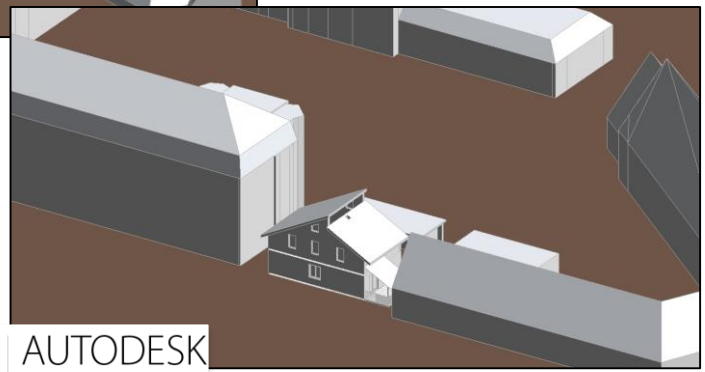


CityGML



IFC2x3 CV2.0



AUTODESK REVIT

METHODOLOGY
VALIDATION (USERS)

Question	Answer
Were you able to open the data?	100%
Data helpful?	80% Yes 20% Maybe
How can the data Help?	1- To exchange 3D-data between GIS and BIM. 2- Give a context to design & Visualization
How to improve?	1- More detailed information 2- Including terrain model 3- Metadata enrichment 4- when its defined as element can be used for structural and environmental simulations in BIM environment
Limitations ?	1- Base level of all buildings is the same 2- Not possible to edit the file after the transfer

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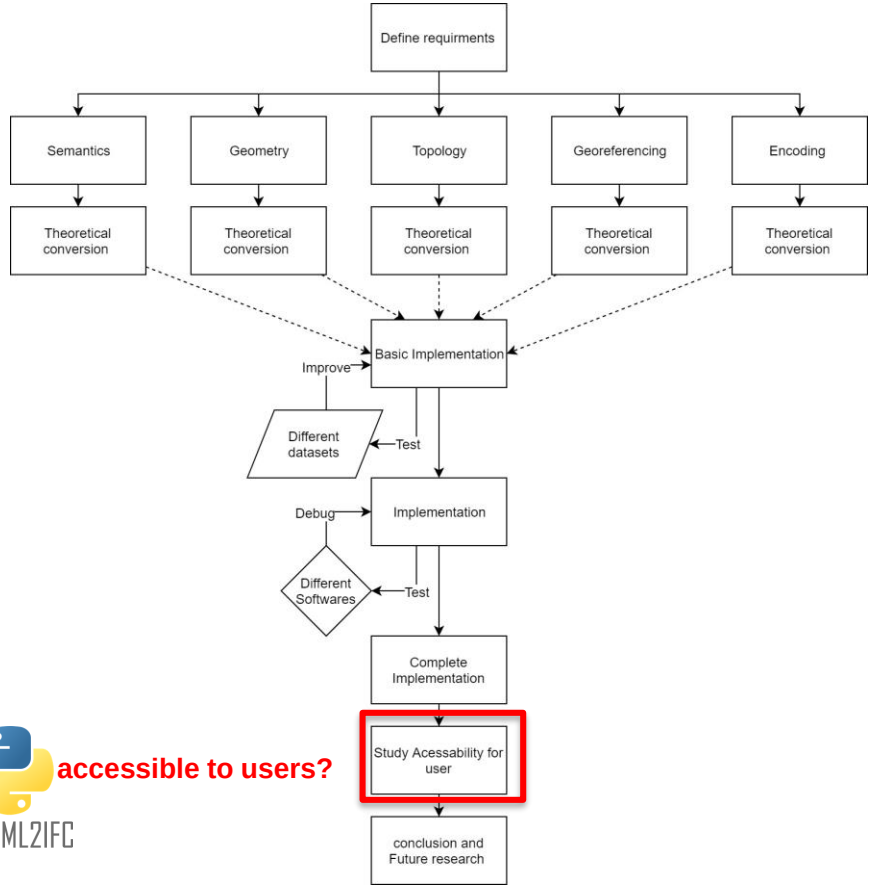
METHODOLOGY; ACCESSIBILITY



