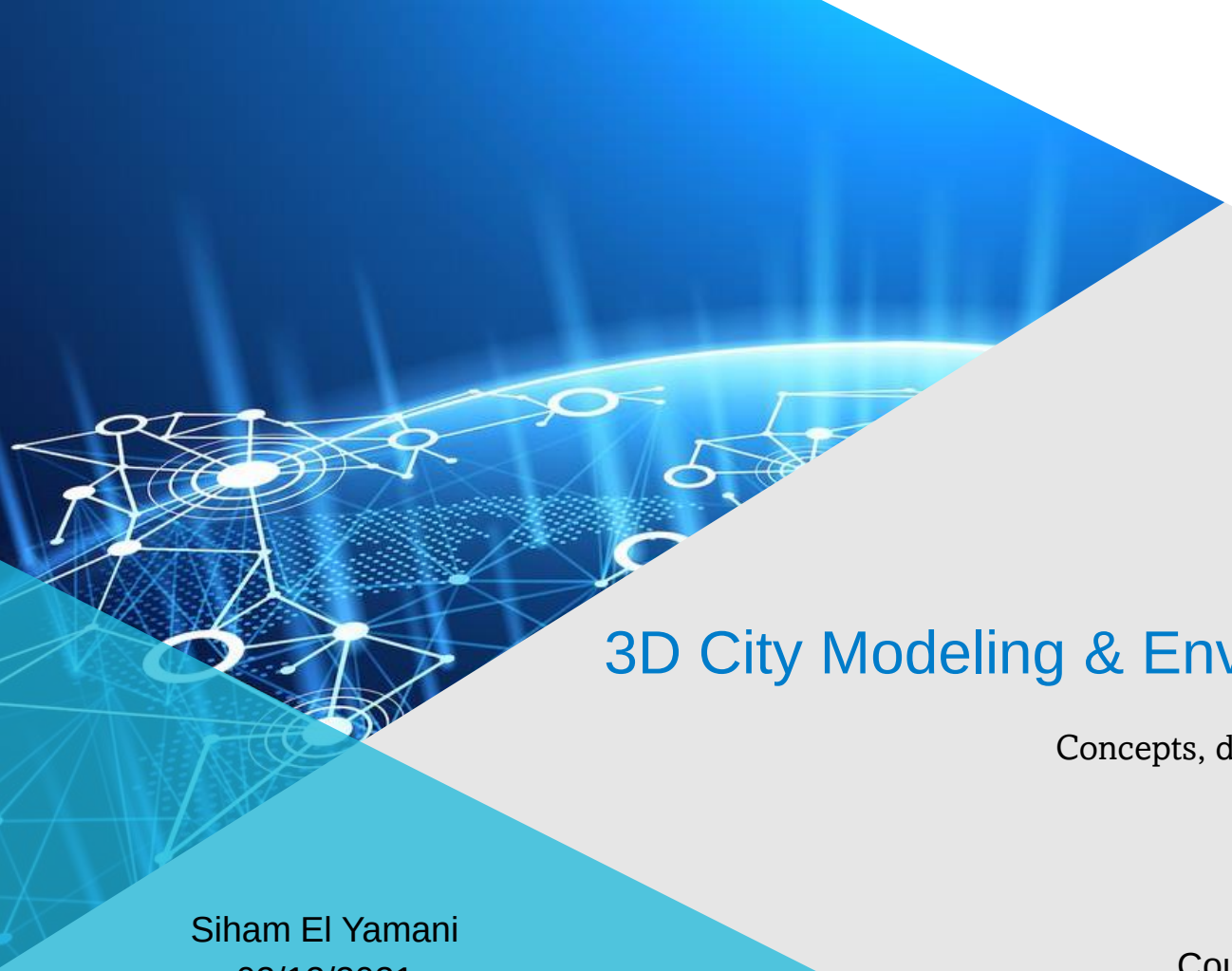

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3D City Modeling & Environment simulation

Concepts, demonstration, research use case

Siham El Yamani
02/12/2021

Course : Advanced GIS

Background - Who Am I?

- Siham El Yamani
- Doctorante en cotutelle : IAV H.II Rabat / Uliège
- Evaluateur Immobilier
- Ingénieur Topographe
- Consultante SIG – Immobilier
- Domaine de recherche :

  Modélisation 3D dans le domaine de l'immobilier

Contenu

1. Introduction et généralités
2. Cas d’usage : Simulation urbaine
3. CityGML : Démonstrations
    - 3.1. CityGML visualization
    - 3.2. CityGML & Cesium
    - 3.2. BIM to SIG (lod 100 – lod 2)
3. Projet de recherche

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introduction et généralités

Introduction

- CityGML est un format de modélisation et d'échange pour les objets urbains 3D qui a été validé comme standard international par l'OGC en 2008.

- Il définit un modèle de représentation des classes et des relations pour les objets les plus courants de la ville sous les différents aspects géométriques, topologiques, sémantiques et texturaux. CityGML est basé sur GML3 (Geography Markup Language) qui est une spécification de l'OGC.
- Le standard CityGML possède plusieurs caractéristiques dont la modularité, la représentation des niveaux de détail, la richesse sémantique, etc.
- La relation entre les objets peut être stockés en utilisant CityGML, par exemple « building » est composé de « building parts ».

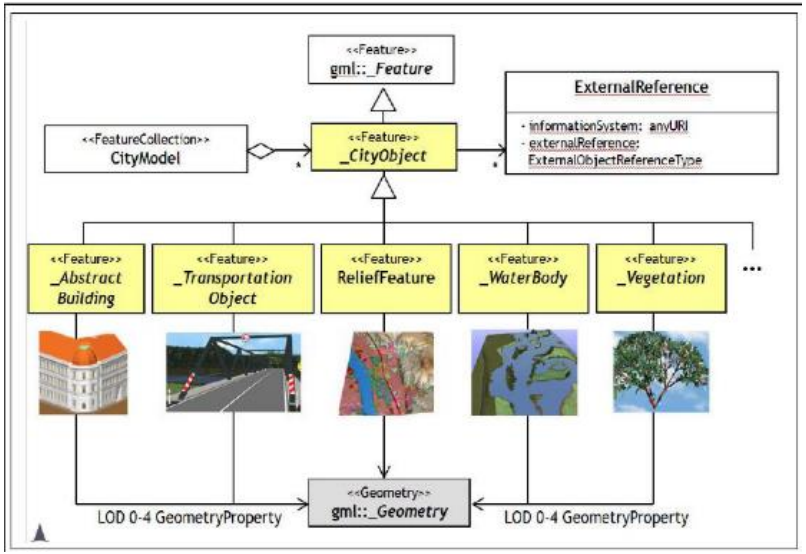
More than a 3D visualization..

