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19-24 May

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Conception, Validation and Publication of ETL Processes for the Conversion of Geospatial Data for openBIM Projects with FME

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Acknowledgements:

Project partner: con terra GmbH

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Problem Definition

- transforming **geodata** to **IFC** is challenging due to **differences** in purpose, semantics, geometry representation, or georeferencing
- info: the Industry Foundation Classes (IFC) provide a software vendor independent geometric-semantic data schema for openBIM projects
- current state: Transforming geodata to IFC is possible, however most tools export **invalid or poor** IFC models.
 - not using the richness of IFC (semantics, spatial structure, georeferencing)
 - the “IFC export” can not be customized according to the BIM project needs

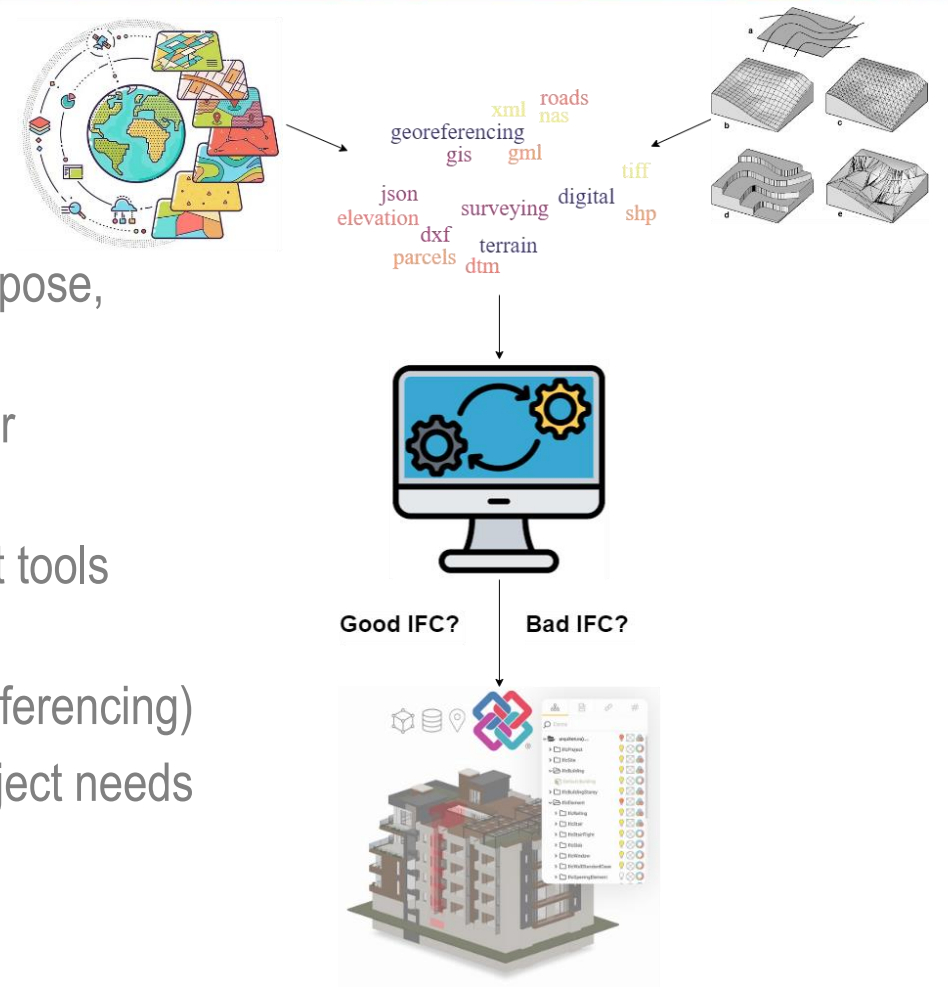




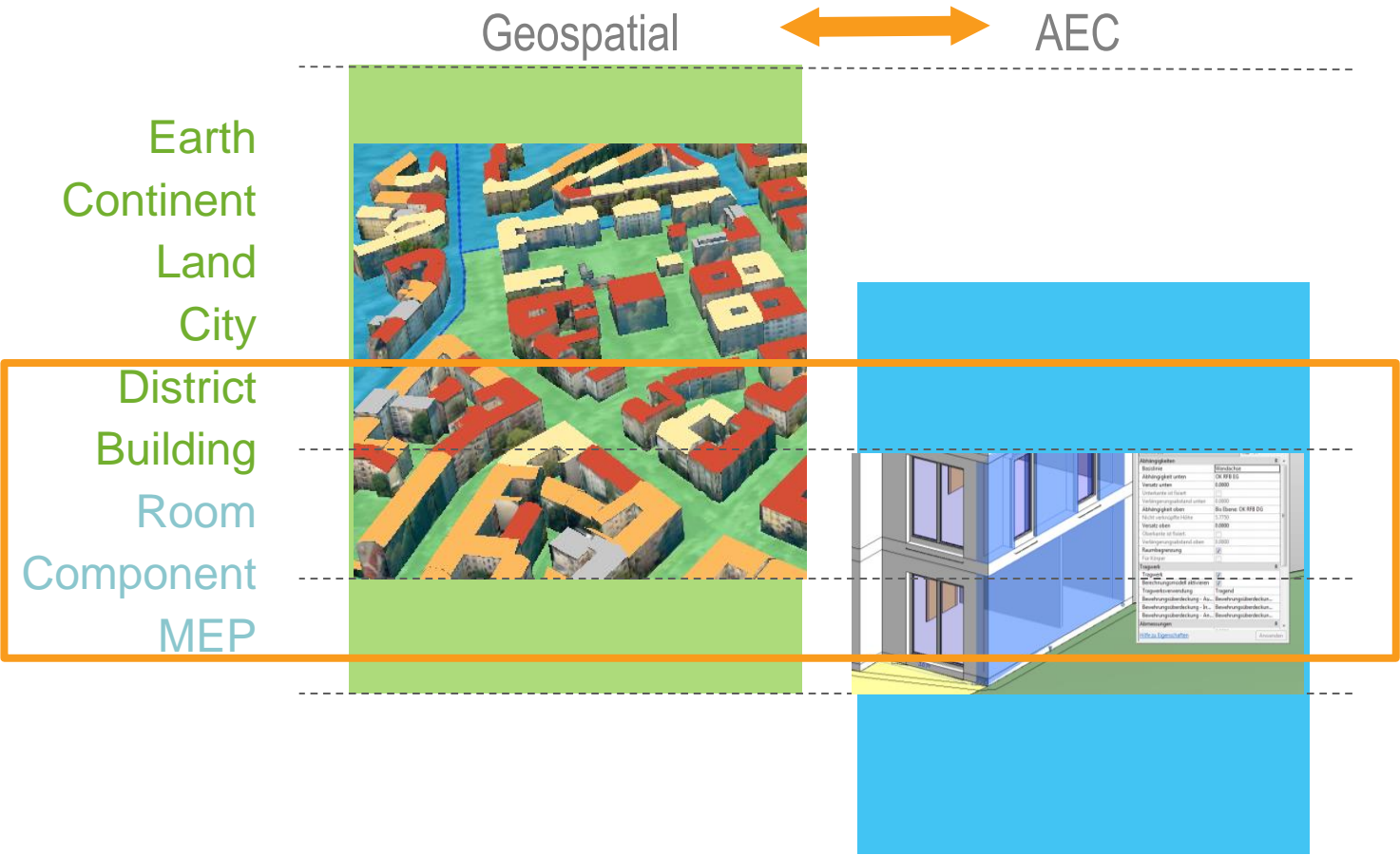
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Motivation: Bi-directional Information Needs



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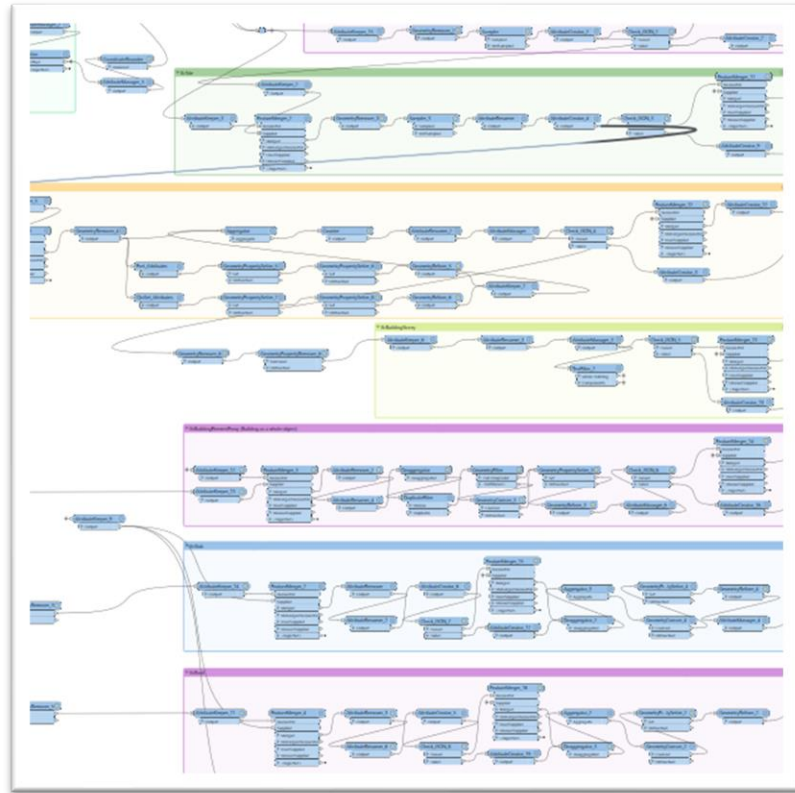
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Info: FME is an Extract-Transform-Load (ETL) software for geospatial data



