

Workshop on 3D City Modelling and Urban Simulation

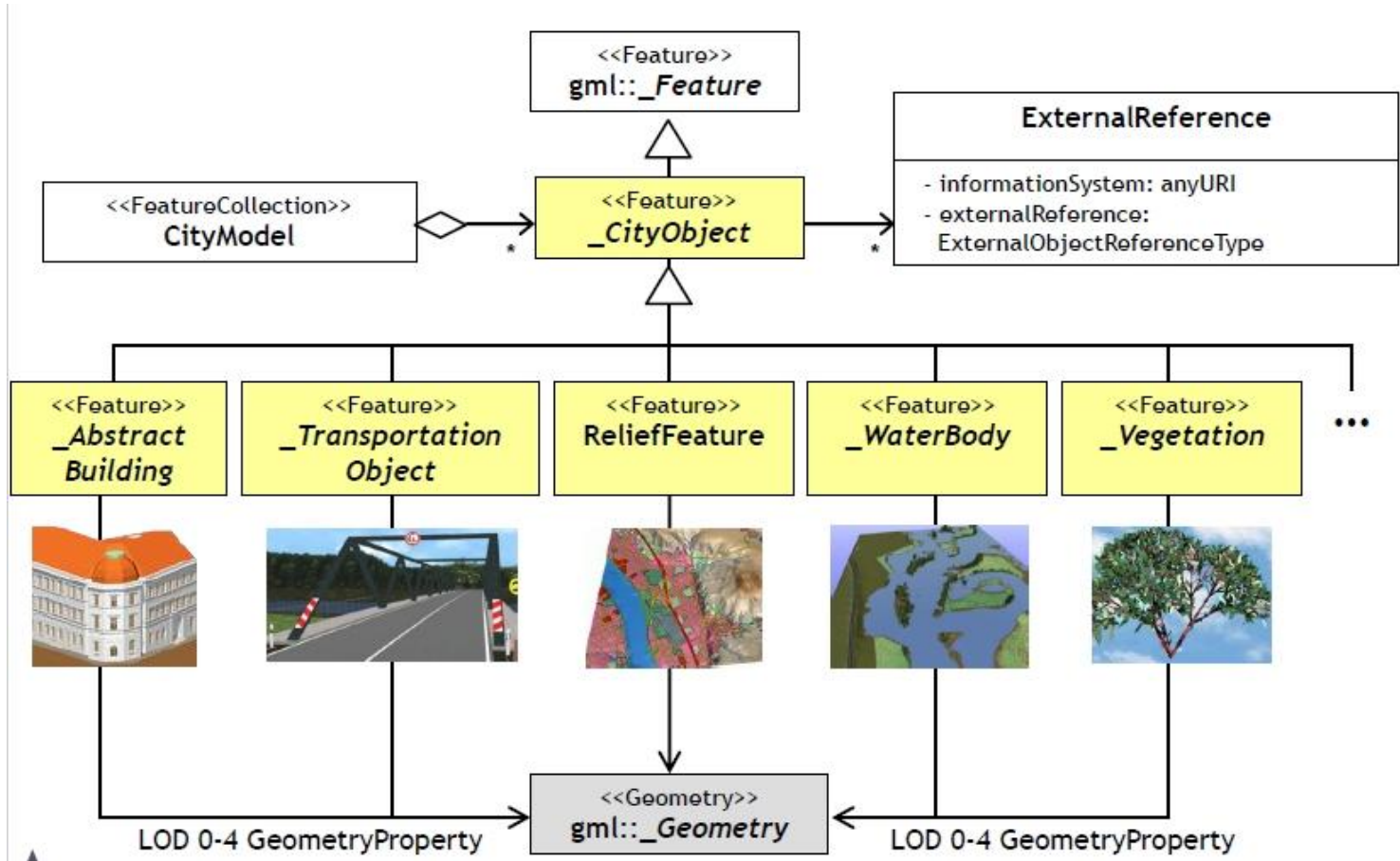
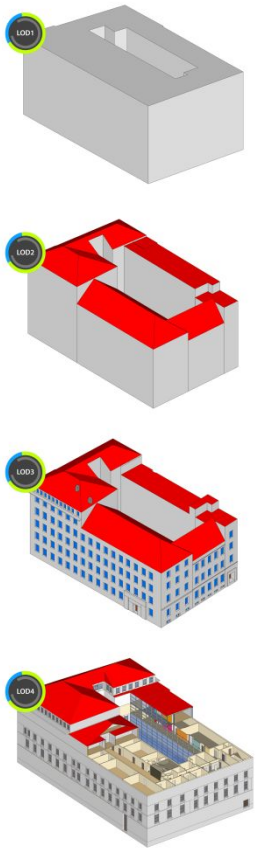
V. Coors, Hyderabad, 21.-22.12.2022

Building Blocks

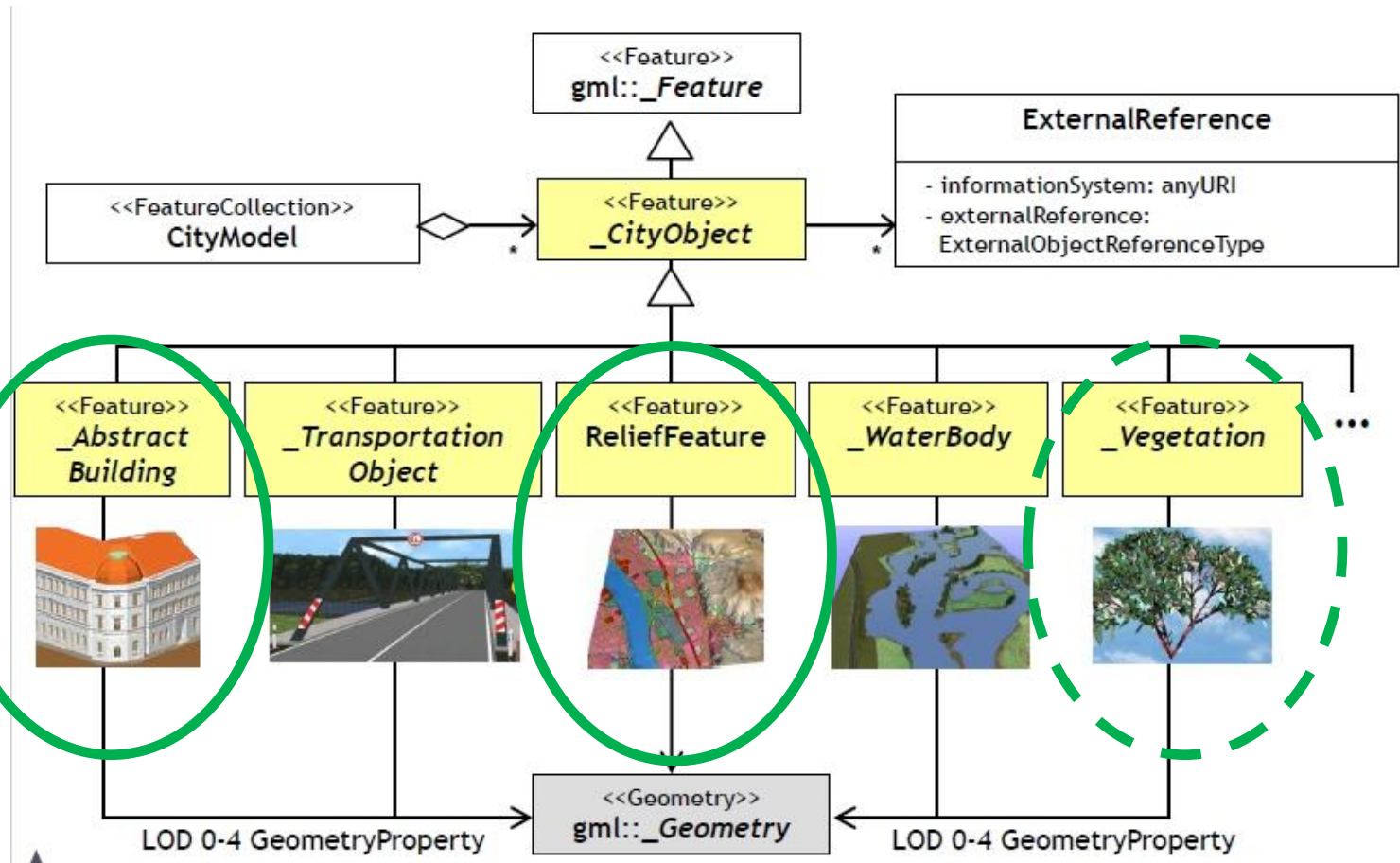
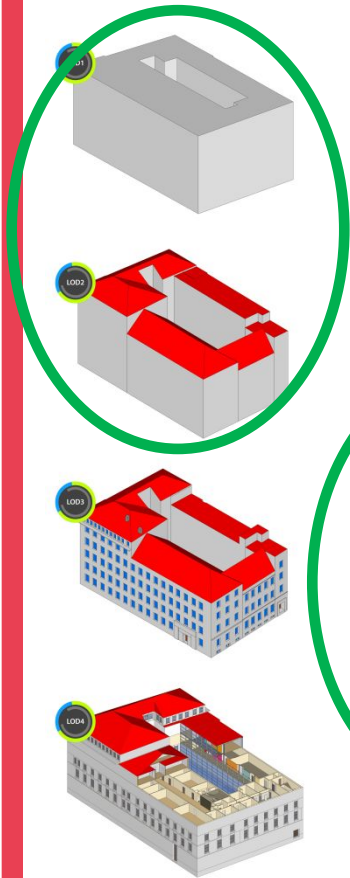
- 3D City and Landscape Model
- Simulation
- Visualization
- Measurements / Sensors