CityGML

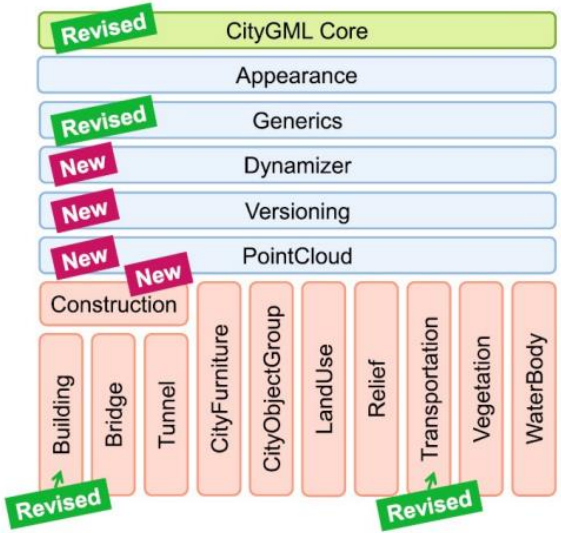
Generic Standard for Urban Environment	Different levels of Information content	Extensibility ADEs	Better Interoperability
-3D Spatial Analysis -3D Simulations	-Hierarchy -LOD Concept	-NoiseADE -EnergyADE etc.	CityGML 3.0 (IFC, etc.)

Thematic Modules

- CityGML se compose d'un ensemble de modules spatiaux pour la représentation en 3D des objets urbains. Son modèle dispose d'un module principal (Core module) et de modules d'extension (Extension modules).



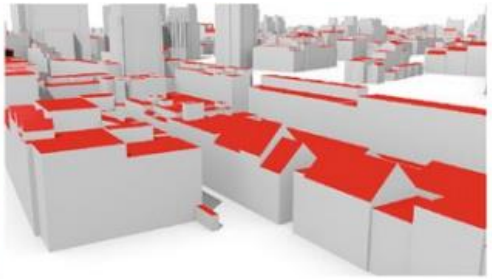
CityGML 2.0



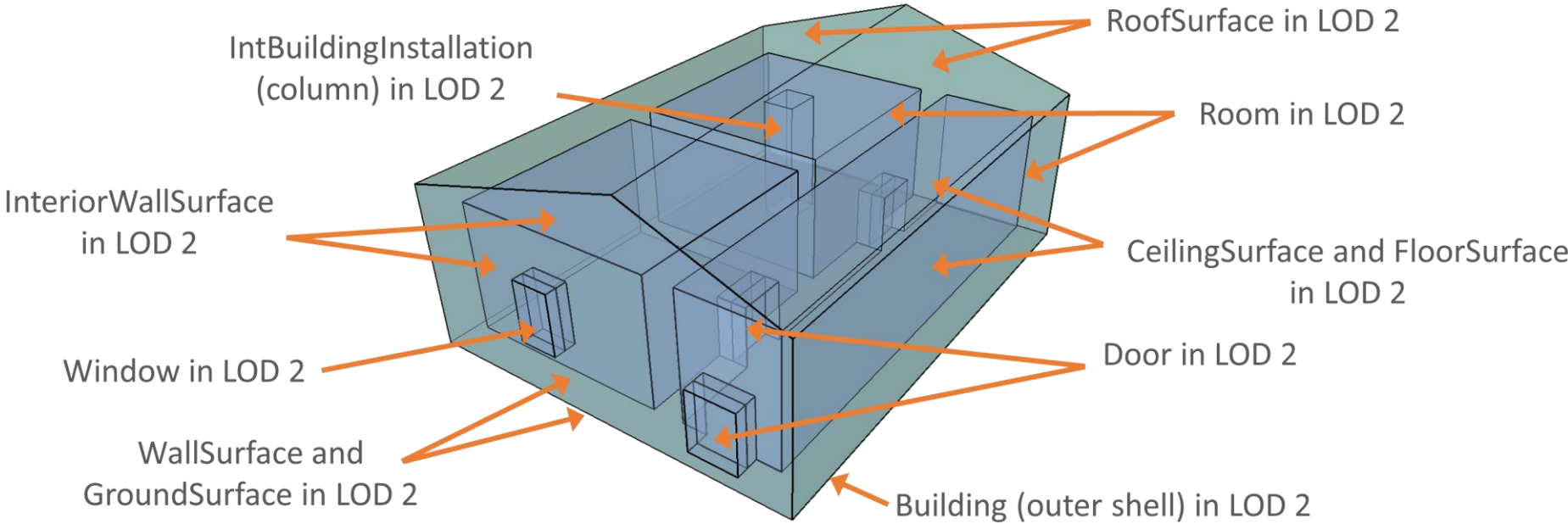
CityGML 3.0

LODs

- CityGML defines different standard levels of detail (LoDs) for 3D objects. These make it the possible to represent objects for different applications and purposes.



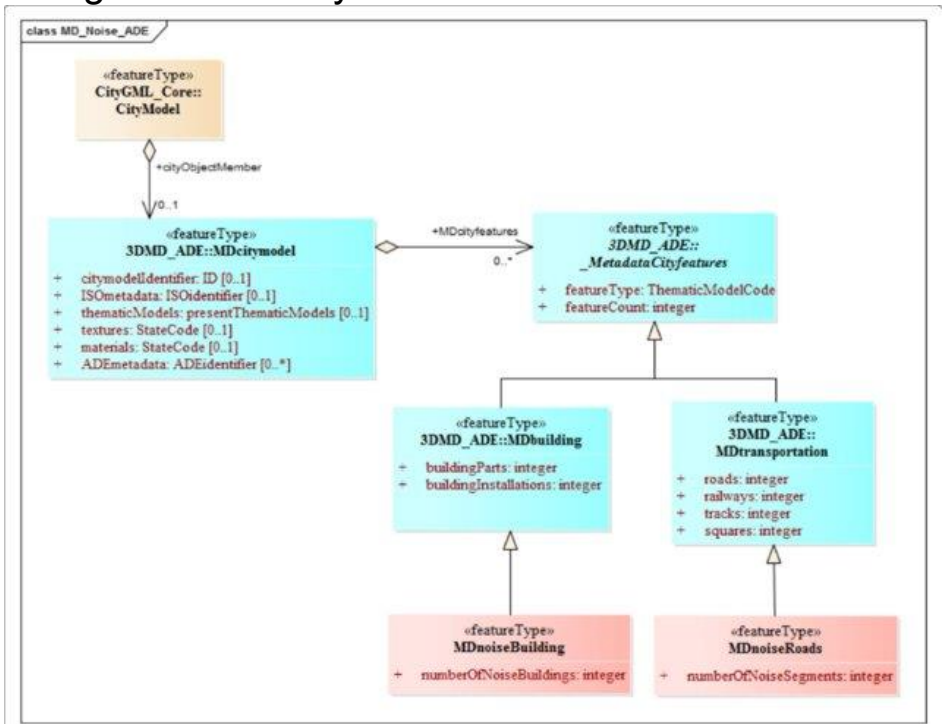
Exemple : Citygml LOD 2



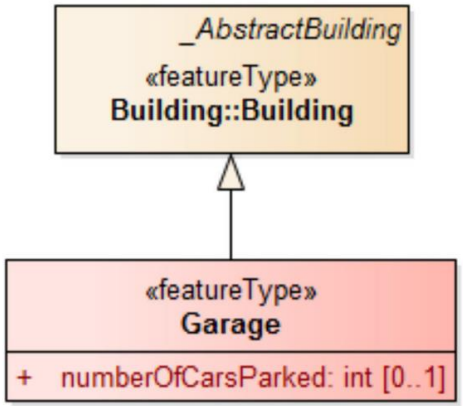
Extensibility ADEs

The ADE concept has been introduced in CityGML in its early days (May 2007). Its two main purposes are:

- Addition of new properties to existing standard CityGML classes.
- Addition of new object types.