FME

- is suitable for **automatic data conversions**, running in the backend (server), e.g. as cronjob
- can be programmed with (easy) **visual programming** and additional python plug-ins
- provides „Reader“ and „Writer“ for many, many, many **geospatial data formats**
- provides many **functional blocks**, called „Transformer“. E.g. buffer, coordinate-transformer, topology builder, terrain draping and many, many more
- has its main focus on **geospatial data**, however it supports IFC for openBIM projects



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Background – IFC

Essential features of the IFC:

- open and text-based (ifc, ifcxml, ifcOwl/RDF)
- semantically structured, component-oriented
- object-oriented inheritance hierarchy
- spatial aggregation concepts
- separation of semantics and geometry
- objectified model relationships
- many different geometry model types
- semantically extensible (domain) and generically extensible (IfcPropertySets)

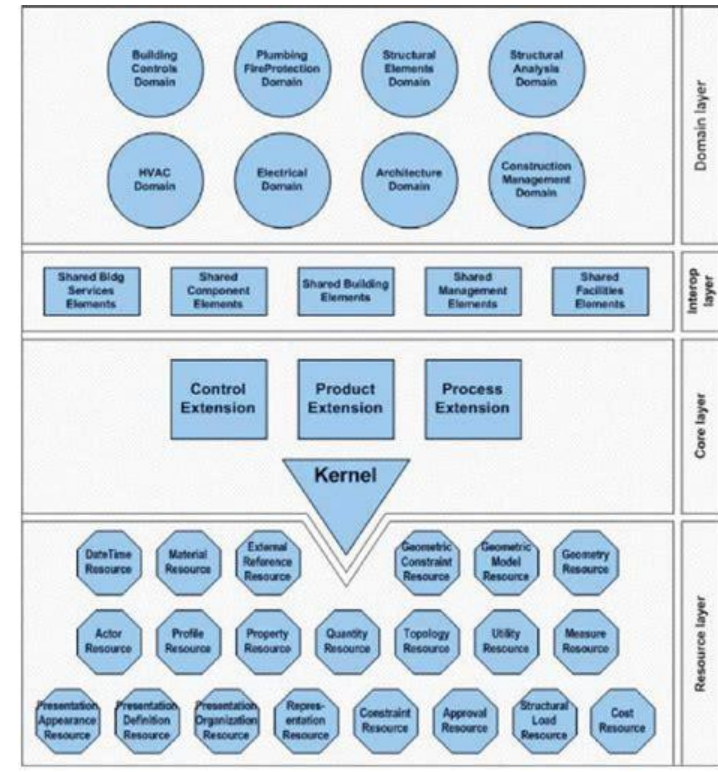




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Aim of the Research

- development of **automated FME** workflows (geospatial data to IFC4)
- using FME Form as a **customizable** framework
- creation of **high-quality IFC4** data
 - **lossless** transformation of geometry, topology, semantics and georeferencing in IFC
 - **preservation** of input attributes
 - creation of **Property-** and **QuantitySets**
- evaluate the **success** of the conversion





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Data: 2D geospatial data (ALKIS: Cadastral parcels = GML with German semantics)

The screenshot shows a GIS interface with a map of cadastral parcels. The left panel displays a tree view of layers, with 'AX_Flurstueck (8513)' selected. The right panel shows the 'Feature Information' for the selected feature, listing various attributes and their values.

Property	Value
Feature Type	AX_Flurstueck
Attributes (44)	
abweichenderRech...	false
amtlicheFlaeche	30896754.0
amtlicheFlaeche.uo...	urn:advuom:m2
anlass(0)	300500
flurnummer	1
flurstueckskennei...	130689001000010005_
flurstuecksnummer...	5
flurstuecksnummer...	1
fme_feature_type	AX_Flurstueck
fme_geometry	fme_donut
fme_type	fme_area
gemarkung_AX_Ge...	0689
gemarkung_AX_Ge...	13
gemeindeguehoe...	048
gemeindeguehoe...	74
gemeindeguehoe...	13
gemeindeguehoe...	0
gml_id	DEM0074Z0000RUU
gml_original_coord...	urn:advcrs:ETRS89_UTM33
gml_parent_property	featureMember
istGebucht.xlink_href	urn:advvoid:DEM0074Z0002bNd
lebenszeitintervall...	2021-11-26T13:11:58Z
modellart(0).AA_M...	DLKM
nas_transaction	none
rechtsbehelfsverfa...	false
sonstigeEigenschaf...	RiB 453, 1
sonstigeEigenschaf...	LF20
weistAuf(0).xlink_hr...	urn:advvoid:DEM007400ctgyfh
xml_ns_uri	http://www.adv-online.de/namespac...
xml_type	xml_area
zeigtAuf(0).xlink_href	urn:advvoid:DEM0074Z0000Pgd
zeigtAufExternes(0)...	http://www.lverma-mv.de/_fdv#5040
zeigtAufExternes(0)...	2.1
zeigtAufExternes(1)...	http://www.lverma-mv.de/_fdv#5030
zeigtAufExternes(1)...	2011/68038-58
zeigtAufExternes(2)...	http://www.lverma-mv.de/_fdv#5020
zeigtAufExternes(2)...	2004/00676-11