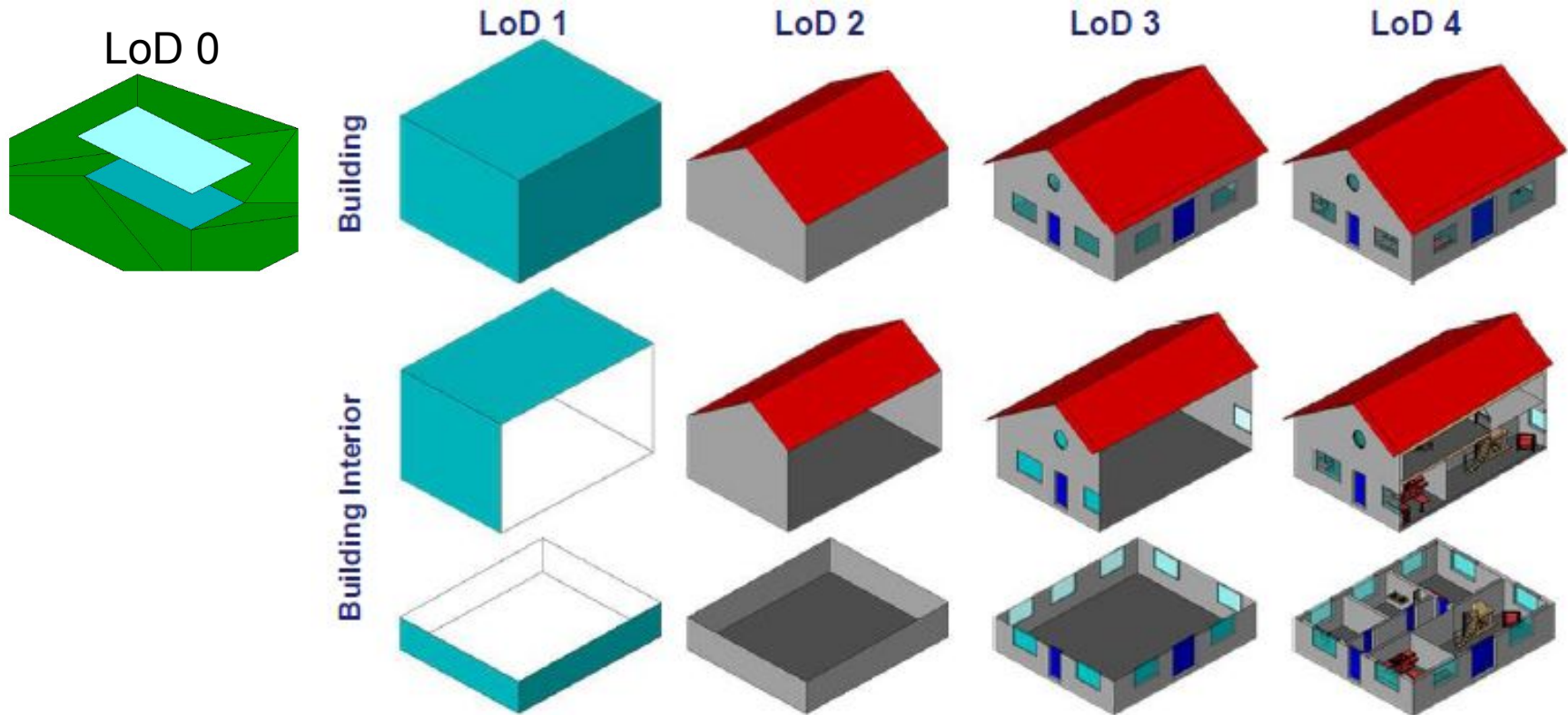
CityGML



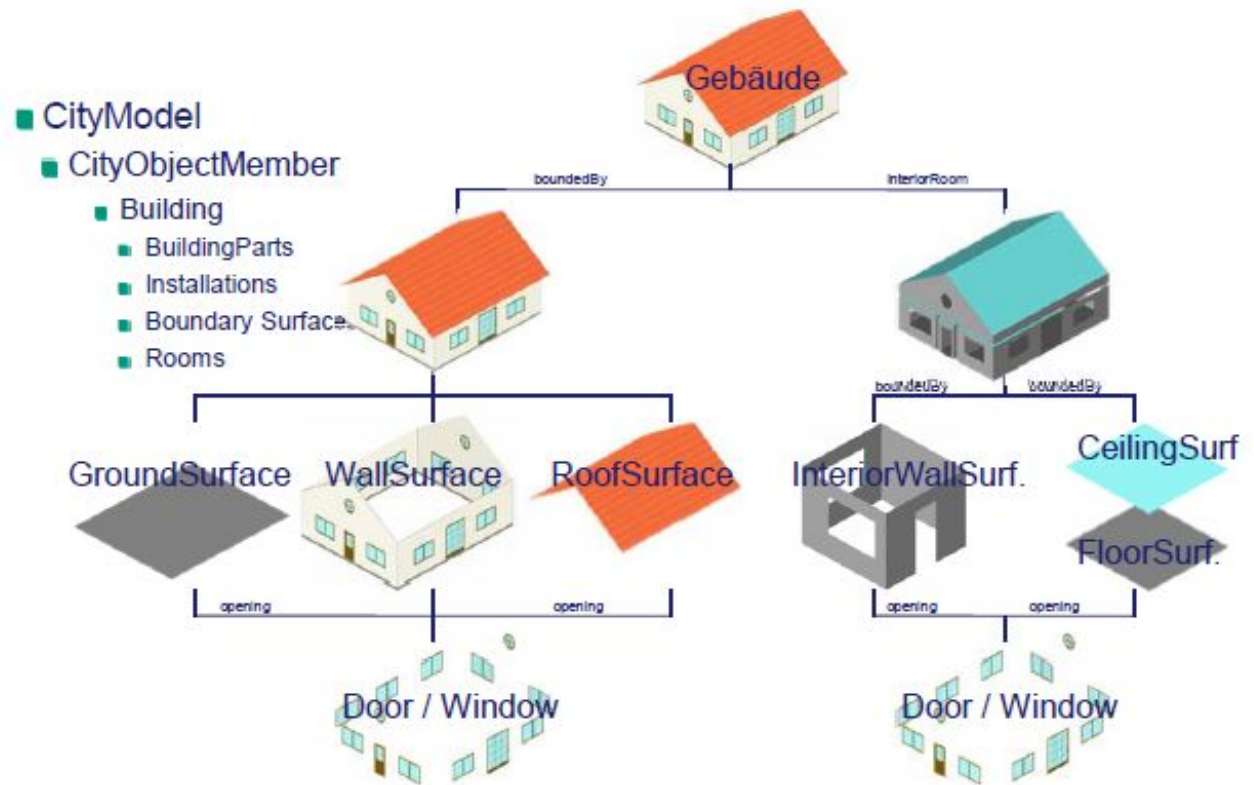
CityGML



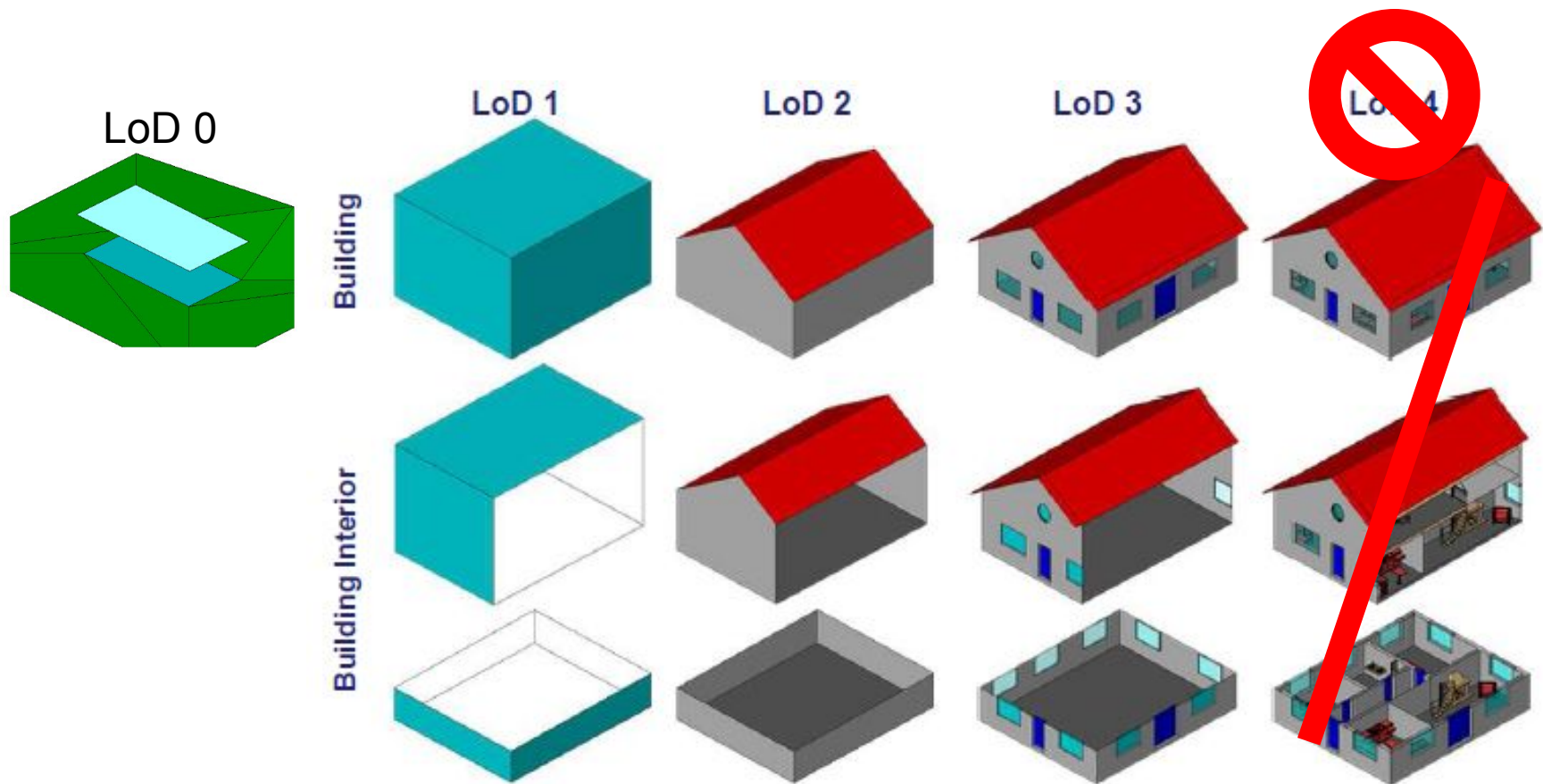
Building Model



Building Model



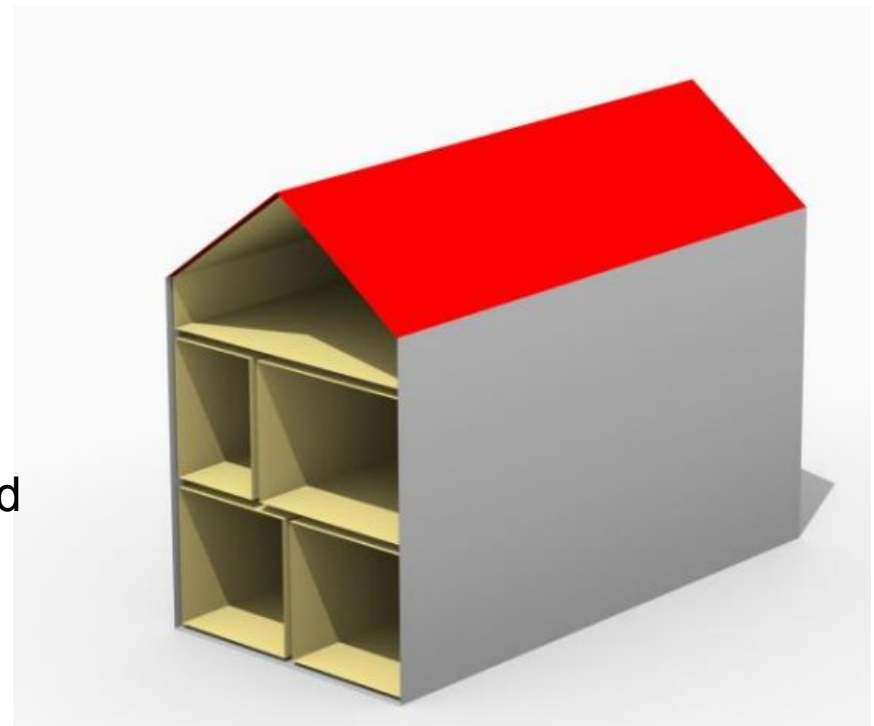
New LoD concept in CityGML 3.0



Interior in all LoD

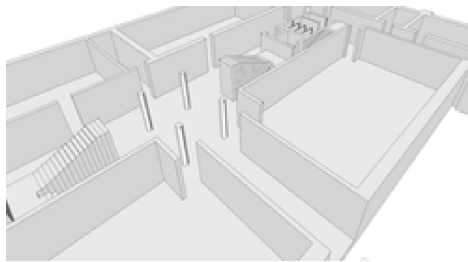
LoD 2 building model
with LoD 2 interior model (rooms)

More general:
Any building subdivision can be modeled
(rooms, Storeys, Apartments,...)

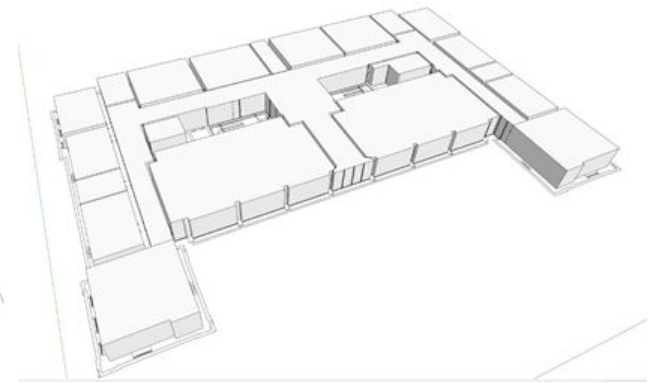
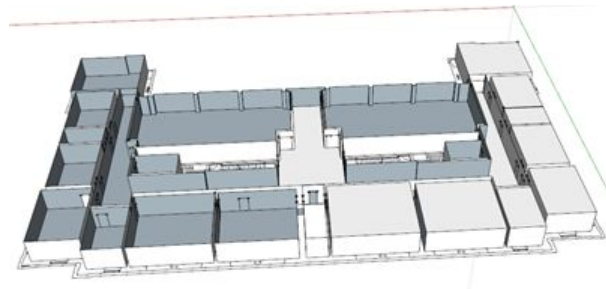


CAD / CityGML

- CAD/BIM-Model (Layer-based)
- Walls, ceiling, floor as volumetric elements
- In CityGML: Room

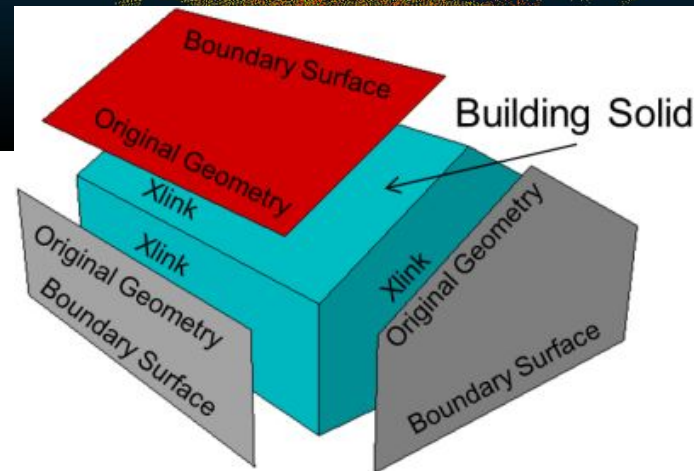
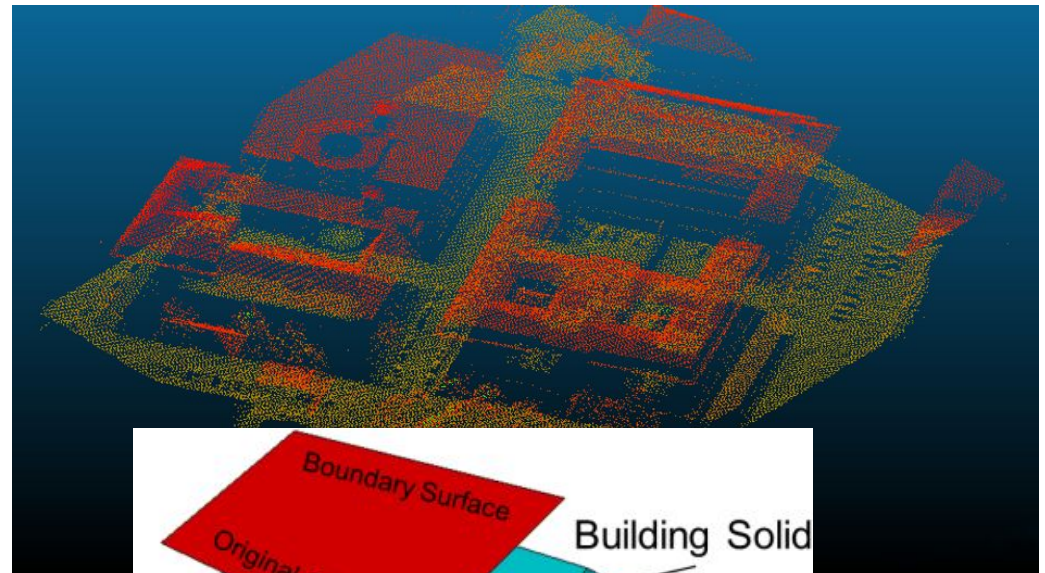
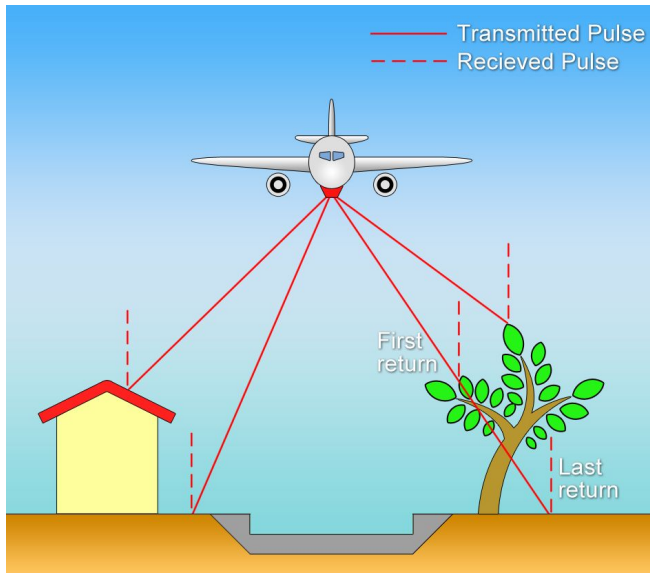