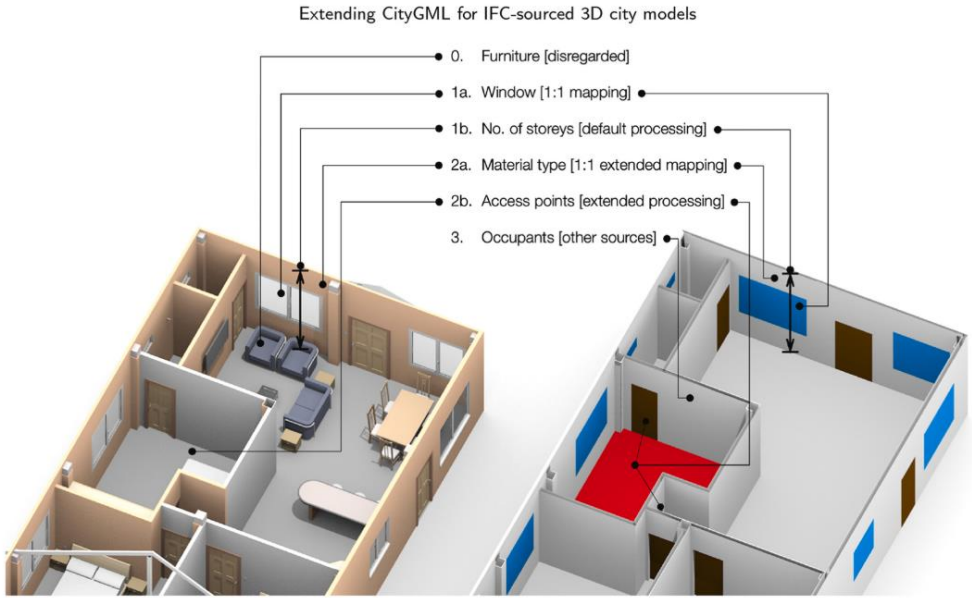
Extensibility ADEs : example

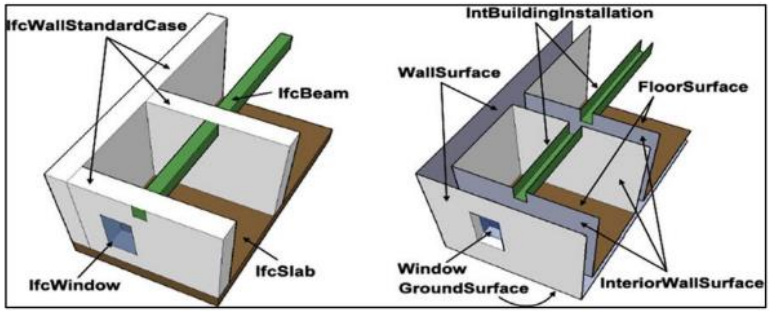



```
<element name="Garage" type="GarageType"
     substitutionGroup="bldg:_AbstractBuilding"/>
<complexType name="GarageType">
   <complexContent>
     <extension base="bldg:BuildingType">
       <sequence>
         <element name="numberOfCarsParked"type="xs:
              integer" minOccurs="0"maxOccurs="1"/>
       </sequence>
     </extension>
   </complexContent>
</complexType>
```

Better Interoperability

- Bridging the gap between two different enviornments (example geometry).
- The last version of CityGML 3.0 is more suitable to be connected to IFC (space concept)

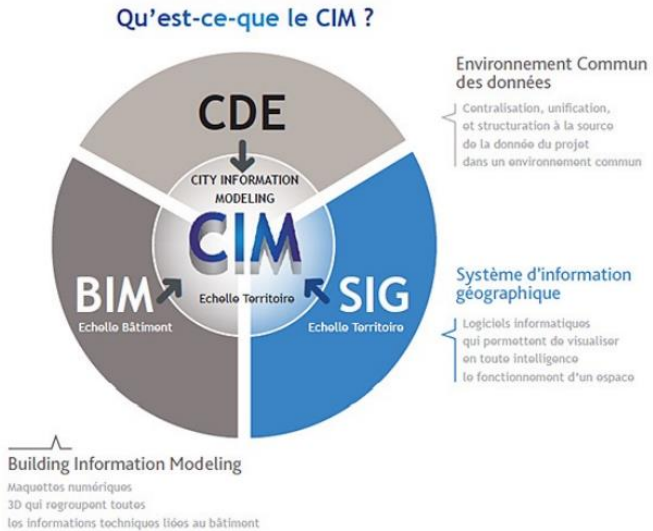




F.Biljecki 2021

CIM – City Information Modeling

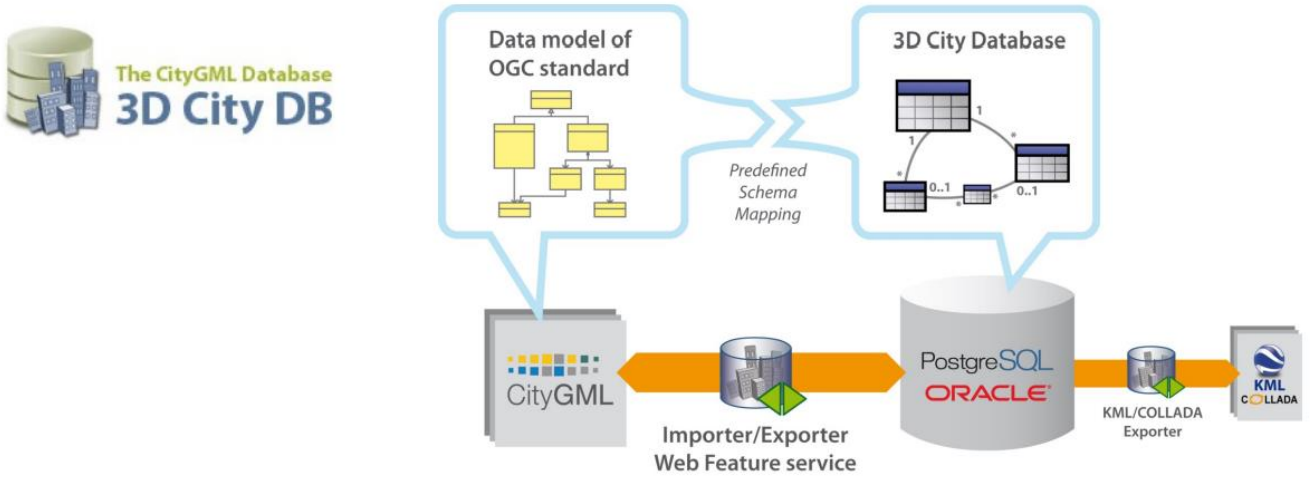
- CIM concept: the integration of Building Information Modelling (BIM), geographic information system (GIS), and a complete and up-to-date urban database, which enables analysis and simulation.



- *https://be-smartcity.com/2019/09/06/city-information-modeling-cim-modeliser-lensemble-des-amenagements-urbains/*

CityGML implementation

- A Conceptual model / relational schema model of 3D data base, 3DCityDB



Challenge..

- Implementation issues :
- CityGML files become very large (more cities).
- All classes tables should be added
- Complex data models

Increasing the need to develop more specific use case models (ADEs) for Urban simulation.