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Data: Digital Terrain Model (GeoTIFF, ca. 7 x 3.5 km)

The screenshot shows a GIS application window with the following components:

- Display Control:** A tree view showing a layer named 'XYZ_DGM1 [COG] (1)' which is expanded to show a sub-layer 'COG (1)'. The 'COG (1)' layer is checked and highlighted in blue.
- Map View:** A grayscale terrain model showing a dark, elevated area with a red cursor point located on the peak.
- Feature Information:** A table displaying the properties of the selected feature.

Property	Value
Row and Column	1200, 3290
Ground Location	267459, 5.96273e+06
Band 0 (REAL32): z	37.899

Features Selected: 0 of 0

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Data: Digital Terrain Model (DTM Breaklines, DXF)

The screenshot shows a GIS application window with a map view and a feature information panel. The map displays a coastline with several breaklines. The feature information panel on the right provides details for a selected breakline feature.

Property	Value
autocad_ucs_ydir_x	0
autocad_ucs_ydir_y	1
autocad_ucs_ydir_z	0
autocad_vertexflag	0...
fme_color	0.0
fme_feature_type	BREAKLINE
fme_geometry	fme_line
fme_type	fme_line
Geometry	
Coordinate System	Unknown
Dimension	3D
Number of Vertices	216
Min Extents	264981.463, 5960423.1, 37.9
Max Extents	266000, 5962153.327, 37.9
IFMELINE (2...	
Closed	No
Coordinate...	
0	266000, 5962153.327, 37.9
1	265998.813, 5962152.59, 37.9
2	265994.173, 5962150.953, 37.9
3	265990.512, 5962148.283, 37.9
4	265981.604, 5962143.455, 37.9
5	265977.418, 5962140.517, 37.9
6	265969.029, 5962136.484, 37.9
7	265961.952, 5962132.991, 37.9
8	265956.186, 5962130.037, 37.9
9	265950.433, 5962125.766, 37.9
10 - 205 Show All or 20 more	
206	264988.793, 5960524.136, 37.9
207	264995.007, 5960500.188, 37.9
208	264996.599, 5960490.942, 37.9
209	264994.856, 5960481.772, 37.9
210	264993.037, 5960469.267, 37.9
211	264994.325, 5960458.733, 37.9
212	264996.826, 5960450.245, 37.9
213	264997.963, 5960437.134, 37.9
214	264995.235, 5960426.903, 37.9
215	264994.55, 5960423.1, 37.9



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Methodology: Decision Tree

- Decision tree as concept to...
 - map **geospatial entities** to corresponding **IFC entities**
 - determine **attributes** and **parameters** required for the transformation
 - identify** potential challenges early in the process
 - develop **resolution strategies** for error handling
- Serves for FME-independent communication with project partners