How to make CityGML2IFC **accessible to users?**

Motivation

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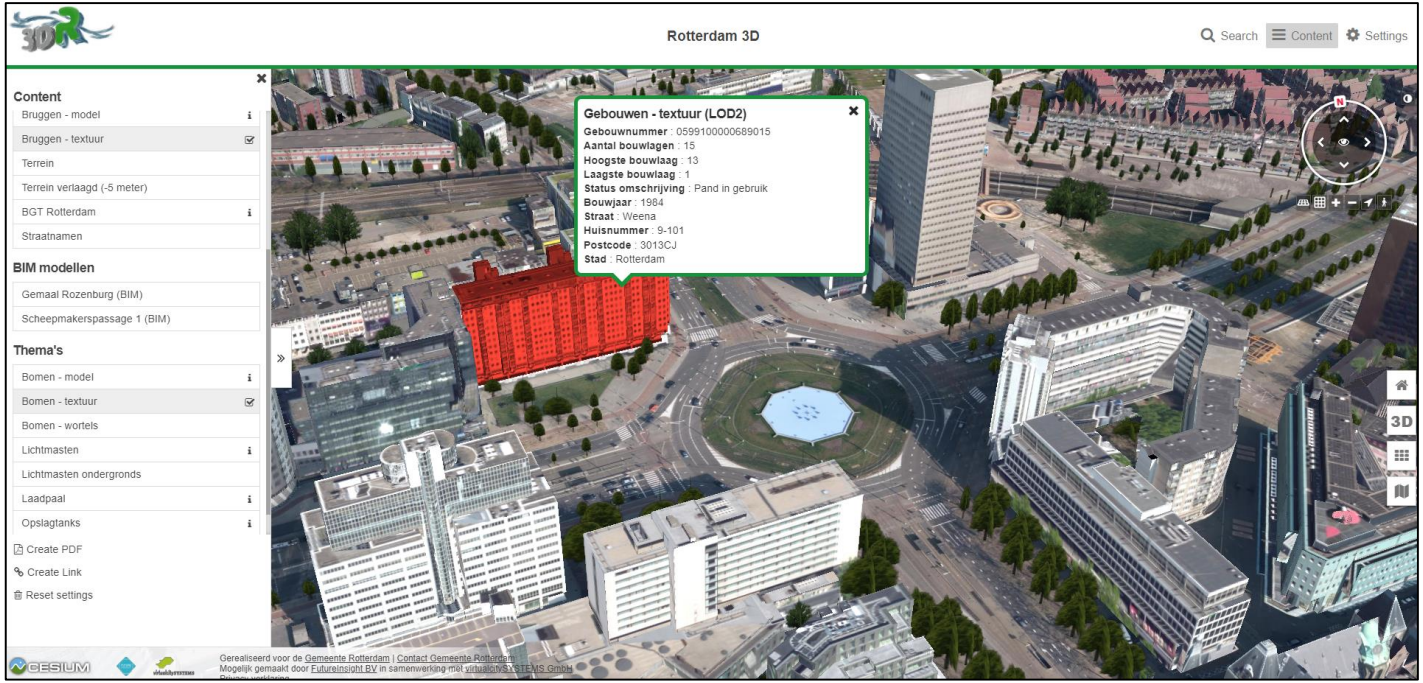
METHODOLOGY; ACCESSIBILITY



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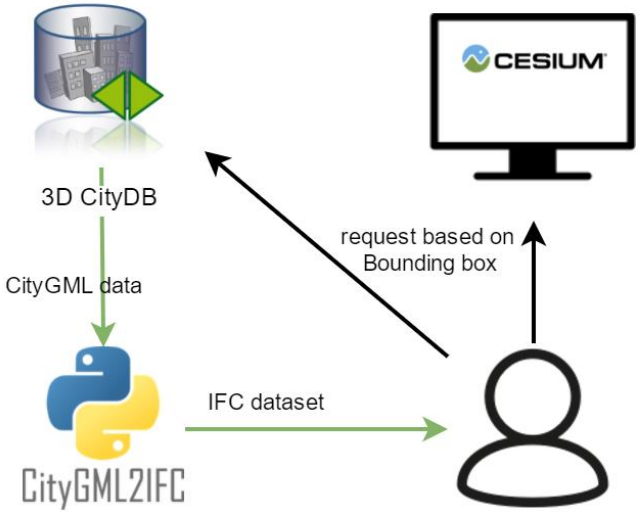