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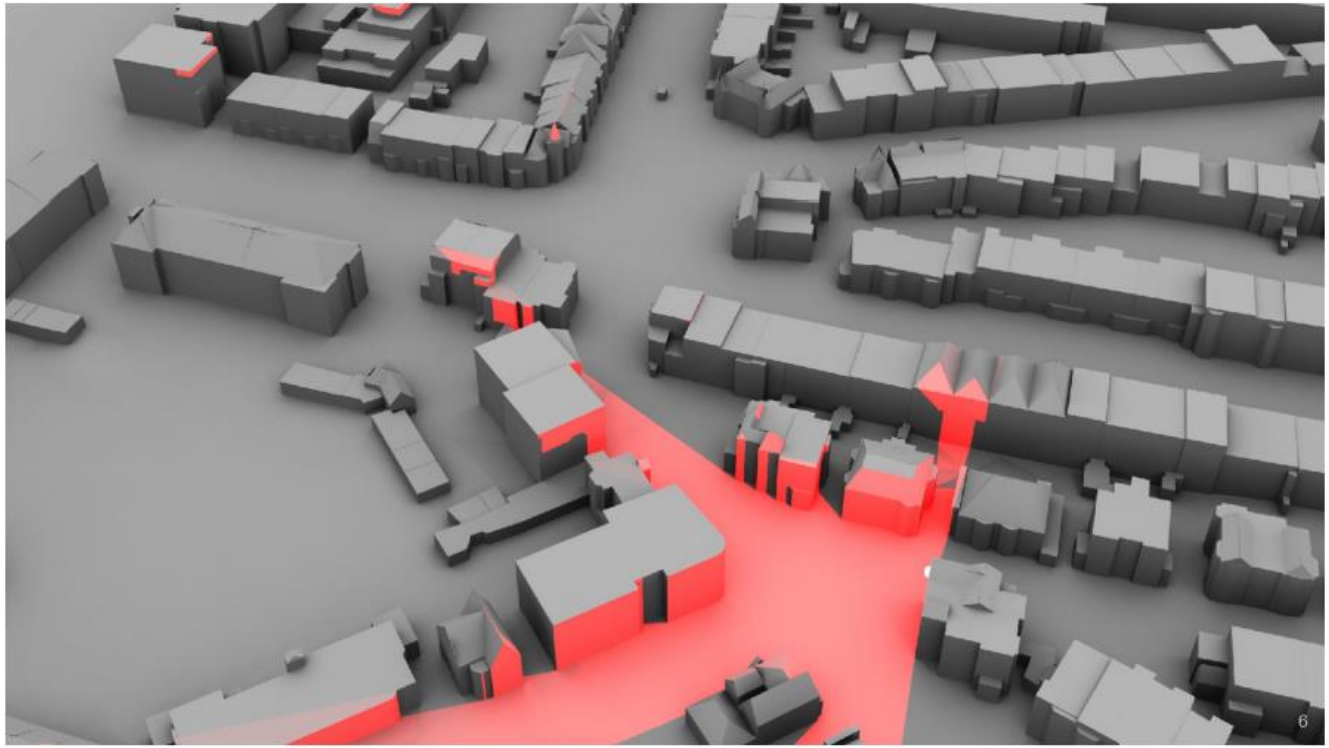
CityGML : Use Case applications

Noise simulation

Noise propagation

Source: TUDelft

Visibility Simulation



Visibility analysis

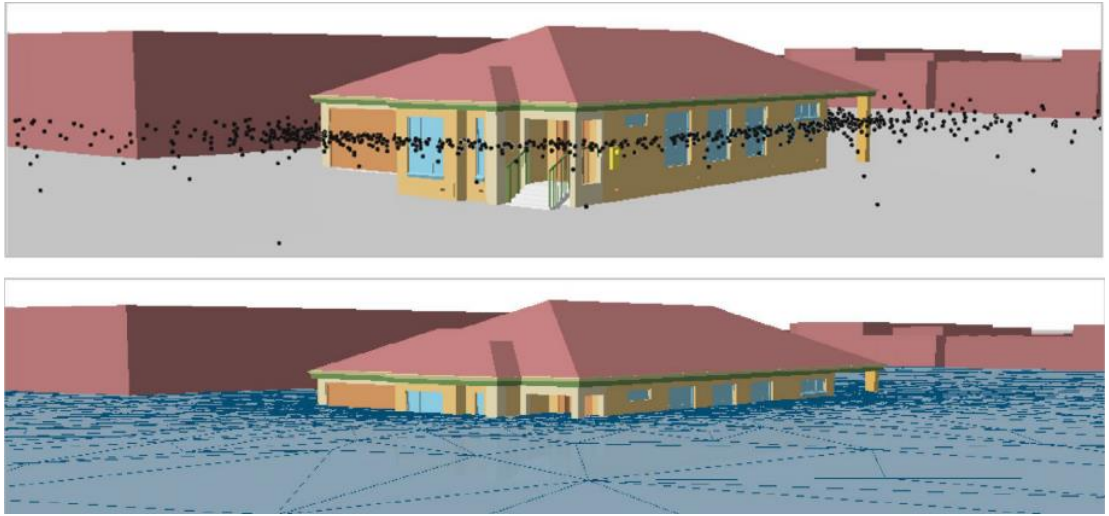
Source: TUDelft

Energy Simulation

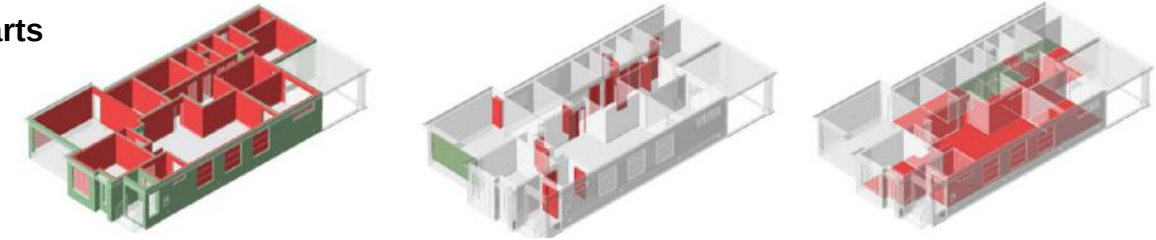
Example of using a CityGML to Model Building's Energy Demand in Ludwigsburg — Grünbühl (The energy modeling is calculated with SimStadt2 software)