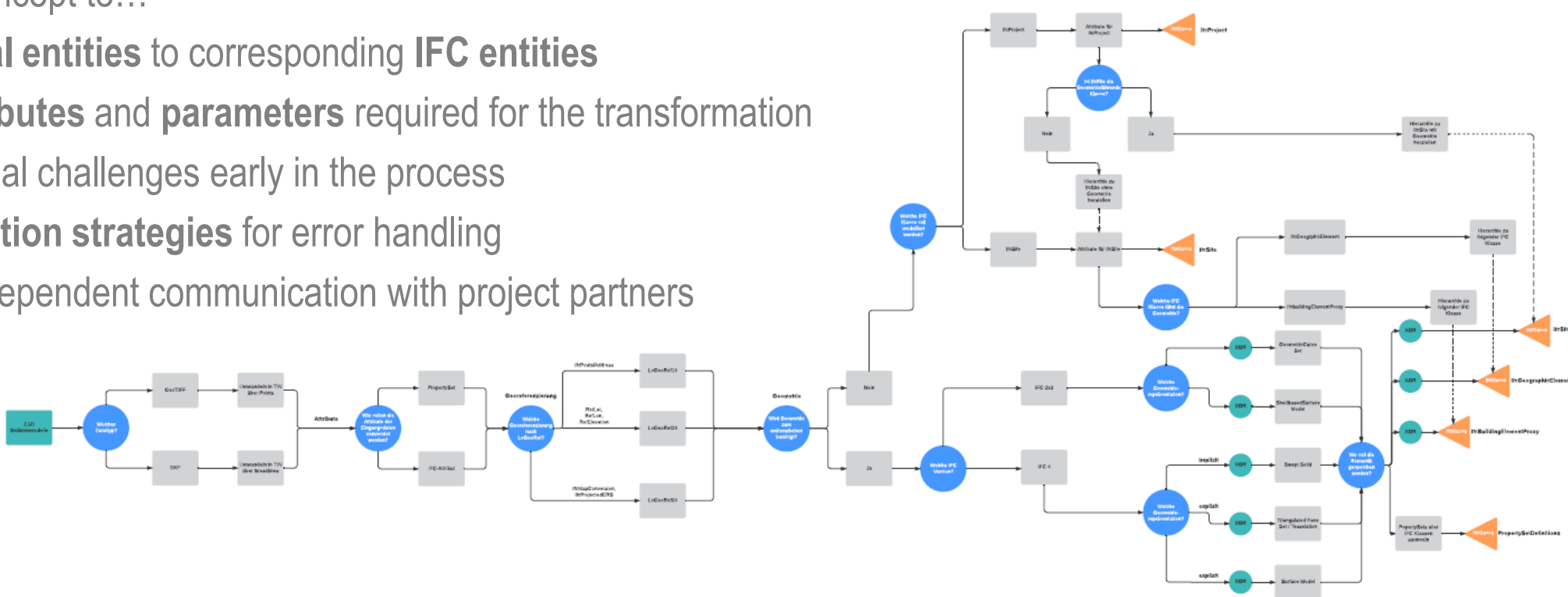




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Methodology and Realization

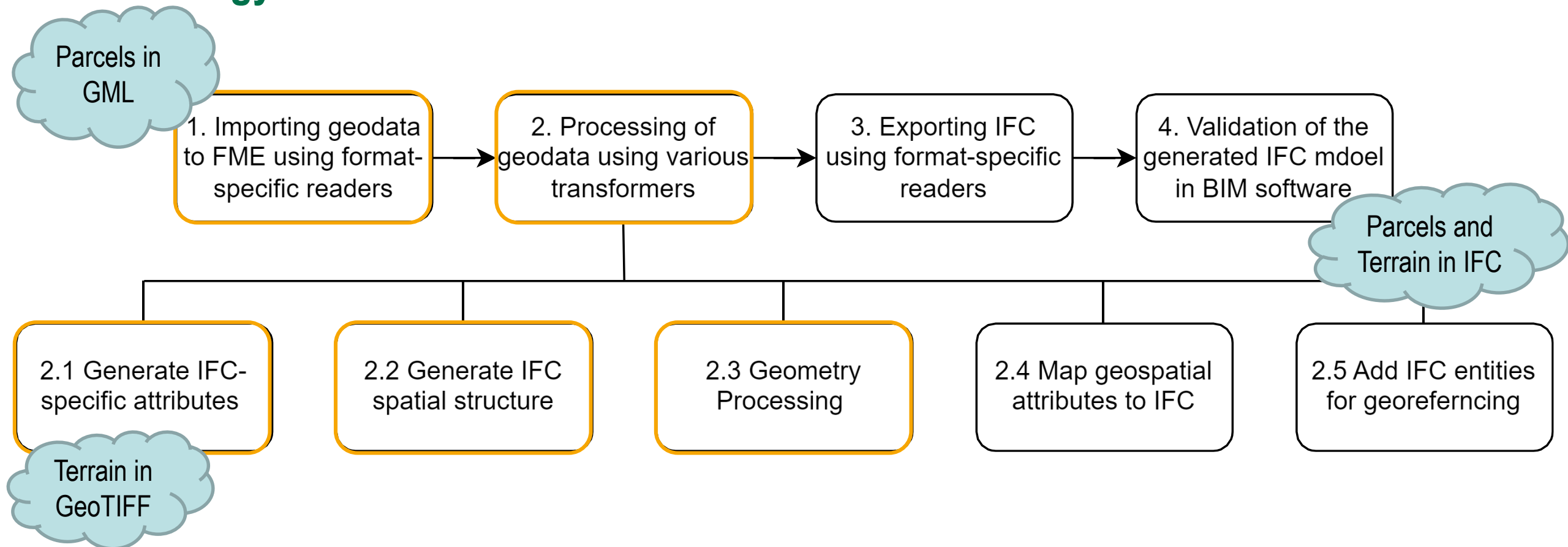




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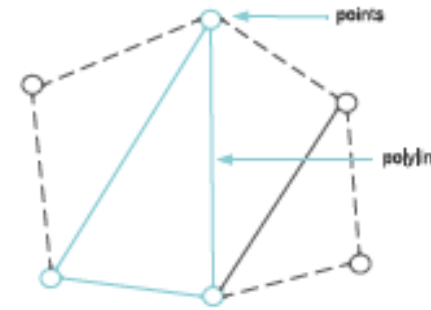
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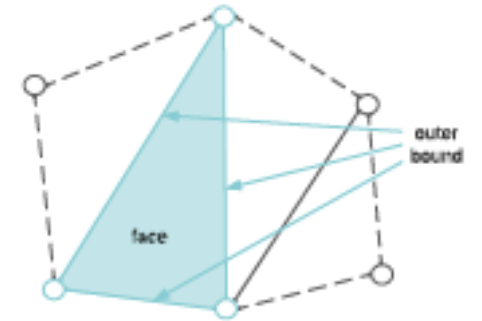
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Excursus: geometry representation for terrain in IFC