CAD / BIM Modell



CityGML Modell

3D Building Model



CityGML Tutorial

[Chapter 1: Introduction CityGML](#)

[Chapter 2: Building Module](#)

► [Click to expand](#)

[Chapter 3: Validation](#)

[Chapter 4: Application: Urban Simulation](#)

[Chapter 5: Visualization](#)

[Chapter 6: 3D City Modeling using ArcGIS CityEngine](#)

More Modules TBA

Extras:

- [Solid Geometrie in FME 2019](#)
- [Solid Geometrie in FME 2019 on youtube, Teil 1](#)
- [Solid Geometrie in FME 2019 on youtube, Teil 2](#)
- [Adding an attribute to the CityGML dataset \(with attribute-join\)](#)
- [Rhinceros3D/ArcGIS CityEngine \(2D/3D Shapefile\) to CityGML v2.0 \(Building/BuildingPart\) in LoD 1 and LoD 2](#)

<https://transfer.hft-stuttgart.de/gitlab/coors/3d-stadtmodelle/-/wikis/EN/CityGML-Tutorial>

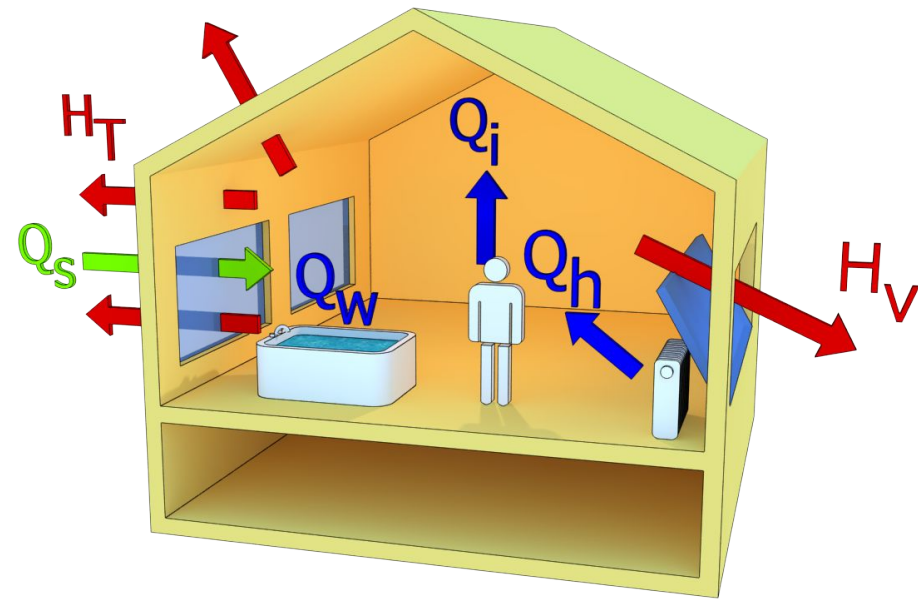
Building Blocks

- 3D City and Landscape Model
- Simulation
- Visualization
- Measurements / Sensors



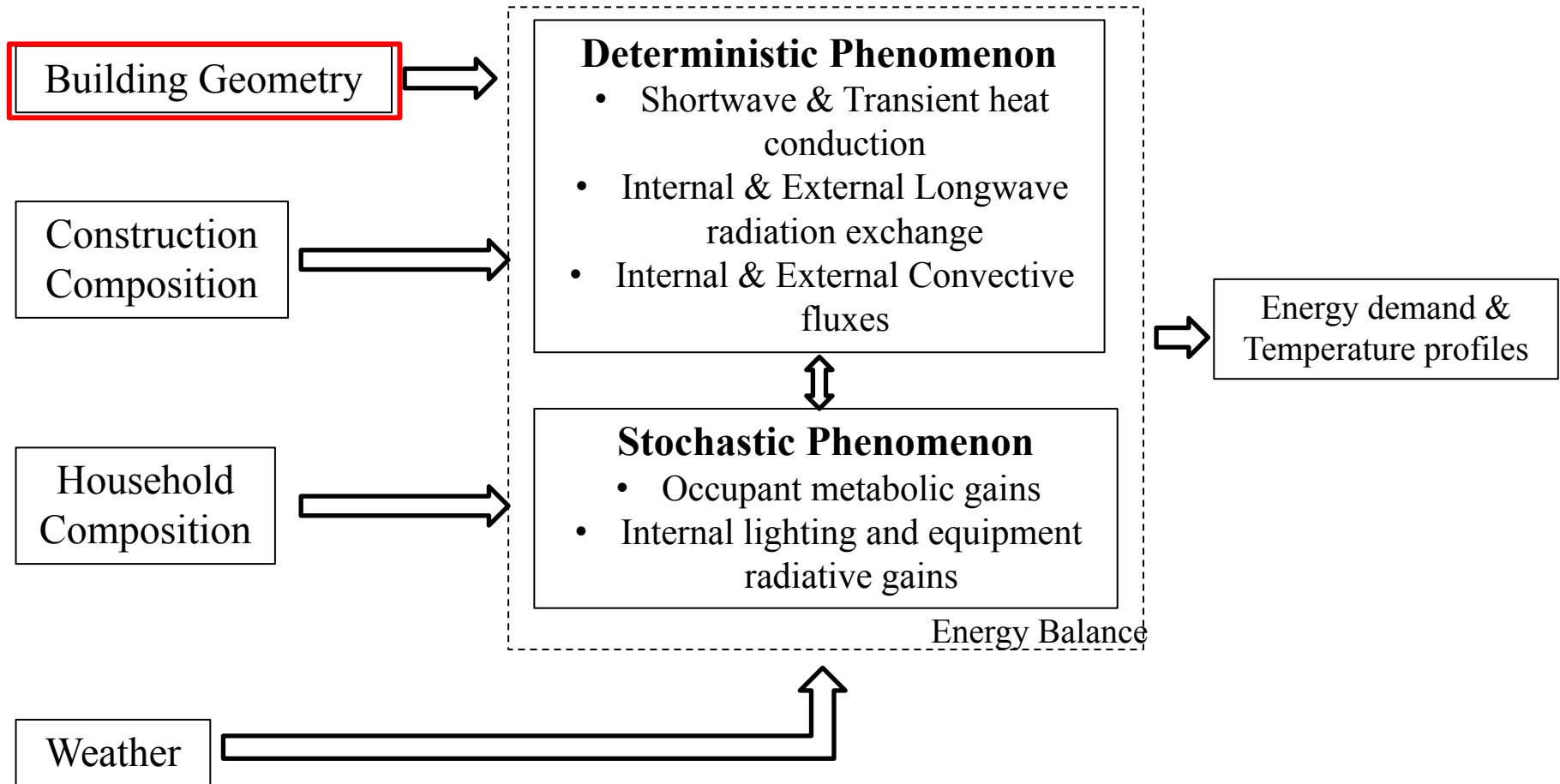
Heating demand

- Q_h heating demand
- Q_w hot water heating demand
- Q_s solar gains
- Q_i internal gains
- H_T transmission heat loss
- H_V ventilation losses