Urban Flood Simulation

Damaged outdoors parts



Damaged indoors parts



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Démontration 1

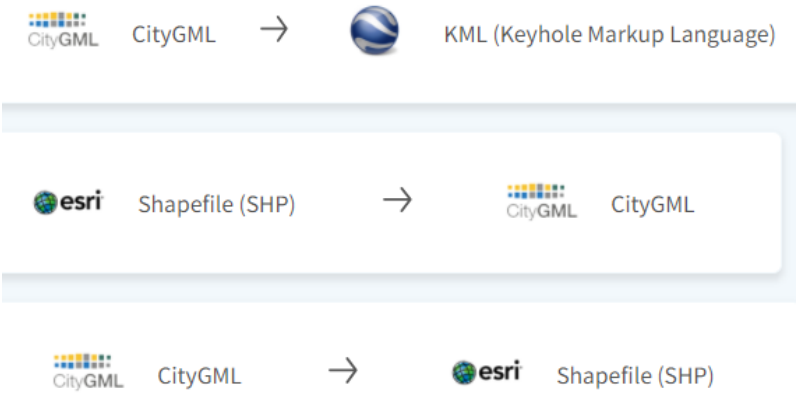
Urbis & FME inspector

Installation et étapes

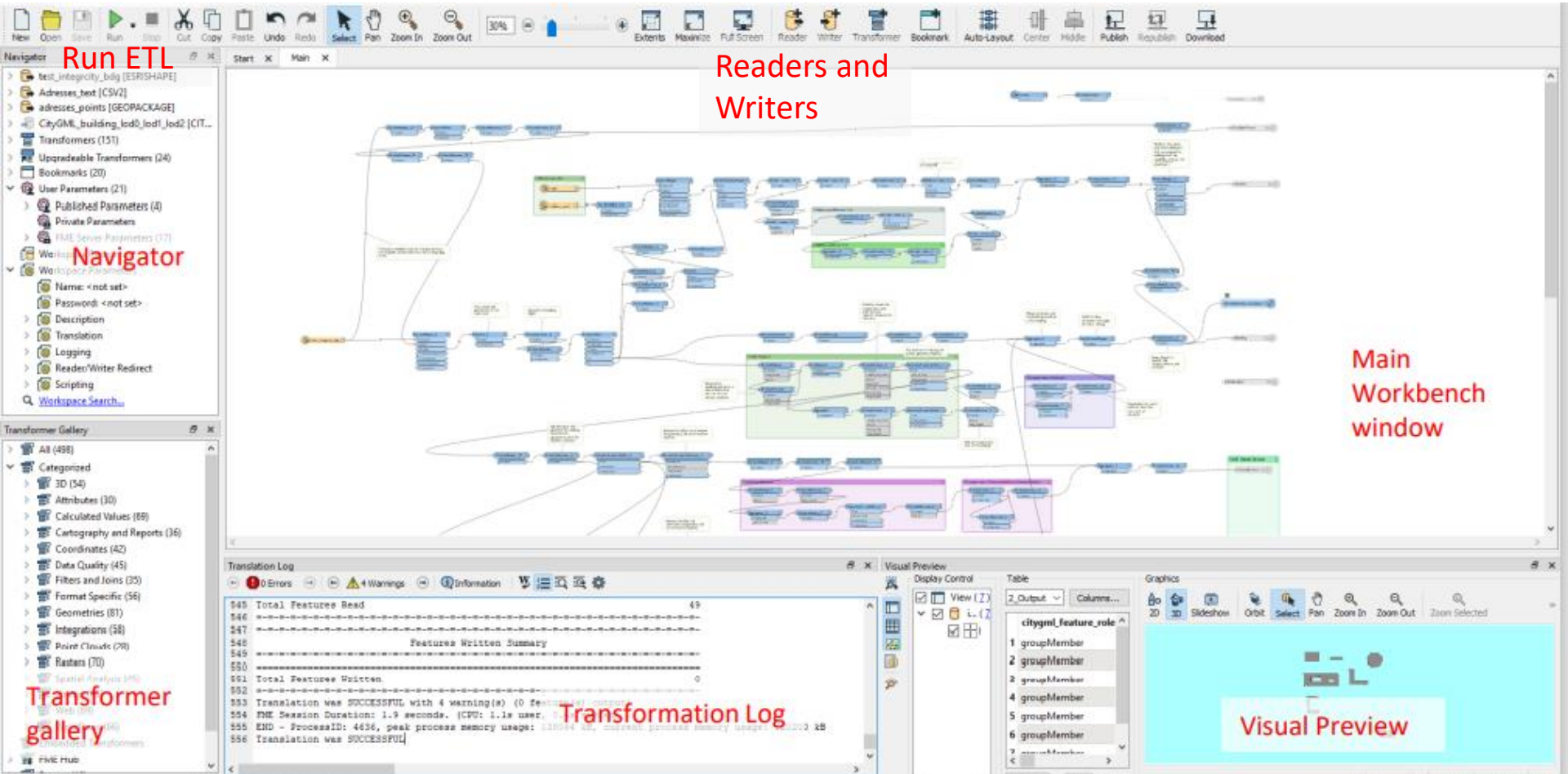
- Télécharger « FME installer »
- Obtenir License sur Gitan : http://www.gitan.ulg.ac.be/
- Télécharger Portail Urbis : https://datastore.brussels/web/urbis-download
- Choisir le produit > Urbis-Adm 3D
- Sélectionner le format > CityGML
- Définir la zone et la temporalité
- Ouvrir via « FME DATA Inspector »

FME Basics

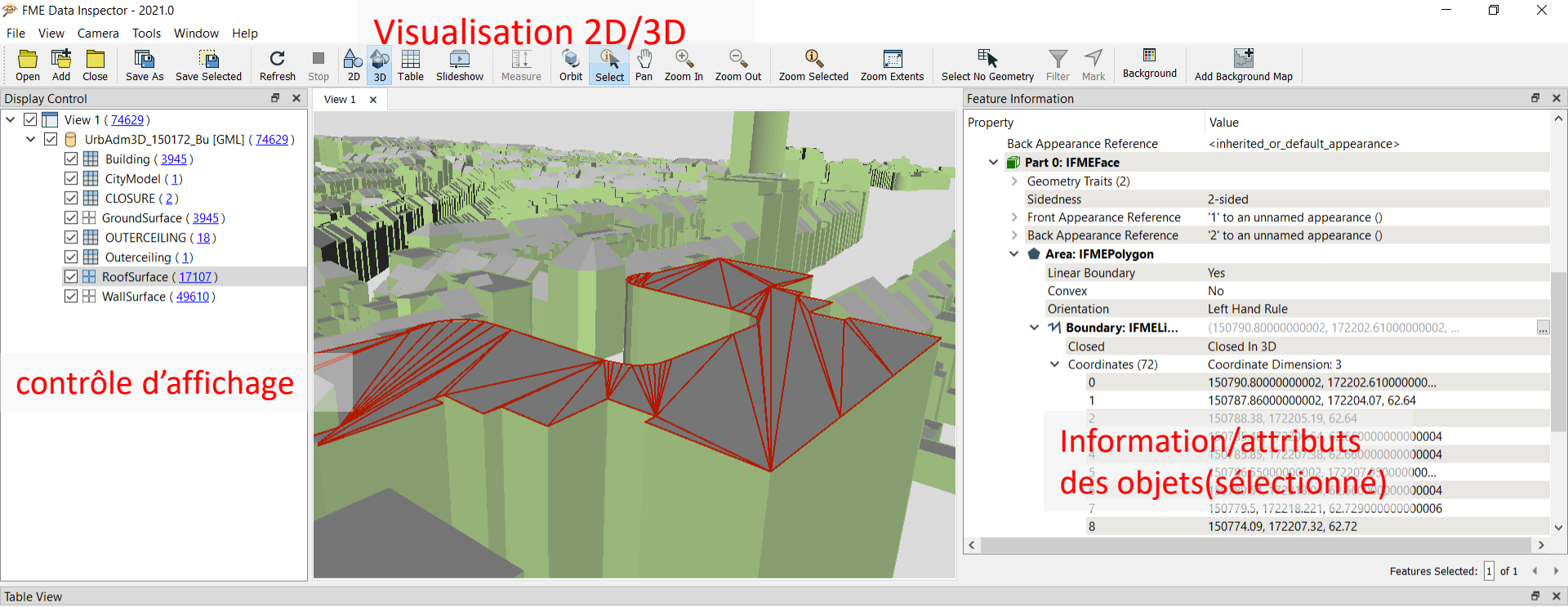
- FME : data integration tool used for *transforming* data.
- FME performs (Extract, Transform, Load) :
- Conversions examples :