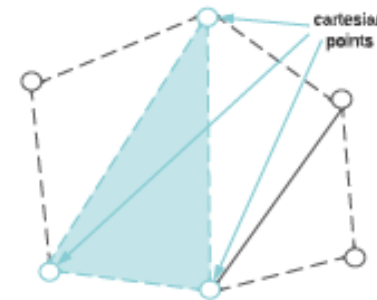
- **GeometricCurveSet**
 - describes a 3D object through a collection of curves
 - curves can be lines, arcs or complex shapes
- **ShellBasedSurfaceModel**
 - uses a shell to represent the outer surface of a 3D object
 - shell consist of a collection of closed surfaces (faces)
- **IfcTriangulatedFaceSet** (IFC4 only)
 - represents the surface of a 3D object by triangulation
- **ExtrudedAreaSolid**
 - surfaces extruded along a path



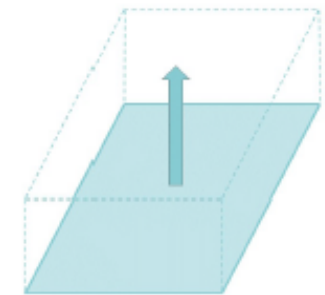
GeometricCurveSet



ShellBasedSurfaceModel



TriangulatedFaceSet



ExtrudedAreaSolid



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Methodology and Realization

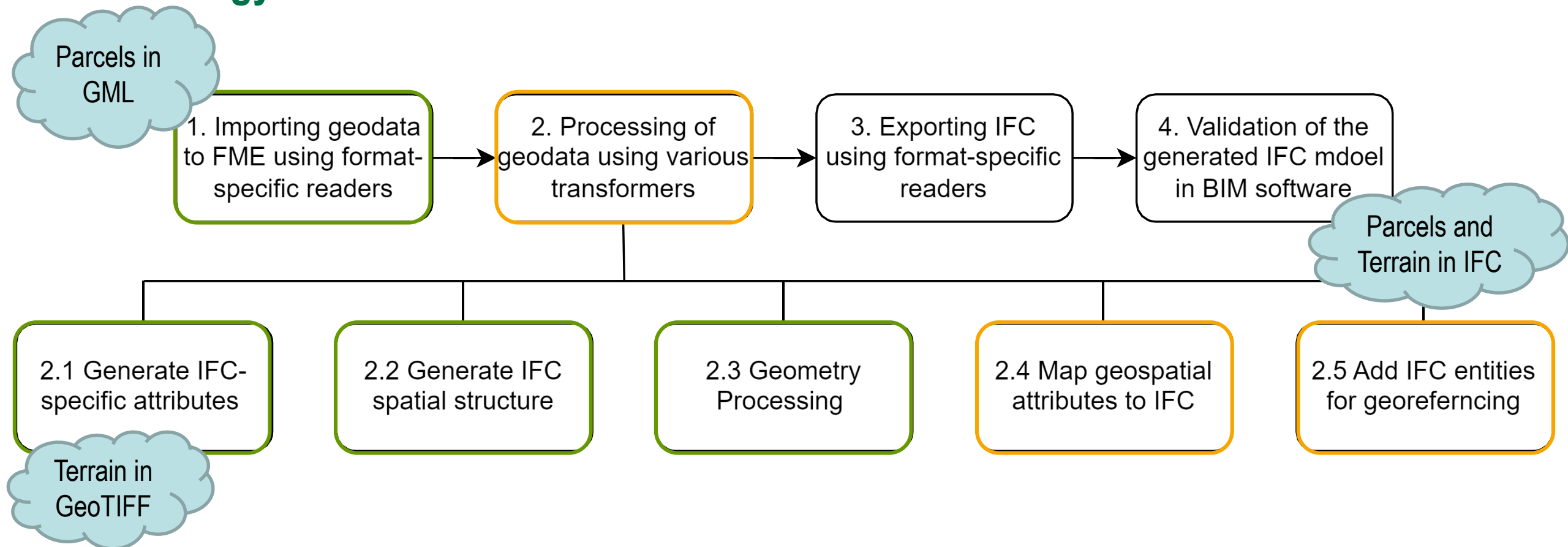




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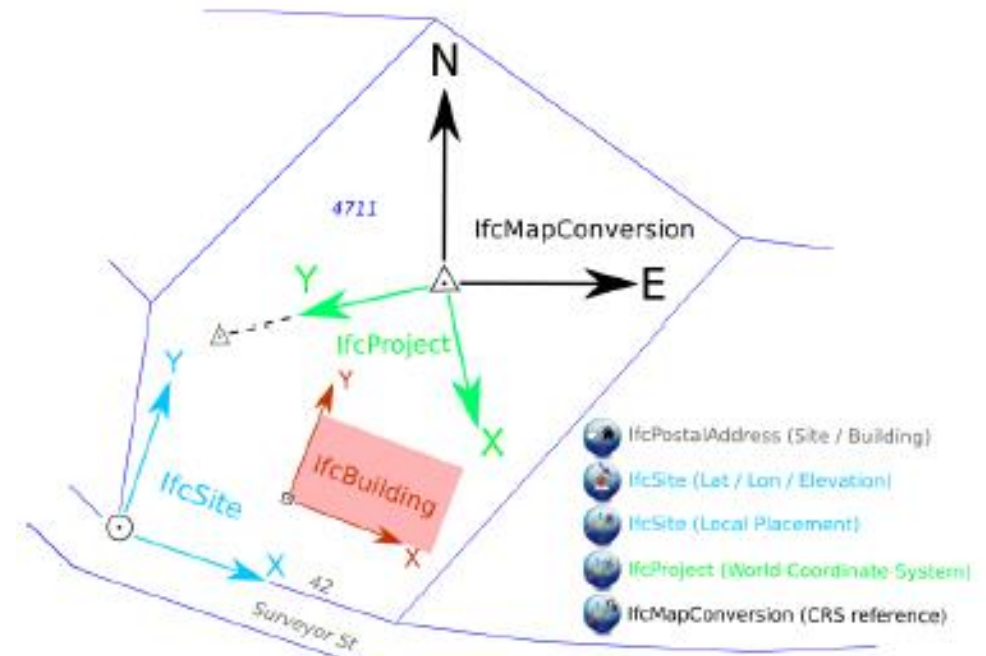