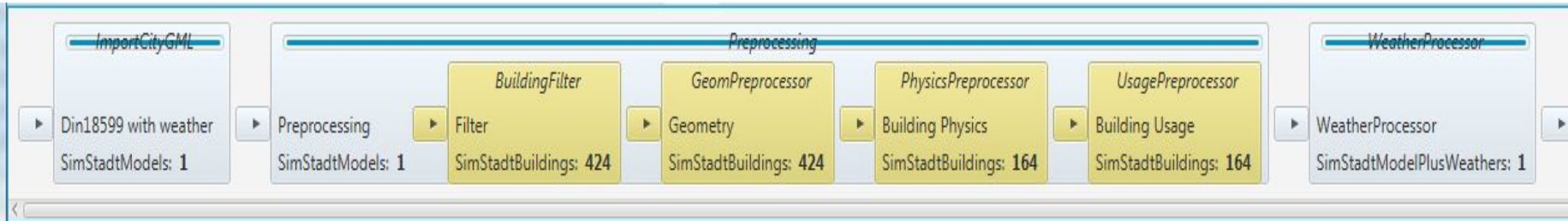
Hochschule für Technik Stuttgart

Simulation Model Components

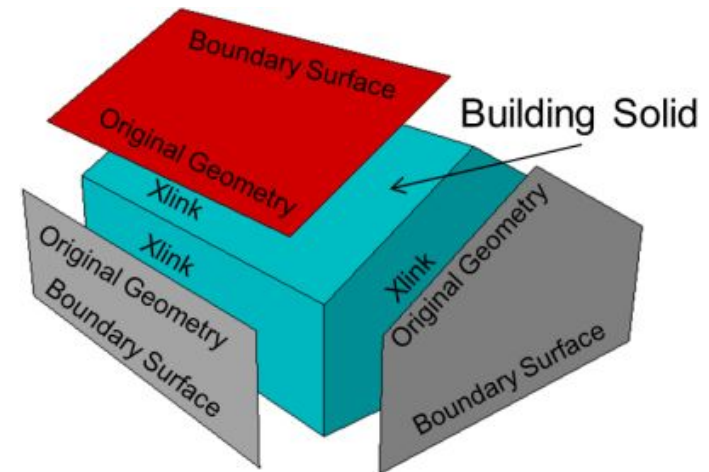


Questions to be investigated: To what extent does the uncertainty in building geometry affects the energy estimation predictions or rather is there any significant impact at all?

SimStadt Workflow

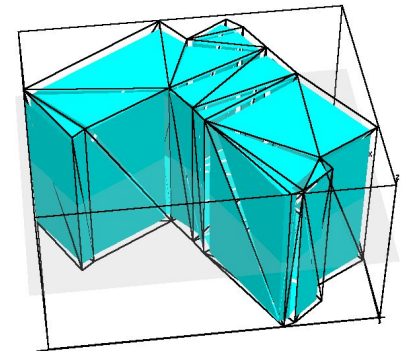
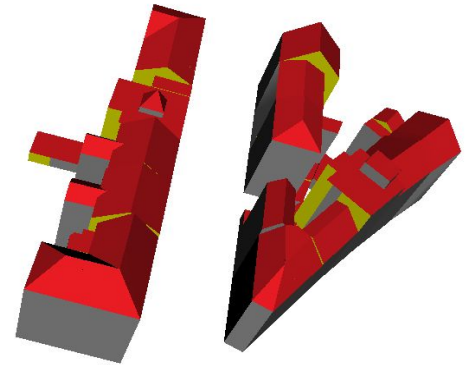


- Input:
 - 3D Citymodel ++
 - CityGML & Energy ADE
 - Weather data
- Simulation
 - Heating demand per building
 - DIN V 18599 Monthly Energy Balance
 - Refurbishment scenarii
 - Irradiation
 - District heating network layout



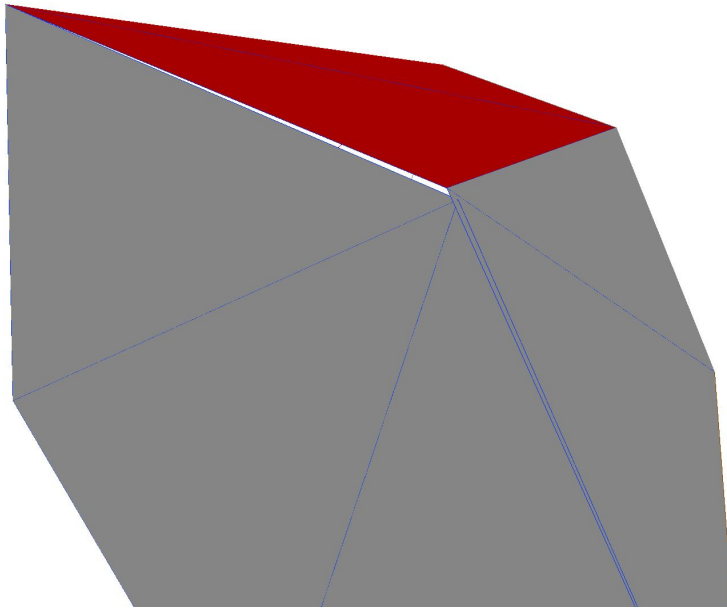
Attributes derived from 3D Geometry

- **Volume [m³]**
- Roof Area [m²]
- sun / wind exposed Wall Area [m²]
- **Wall area to builings [m²]**
- Area Groundfloor [m²]
- Orientation Wall-/Roofsurfaces
- Number of storeys (if not in the dataset)
- Building Typology (classification)