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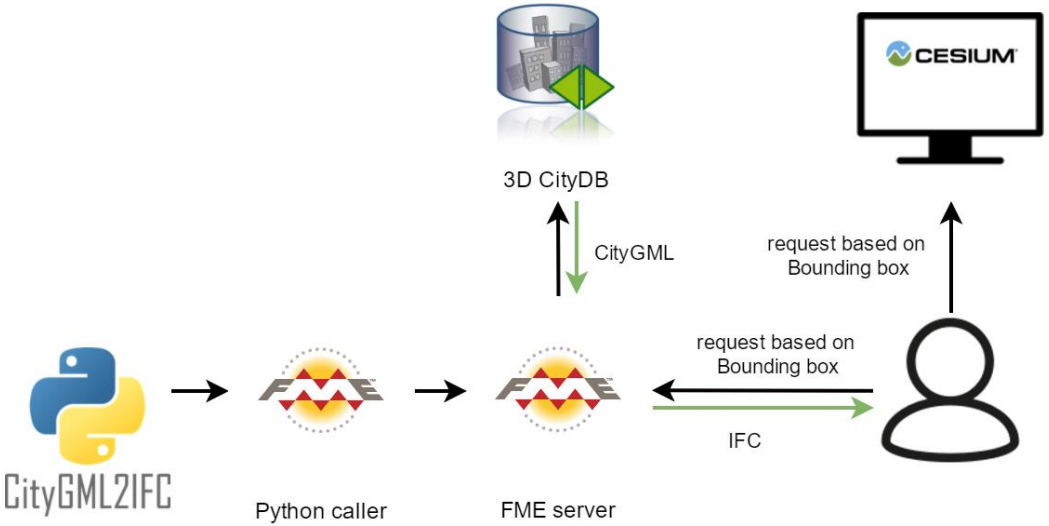

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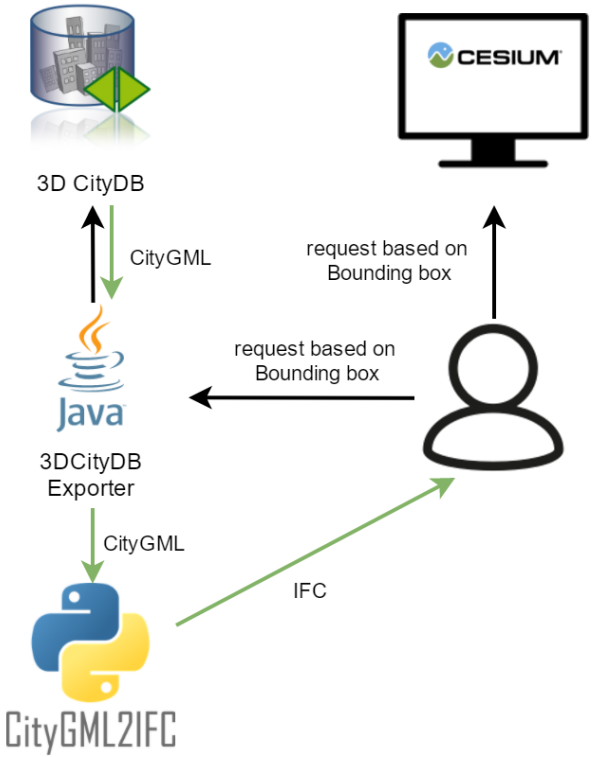