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Excursus: Georeferencing in IFC4 and options in IFC2x3

- **LoGeoRef10**
 - postal address in **IfcPostalAddress**
 - referenced by **IfcSite** or **IfcBuilding**
- **LoGeoRef20**
 - geographic coordinate → **RefLatitude**, **RefLongitude** and **RefElevation** in **IfcSite**
- **LoGeoRef50**
 - offset between project coordinate system and global origin of a coordinate reference system in **IfcMapConversion** (with Easting, Northing, Orthogonal Height and rotation of XY-plane)
 - **IfcProjectedCRS** for metadata



"Coordinate hierarchy:"

- Geodetic CRS or Engineering CRS (Geospatial domain)
 - ↳ Project CRS called World Coordinate System (WCS) (BIM domain)
 - ↳ Site Placement (BIM domain)
 - ↳ Building Placement (BIM domain)
 - ↳ ...

C. Clemen & H. Görne, 2019





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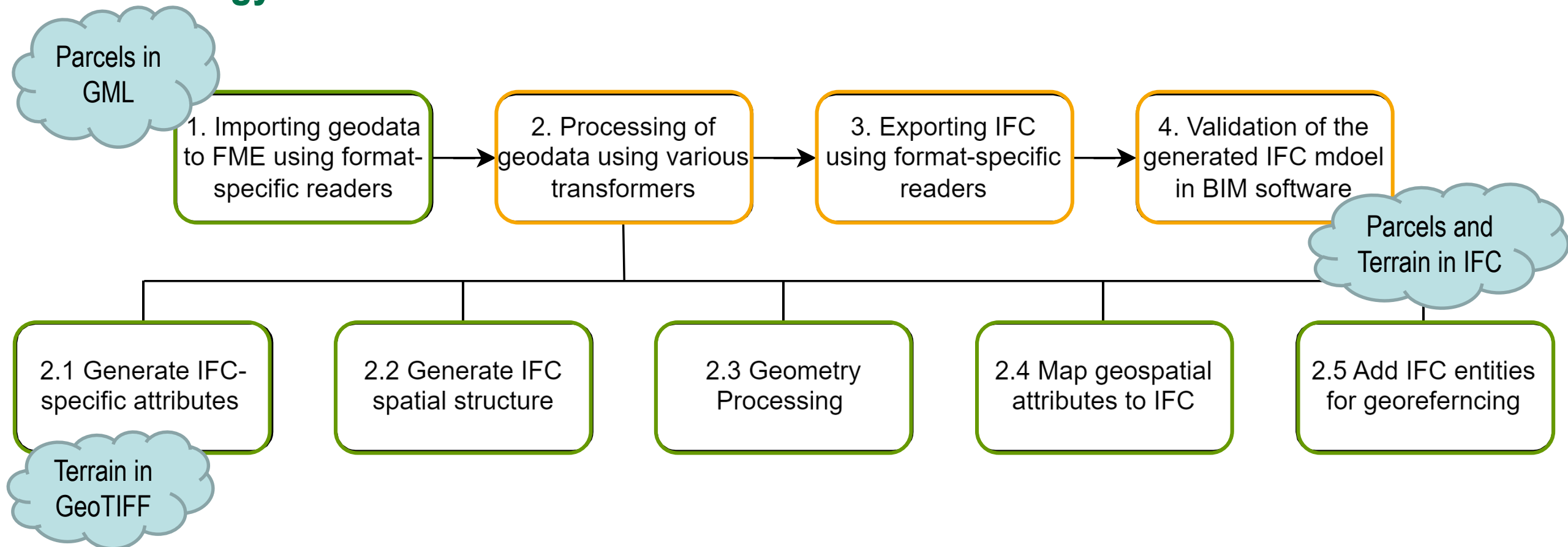