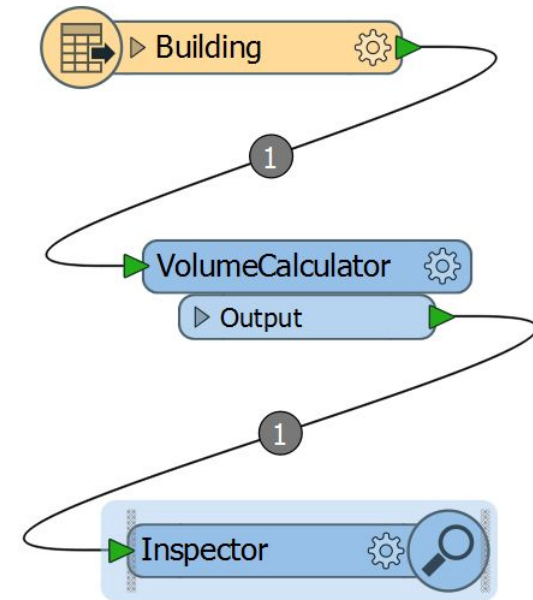


$$V = \sum_{i=1}^n \frac{|\det(a_i - b_i, b_i - c_i, c_i - d_i)|}{6}$$

Solid Geometry



Ground Surface 3m x 5m
Eaves Height: 3m
Ridge Height: 4,5m
Volume: 56,25 m³

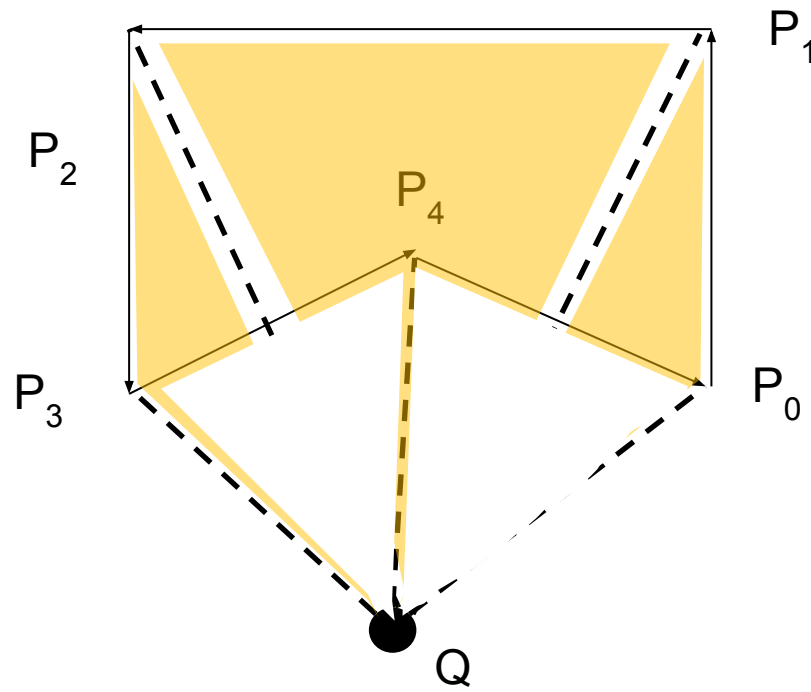


FME Workflow
Volumenberechnung

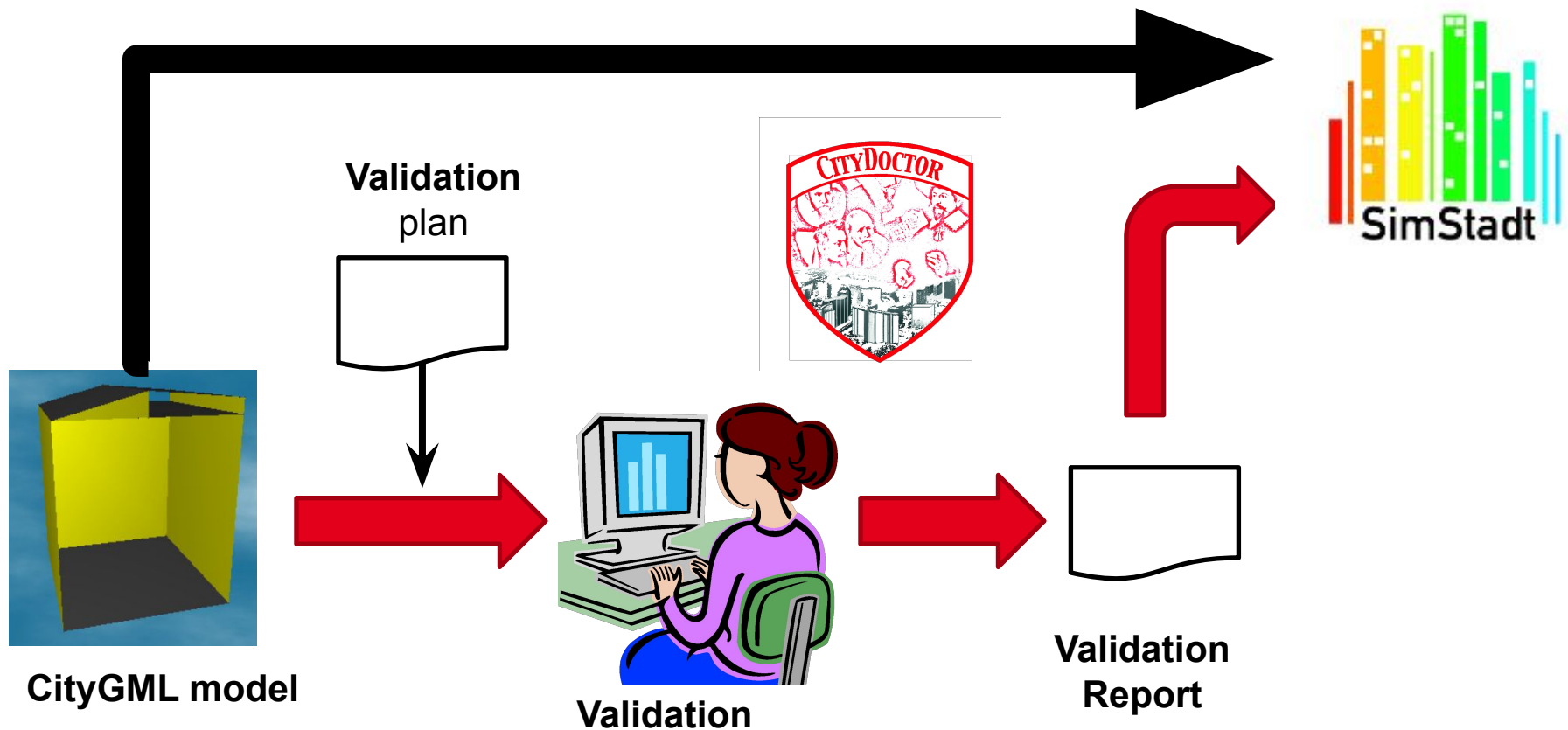
Volume

error		Volumen [m ³]
No error		56,25
GE-gml:PO-NUMPONITS		48,75
GE-gml:PO-DUPPOINT-2	Self intersection	52,5
GE-gml:PO-DUPPOINT-3	Duplicated line	56,25
GE-gml:PO-PLANAR	No planar surface	52,5
GE-gml:SO-POLYPEREGDE-1	Minimal hole	56,1875
GE-gml:SO-POLYPEREDGE-2	Large hole	37,5
GE-gml:SO-FACEORIENT	Face orientation	18,75

Why?



Does the 3D model fits simulation demands?



CiD4Sim



City Doctor Validation Plan for SimStadt (CiD4Sim)

- Based on CityGML Quality Interoperability Experiment OGC 16-064r1
- Implementation Independent
- <https://gitlab.com/volkercoors/CiD4Sim/wikis/home>

Validation (batch process)

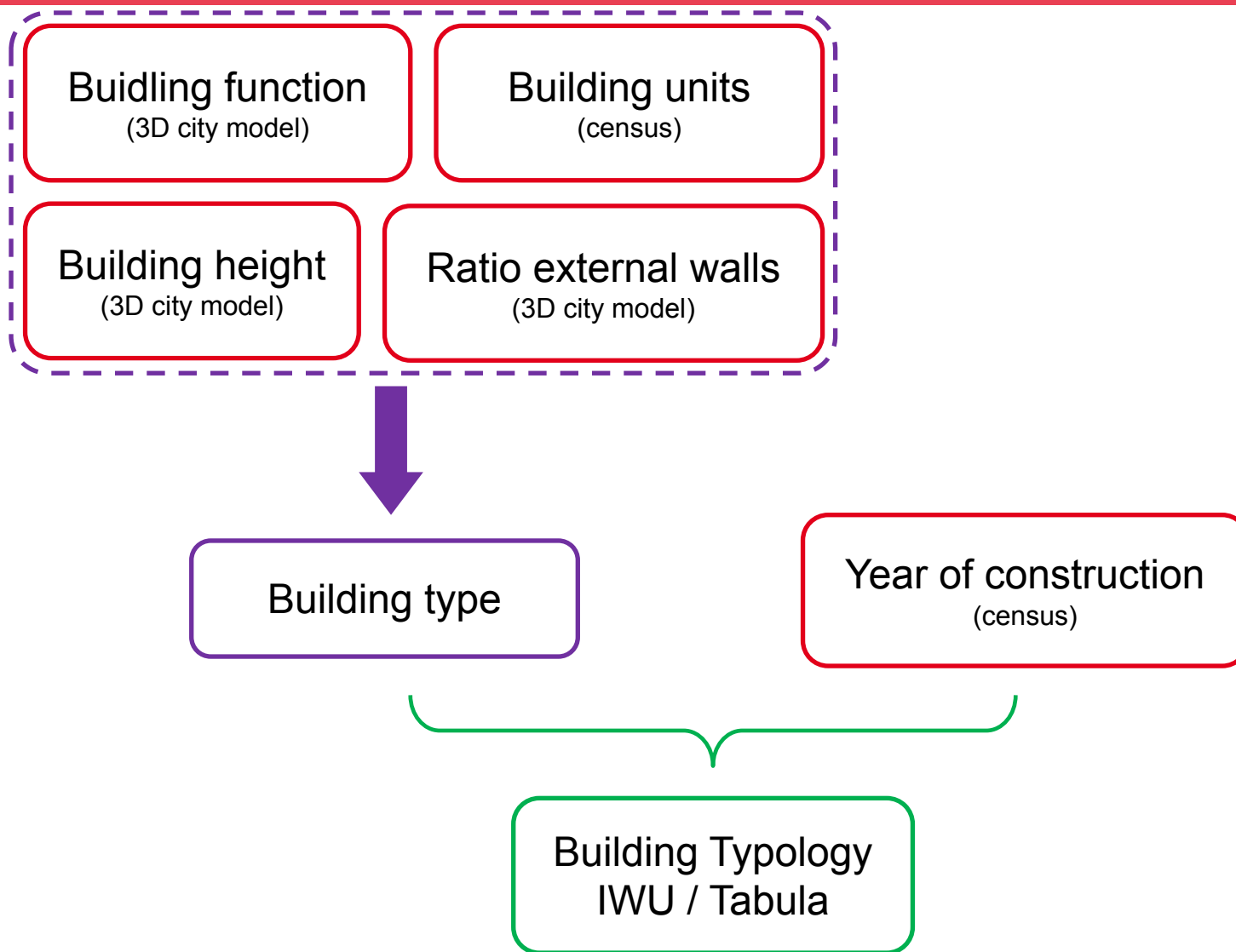
Streaming 3.3 GB CityGML-File checked in 4m 50s

- Machine: Windows, i5-2400 @ 3.10 GHz
- Using < 2 GB RAM
- Using 1 Core
- Output: Report-File (xml or pdf)

Errors:

- 20% Buildings, 0% Vegetation, 11% Transportation, 28% LandUse, 0% Bridge, 7%Water, 15%Overall

Use of building typology to fill data gaps



Deutsche Gebäudetypologie

Systematik und Datensätze

UND UMWELT GmbH

Annastraße 15

64285 Darmstadt

Telefon: (0049) 06151/2904-0

Telefax: -97

eMail: info@iwu.de

Internet: <http://www.iwu.de>

Stand: 22. Juni 2005

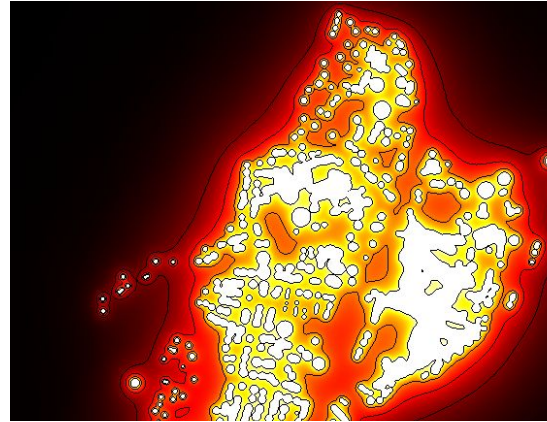
Baualtersklasse			EFH	RH	MFH	GMH	HH
A	vor 1918	Fachwerk	EFH_A 		MFH_A 		
B	vor 1918		EFH_B 	RH_B 	MFH_B 	GMH_B 	
C	1919-1948		EFH_C 	RH_C 	MFH_C 	GMH_C 	
D	1949-1957		EFH_D 	RH_D 	MFH_D 	GMH_D 	
E	1958-1968		EFH_E 	RH_E 	MFH_E 	GMH_E 	HH_E 
F	1969-1978		EFH_F 	RH_F 	MFH_F 	GMH_F 	HH_F 
G	1979-1983		EFH_G 	RH_G 	MFH_G 		
H	1984-1994		EFH_H 	RH_H 	MFH_H 		
I	1995-2001		EFH_I 	RH_I 	MFH_I 		
J	nach 2002		EFH_J 	RH_J 	MFH_J 		