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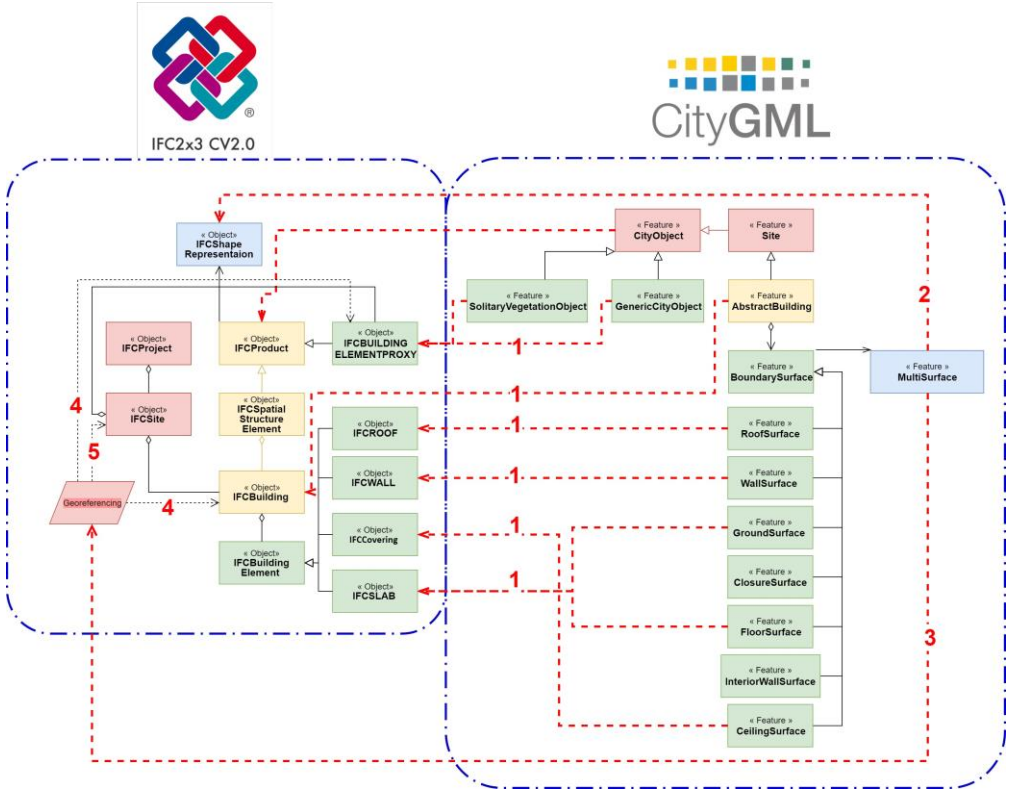
CONCLUSION

RESULTS

HOW TO MAKE 3D CITYMODELS ACCESSIBLE IN DESIGN & CONSTRUCTION SOFTWARE?



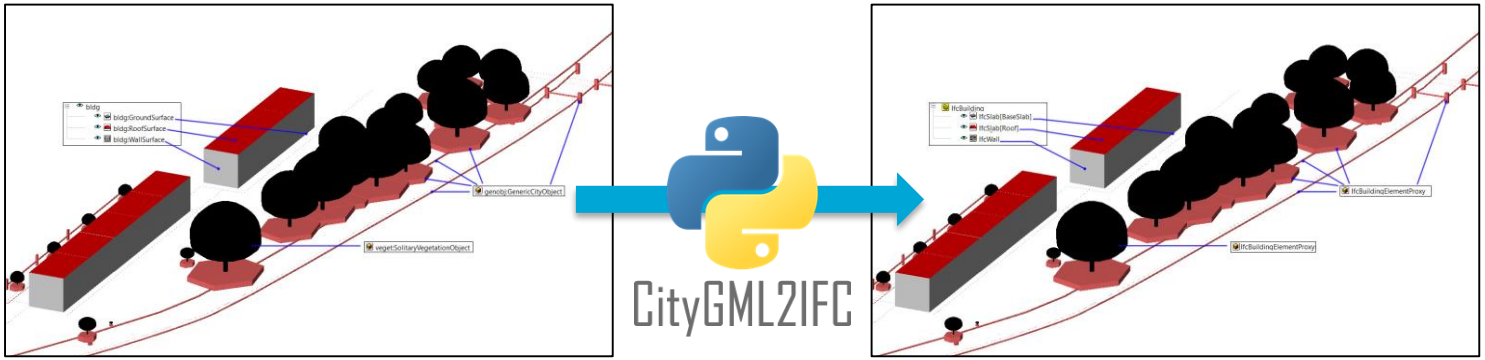
CONCLUSION

RESULTS

- An open conversion methodology to convert a complete CityGML to IFC. That can be further extended or implemented in different software.