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Results – 2D cadastral data to IFC4

Browser Toolbar

- [-] IfcProject: 2D ALKIS zu IFC
 - [+] IfcSite_1000_130579001001770007
 - [-] IfcGeographicElement[1]
 - [-] IfcGeographicElement
 - [+] IfcSite_1001_130576001000590001
 - [+] IfcSite_1002_130427002002200003
 - [+] IfcSite_1003_13057600100060
 - [+] IfcSite_1004_130579001002190003
 - [+] IfcSite_1005_13045800200074
 - [+] IfcSite_1006_130576001003860030
 - [+] IfcSite_1007_13042700200215
 - [+] IfcSite_1008_130576001003860022
 - [+] IfcSite_1009_13048100100170
 - [+] IfcSite_100_130358001001770008
 - [+] IfcSite_1010_130576001000480008

Element Toolbar

- [-] * IFC
 - [-] IfcGeographicElement
 - [-] * IfcProject
 - [-] * IfcSite

Property Toolbar

Name	Value	Description
Internal Type	IfcGeographicElement	
IFC OID	78815	
GUID	MDUCFMIATmOxZN5dQ...	
GUID (readab...)	8d78c3d6-b0a7-7063-b...	
Name	IfcGeographicElement	
Description	Parcel	
Object Type	area features	
Layer Name		
Color	---	No Color
Local Placements		
[-] Placement	IfcSite (#76767)	
[-] Position	0.000000, 0.000000, 0.00...	
[-] X Directi...	1.000000, 0.000000, 0.00...	
[-] Y Directi...	0.000000, 1.000000, 0.00...	
[-] Z Directi...	0.000000, 0.000000, 1.00...	
[+] Placement	IfcGeographicElement (#78...	
Global Placement		
Geometry		
[-] TriangulatedF...	SurfaceModel	TriangulatedFaceSet
[+] SurfaceM...	510 Faces	
Calculated Valu...		
[-] BoundingBox...		4115.59 [m]
[-] BoundingBox...		3736.92 [m]
[-] BoundingBox...		6.36 [m]



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Results – 2.5D terrain model to IFC4

The screenshot displays a software interface for a 2.5D terrain model. The central view shows a red, textured terrain model. The interface includes several toolbars and panels:

- Browser Toolbar:** Shows a tree view with the following structure:
 - IfcProject: 2,5D DTM zu IFC
 - IfcSite_DTM
 - IfcGeographicElement [1]
 - IfcGeographicElem...

- Element Toolbar:** Shows a list of elements:
- IFC
 - IfcGeographicElement
 - IfcProject
 - IfcSite
- Property Toolbar:** Shows a table of properties for the selected element.

Name	Value	Description
Entity Information		
Type	IfcGeographicEle...	
Internal Type	IfcGeographicEle...	
IFC OID	98272	
GUID	M\$NLDm5cSU_6p...	
GUID (readable)	bf5d5370-1667-1...	
Name	IfcGeographicEle...	
Description	DTM_Bad_Kleinen	
Object Type	area features	
Layer Name		
Color	---	No Color
Placement		
Geometry		
IfcTriangulatedFac...	SurfaceModel	IfcTriangulatedFaceSet
SurfaceModel	28014 Faces	
Calculated Values (If...		
BoundingBoxLeng...	7147.18 [m]	
BoundingBoxLeng...	3848.01 [m]	
BoundingBoxLeng...	43.62 [m]	
SurfaceArea	24536706.97 [m ²]	



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Summary

- our FME Workspace **offers**:
 - **automated** workflows for transforming geospatial data into **high-quality** IFC4 files
 - operates **without static** values
 - easily **adjustable** → enables use of **future** IFC versions
 - preserves **semantics** and **spatial structure**
- **limitations**:
 - currently relies on external Python-based transformer for LoGeoRef50





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Outlook

- automated **calculation** of **rotation** component for LoGeoRef50
- implementation of **LoGeoRef 30** and **40**
- **more** geometry representations e.g. CSG
- **more** data formats

- entire FME process is provided by con terra as **Software as a Service**
 - can be used to **extend** other existing processes





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Commission 10

Construction Economics and Management

Serving Society for the Benefit of People and Planet

<p>9 INDUSTRY, INNOVATION AND INFRASTRUCTURE</p> 	<p>11 SUSTAINABLE CITIES AND COMMUNITIES</p> 	<p>4 QUALITY EDUCATION</p> 
	<p>17 PARTNERSHIPS FOR THE GOALS</p> 	<p>8 DECENT WORK AND ECONOMIC GROWTH</p> 