FME Workbench



FME Data Inspector



FME Data Inspector - 2021.0

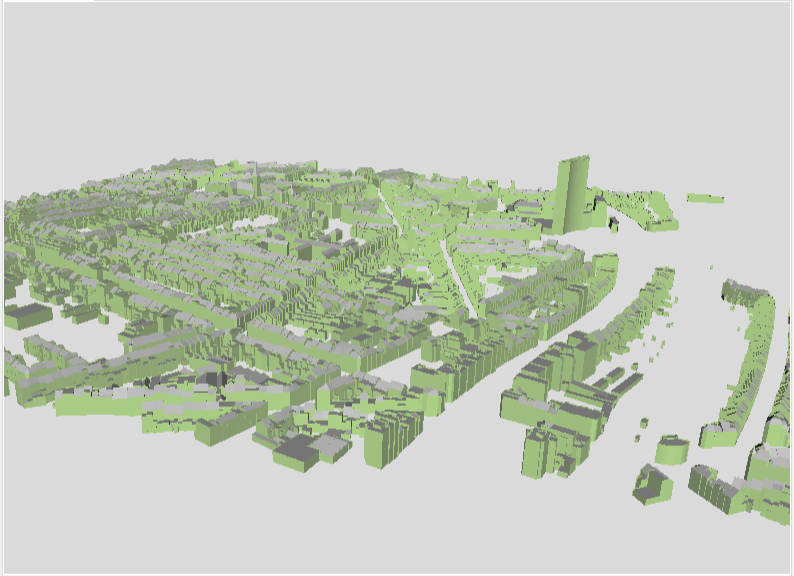
File View Camera Tools Window Help

Open Add Close Save As Save Selected Refresh Stop 2D 3D Table Slideshow Measure Orbit Select Pan Zoom In Zoom Out Zoom Selected Zoom Extents Select No Geometry Filter Mark Background Add Background Map

Display Control

- View 1 (74629)
  - UrbAdm3D_150172_Bu [GML] (74629)
    - Building (3945)
    - CityModel (1)
    - CLOSURE (2)
    - GroundSurface (3945)
    - OUTERCEILING (18)
    - Outerceiling (1)
    - RoofSurface (17107)
    - WallSurface (49610)

View 1



Feature Information

Property	Value
gml_geometry (encode...	MultiSurface
Front Appearance Reference	<inherited_or_default_appearance>
Back Appearance Reference	<inherited_or_default_appearance>
Part 0: IFMEFace	
Geometry Traits (2)	
Sidedness	2-sided
Front Appearance Reference	'1' to an unnamed appearance ()
Back Appearance Reference	'2' to an unnamed appearance ()
Area: IFMEPolygon	
Linear Boundary	Yes
Convex	Yes
Orientation	Right Hand Rule
Boundary: IFMELine ...	(150679.329, 172655.539, 30.925), ..., (150679.329, 172655.5...
Closed	Closed In 3D
Coordinates (7)	Coordinate Dimension: 3
0	150679.329, 172655.539, 30.925
1	150679.277855, 172655.737296, 30.925
2	150681.441826, 172656.347034, 30.925
3	150682.247381, 172656.574013, 30.925
4	150682.870432, 172654.347639, 30.925
5	150679.855398, 172653.498099, 30.925
6	150679.329, 172655.539, 30.925

Features Selected: 1 of 1

Table View

UrbAdm3D_150172_Bu [GML] - RoofSurface — Columns...

Building | CityModel | CLOSURE | GroundSurface | RoofSurface

	gml_id	gml_parent_id	citygml_target_uri	citygml_feature_role	citygml_feature_role_attr_name	citygml_feature_role_attr_val	gml_description	gml_name	citygml_creationDate	citygml_terminationDate
1	GML_6449954	GML_1821000281	<missing>	boundedBy	<missing>	<missing>	<missing>	<missing>	<missing>	<missing>
2	GML_6449952	GML_1821000281	<missing>	boundedBy	<missing>	<missing>	<missing>	<missing>	<missing>	<missing>
3	GML_6449953	GML_1821000281	<missing>	boundedBy	<missing>	<missing>	<missing>	<missing>	<missing>	<missing>

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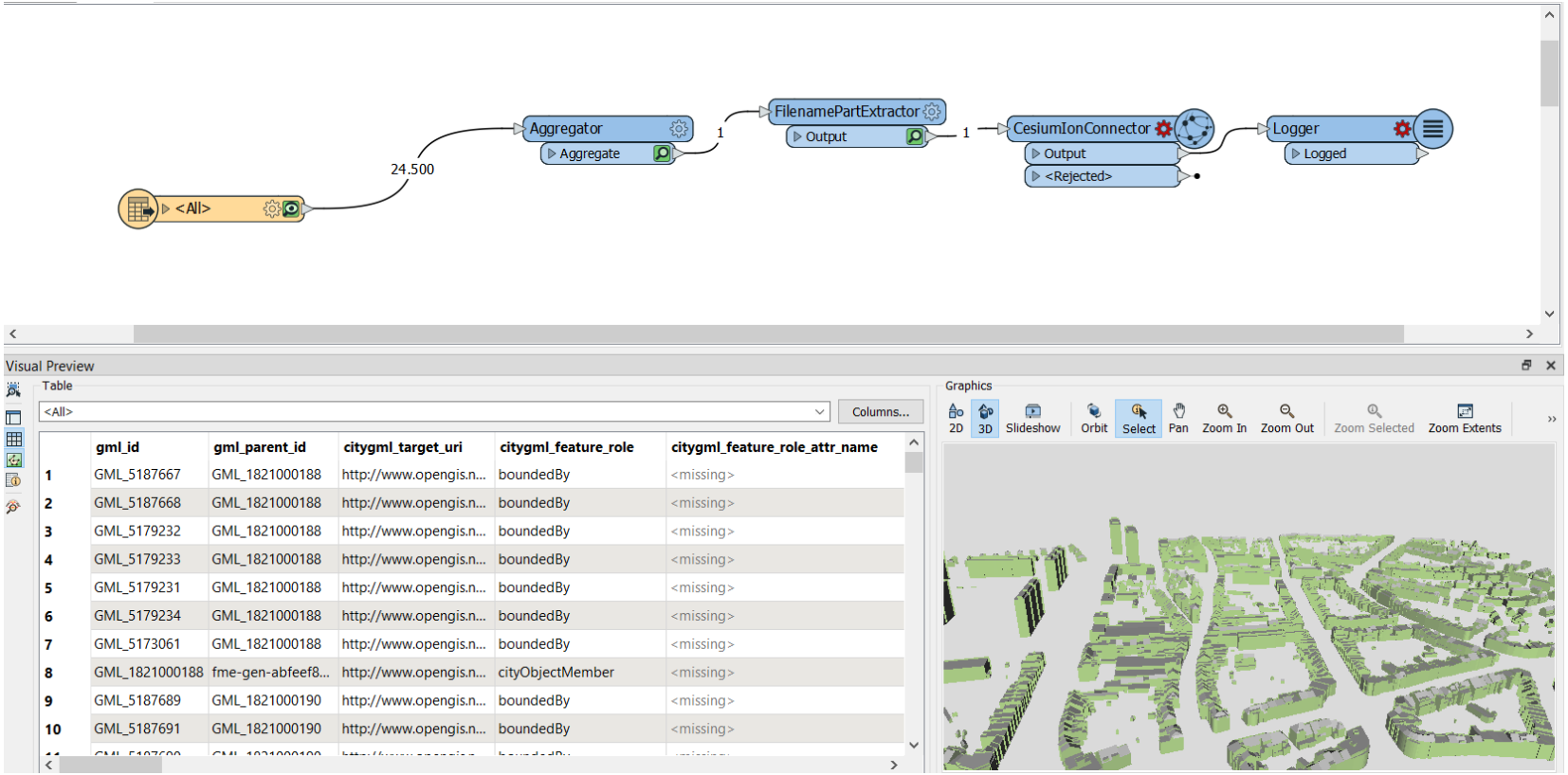
Démontration 2