CityGML

IFC2x3 CV2.0



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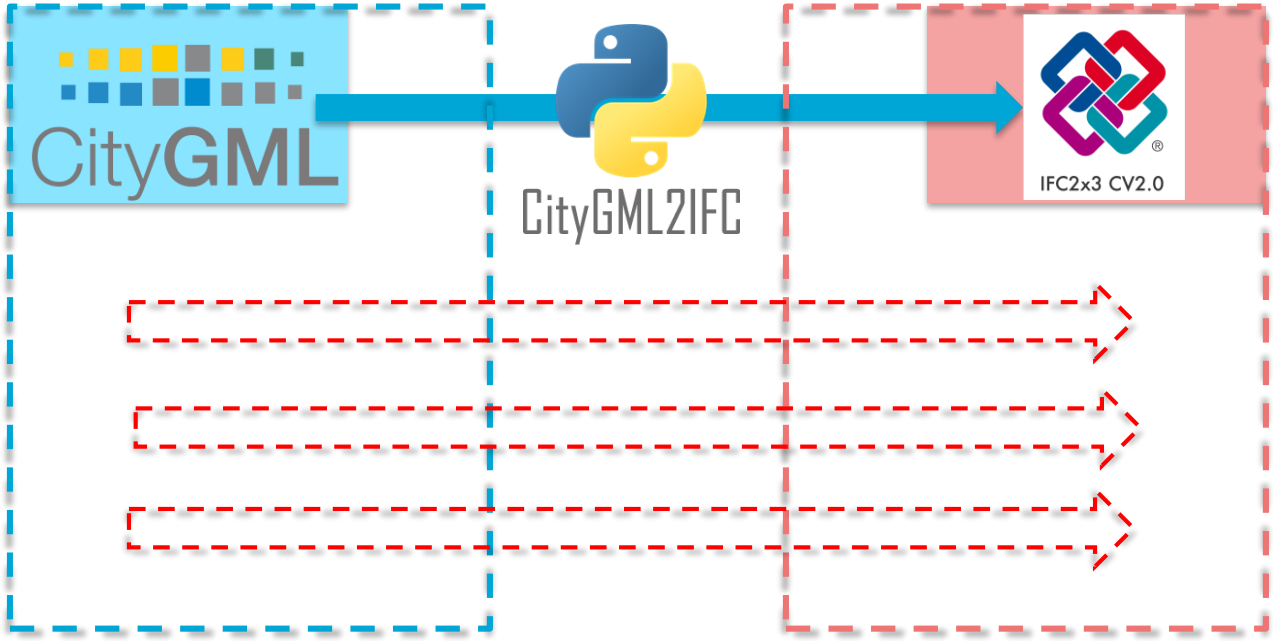
CONCLUSIONS

- A Basic framework of conversion from CityGML to IFC is provided, that can be extended.



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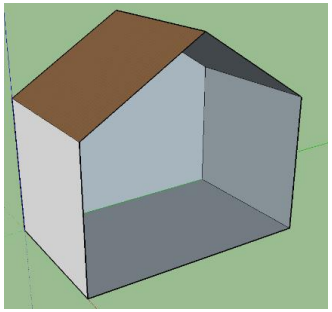
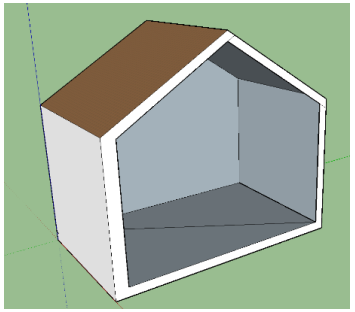
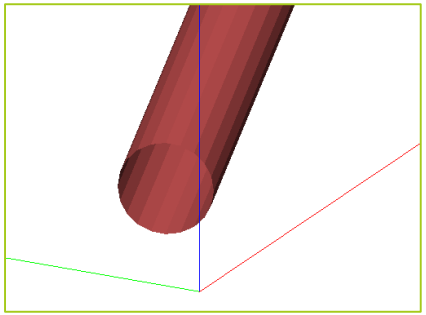
CONCLUSIONS

- The complexity of IFC also comes with flexibility, hence there could different ways to convert some elements from CityGML to IFC.

- Different BIM software deals with IFC data in different ways.

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Questions & comments?

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