EFH_B			
e mit 126,9 m ² Wohnfläche			
isierung:		48.423 kWh/Jahr	
verbrauch		30 kW	
größe ca.:			
isierung:		17.080 kWh/Jahr	
verbrauch		11 kW	
größe ca.:			
chung s sind fett)	U-Wert neu	Mehr- kosten gegen- über reiner Instand- setzung	Kosten je eingesp. kWh
	W/(m ² K)	€/m ²	€/Cent/kWh
ystem 12	0,28	30 €/m ²	1,9
mit iten	0,42	14 €/m ²	1,8
	0,38	14 €/m ²	2,4
	0,45	14 €/m ²	1,4
egebar)	0,16	29 €/m ²	4,2
hen (12	0,18	28 €/m ²	2,7
	0,20	28 €/m ²	1,0
cheiben- g	1,60	10 €/m ²	2,2
	1,60	10 €/m ²	2,2
PK) (m ² K)	(Fenster inkl. Rahmen)		

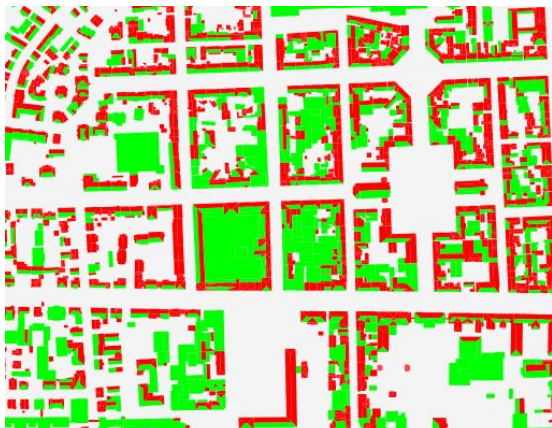
Results SimStadt



Heating Demand and Scenarios



Heat Density Map



PV Potential



District Heating Network Extension

„What if“ Scenarios:

Refurbishment rate needed to achieve climate goals by 2050?

Energy ADE

http://www.citygmlwiki.org/index.php/CityGML_Energy_ADE

**Time
series**

**Energy and
Systems**

**Energy ADE
Core**

**Construction
and Material**

**Occupancy
and Schedule**

Landkreis Ludwigsburg

- 34 municipalities
- Similar Approach
- 3D city model provided by the state surveying (LGL BW)
- census data was not allowed to use
- Year of construction and building typology data bought from a private company
- Some municipalities provided own data sets

EnSysLE Dashboard



EnSysLE Dashboard

[Back to main page](#)

2D 3D

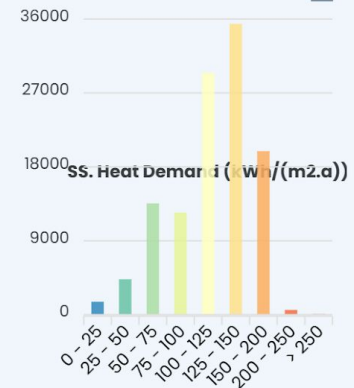
Select Area

Ludwigsburg

Building Energy Simulation

Specific Heat Demand

Building shadow



Specific space heating demand

($\text{kWh}/(\text{m}^2\cdot\text{a})$)

EnSys-LE Dashboard

The application visualizes the simulation of renewable energy potentials as well as the heating and electricity demand of buildings in exemplary counties. It can be used by local stakeholders for various applications such as to access potential sites for renewable energy production or possible district heating systems.

Ilm-Kreis

Dithmarschen

Ludwigsburg

<https://transfer.hft-stuttgart.de/pages/ensysle/application/index.html>

Supported by:

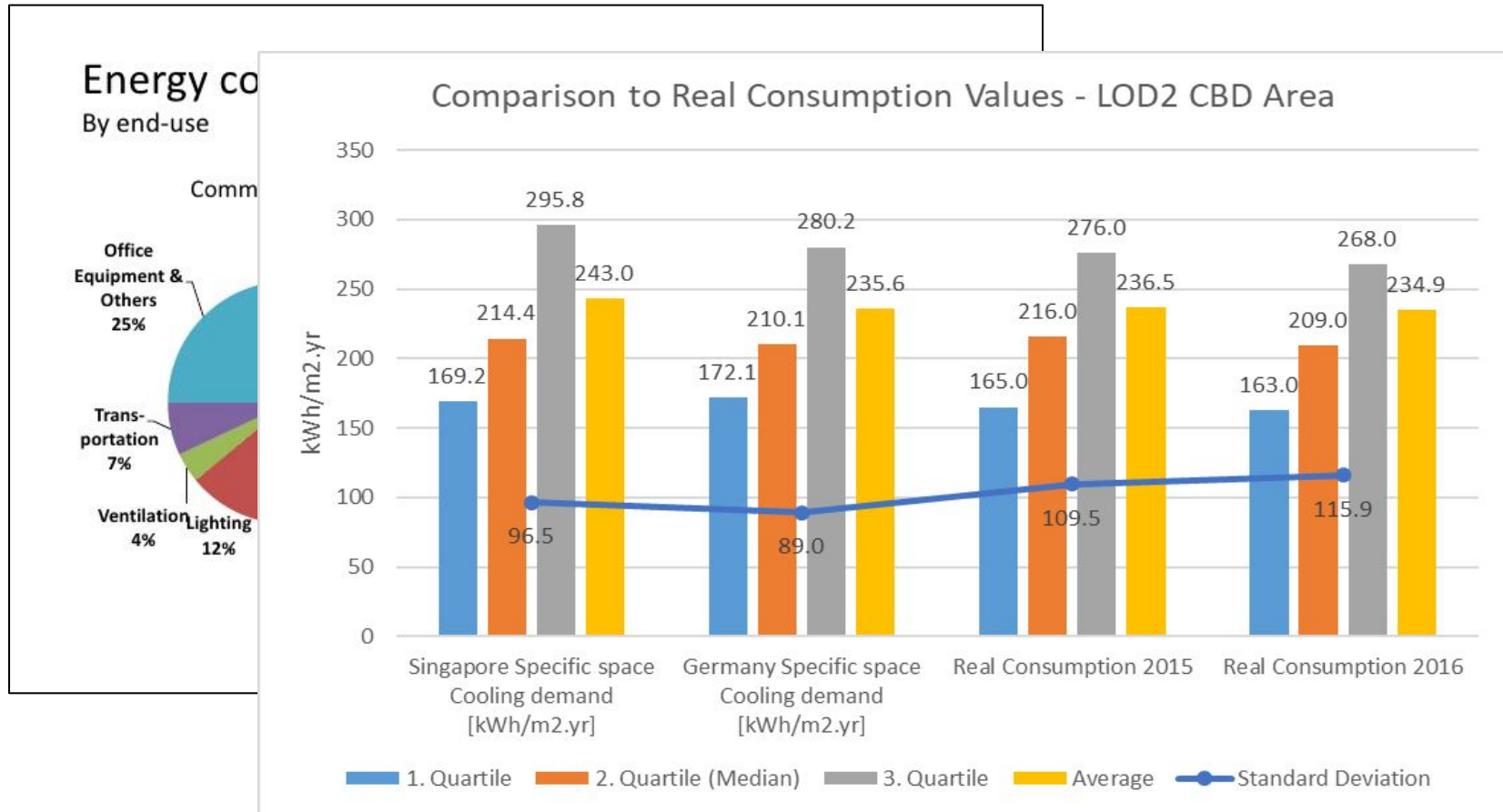


Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

Hochschule für Technik Stuttgart

Urban Simulation: SimStadt Cooling Demand Singapore

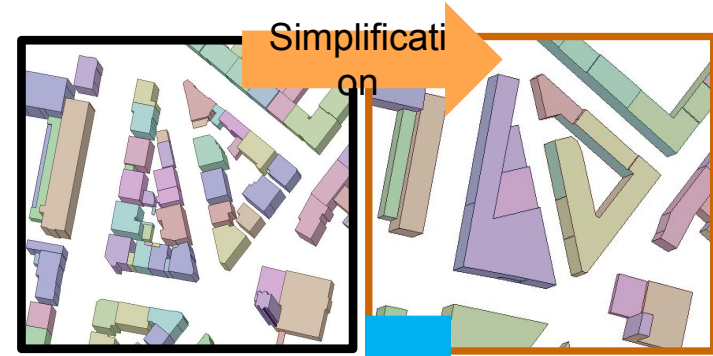


M. Fitzky, Simulation of Cooling Energy Demand Using the 3D Citymodel of Singapore, Master Thesis SS 2019, HFT Stuttgart & Singapore Land Authority (SLA)