CityGML & Cesium

Démontration 2 : 3D citydb , Cesium

- Create a Cesium account : https://cesium.com/ion/account
- Open FME workbench
- Read the CityGML file (Brussels 3D data)
- Prepare data for processing **“Agregator**”
- Add a **FilenamePartExtractor (directory path)**
- **Connect to Cesium “CesiumIconConnector”**

- https://cesium.com/learn/ion/integrations-learn/integrations-fme/



	gml_id	gml_parent_id	citygml_target_uri	citygml_feature_role	citygml_feature_role_attr_name
1	GML_5187667	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
2	GML_5187668	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
3	GML_5179232	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
4	GML_5179233	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
5	GML_5179231	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
6	GML_5179234	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
7	GML_5173061	GML_1821000188	http://www.opengis.n...	boundedBy	<missing>
8	GML_1821000188	fme-gen-abfeef8...	http://www.opengis.n...	cityObjectMember	<missing>
9	GML_5187689	GML_1821000190	http://www.opengis.n...	boundedBy	<missing>
10	GML_5187691	GML_1821000190	http://www.opengis.n...	boundedBy	<missing>

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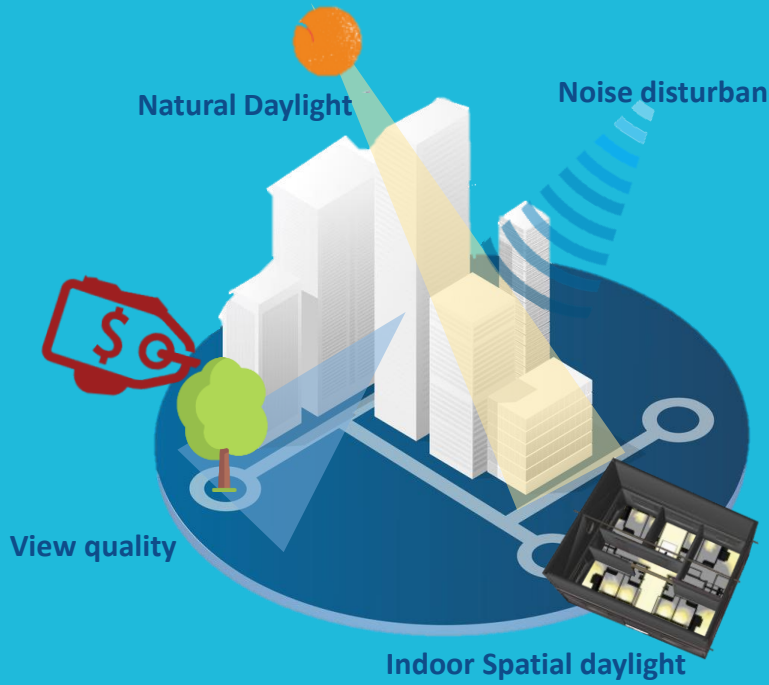
Démontration 3

BIM to GIS

https://community.safe.com/s/article/bim-to-gis-basic-ifc-lod-100-to-lod-2-citygml



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3D Property Valuation Modeling

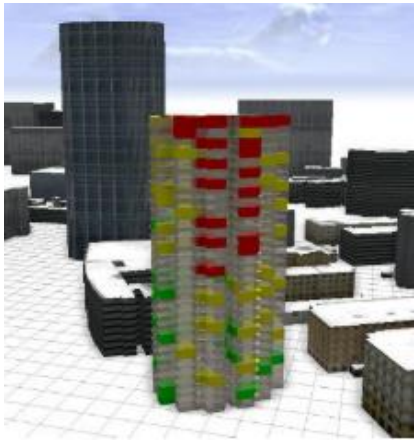
Use Case : real estate valuation

3D Property Valuation Models?

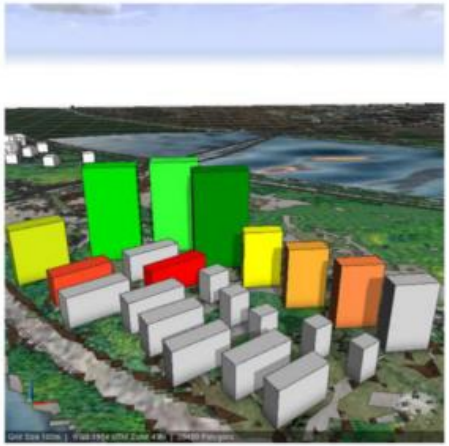
- *Property valuation* = process of determining an accurate estimate of the market price of a property.
- Property valuation should be performed in a 3D space.
- Property value is the association of indoor 3D objects and 3D elements from the outdoor's environment (El Yamani, 2019):
  - Indoor (e.g., quality; volume, height)
  - Outdoor (e.g., view, shadowing, pollution) .

- Integrating 3D modeling techniques and 3D data sources enhance the value estimation (Kara et al., 2020; Ricker, 2019; Zhang, 2019 et al. 2020)

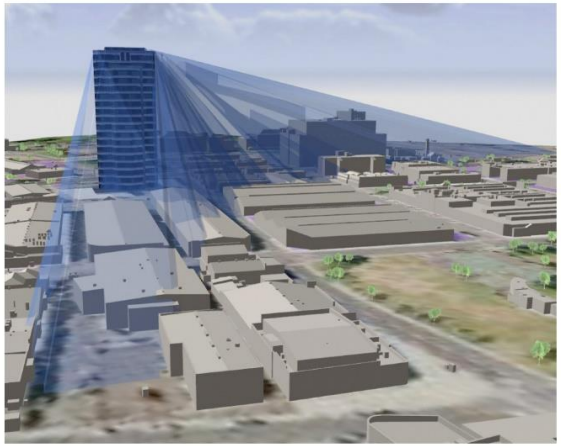
3D Variables simulation



3D sunlight



3D price variation - taxation



3D Visibility

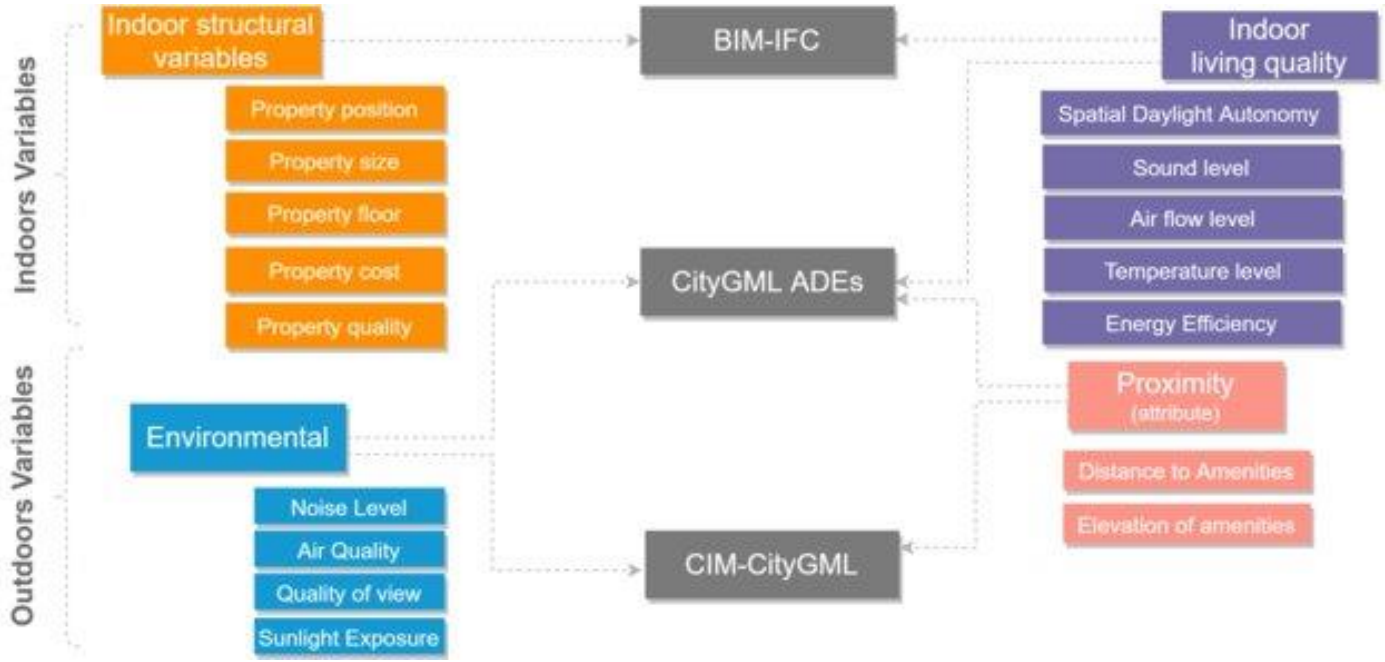
3D Valuation Models Limitations

- V.Models limited to specific contexts (e.g.,taxation).
- 3D techniques integration is mostly restricted to 3D visualization.
- 3D spatial analysis techniques and 3D data sources are not extensively explored or documented for variables simulation impacting property value.

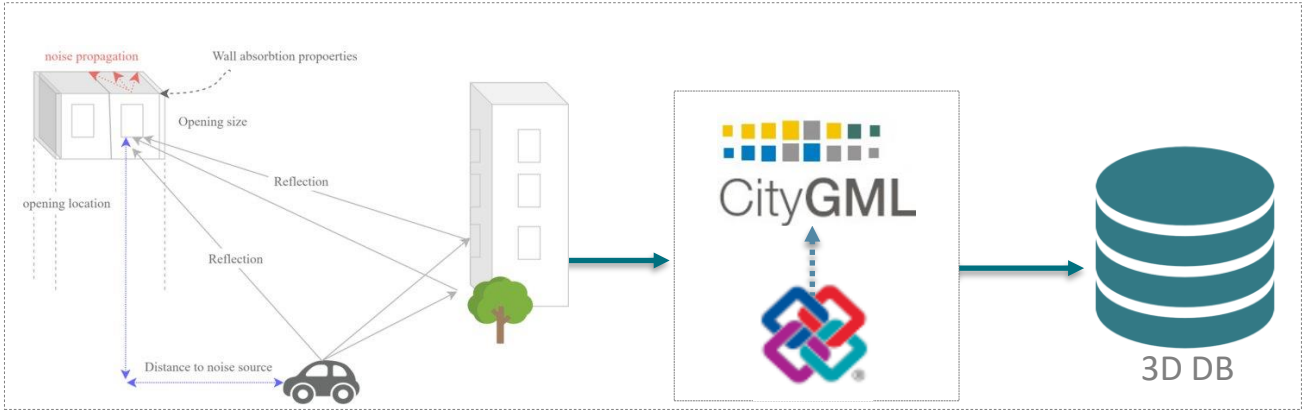
Introduce *Building Information Modeling (**BIM**)* and City information models ***(CIM),*** to model and simulate 3D variables, from indoors (e.g., IFC) and outdoors (e.g., CityGML), and integrated into 3D Property Valuation Model.

‘ADE-Valuation’

Introducing BIM/CIM to our Model



3D Variables Modeling process



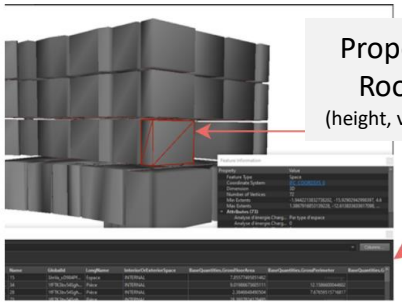
1. Variables Identification
(requirements, classification)

2. Variables Retrieval

3. Variables Implementation

4. Develop
"ADE-Valuation"

Stage 2: Variable's retrieval

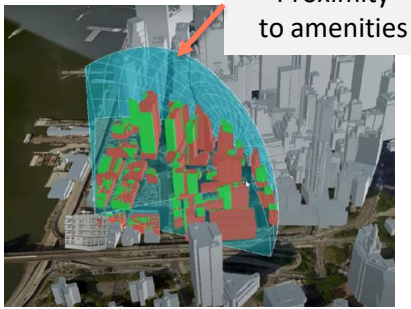


Property
Room
(height, volume)

Property
cost

Property
Floor

3D opening
localisation



Proximity
to amenities

3D visibility

Indoor variables

Outdoors variables

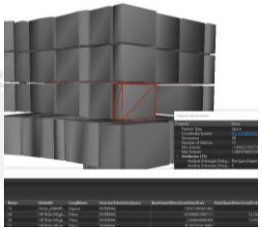
Stage : IFC/CityGML transformation

BIM Model

Export/
mapping

IFC

Mapping/
transformation



CityGML

Thank you!

Any questions?

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Publications

- **El Yamani, S**.; Hajji, R.; Nys, G.A.; Ettarid, M.; Billen, R. 3D Variables Requirements for Property Valuation Modeling Based on the Integration of BIM and CIM. Sustainability, 13, 2814.

- **El Yamani, S.;** Ettarid, M.; Hajji, R. Building Information Modeling Potential for an Enhanced Real Estate Valuation Approach Based on the Hedonic Method. In Building Information Modelling (BIM) in Design Construction and Operations III; WIT Press: Southampton, UK, 2019; Volume 1, pp. 305–316.

- **El Yamani, S.;** Hajji, R., BIM and 3D GIS Integration for Real Estate Valuation, ISTE Ltd, UK, December 2021, chapter 6, pp. 95-109.