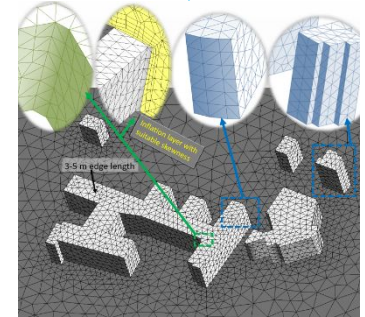
CFD Simulation



Geometry

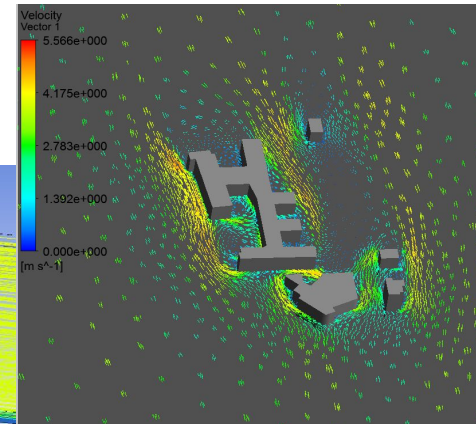
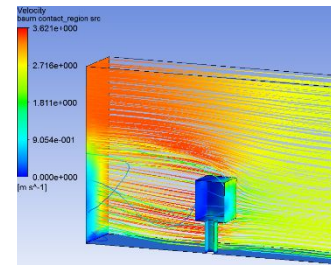


Simplification & Meshing

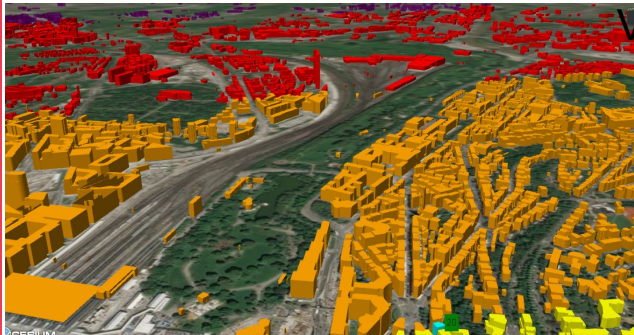


Urban Data platform

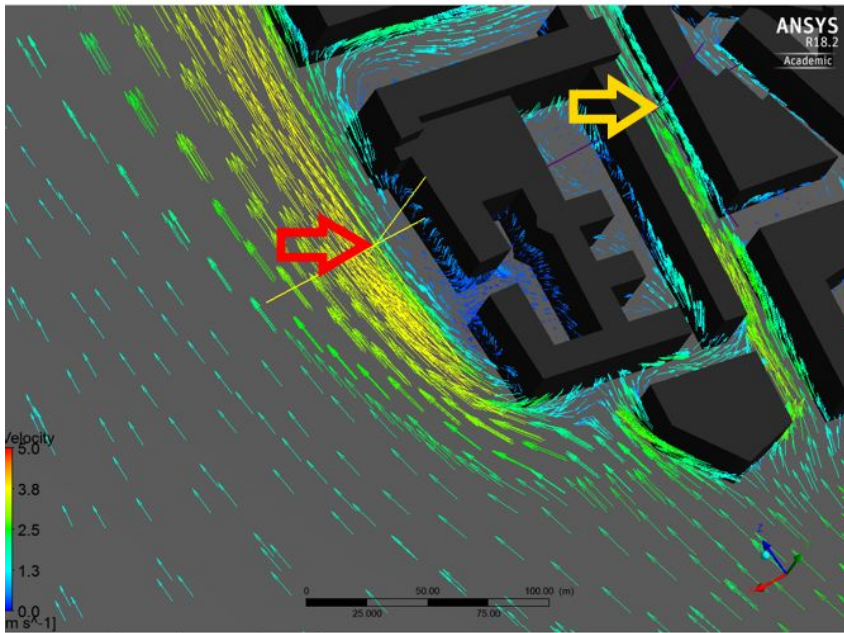
Simulation



Visualisation



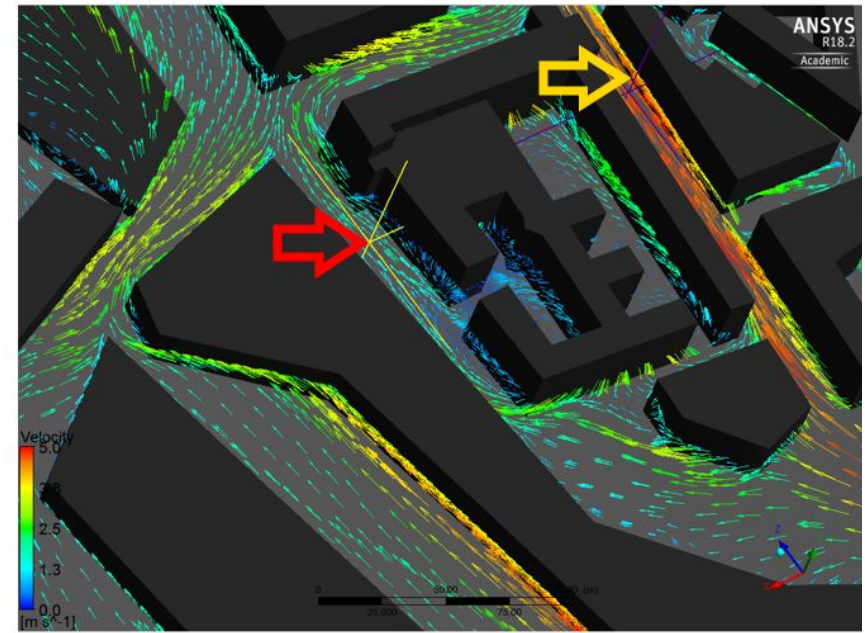
Beyond Buildings: 3D Landscape Model



Simulation ohne Vegetationskörper:

Pfeil rot: 2,9 m/s

Pfeil gelb 2,2 m/s



Simulation mit Vegetationskörpern:

Pfeil rot: 1,6 m/s

Pfeil gelb: 4,5 m/s

L. Rothengaß, Master –Thesis Vermessung

Generierung und Evaluierung eines 3D-Landschaftsmodells für eine CFD-Windsimulation

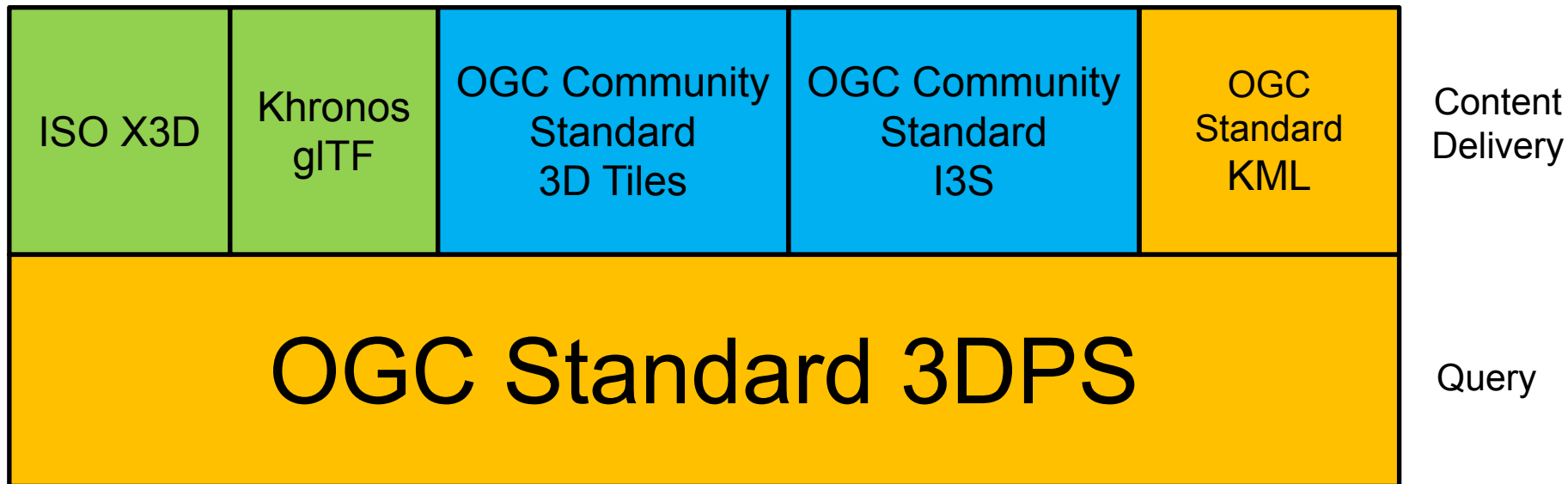
Building Blocks

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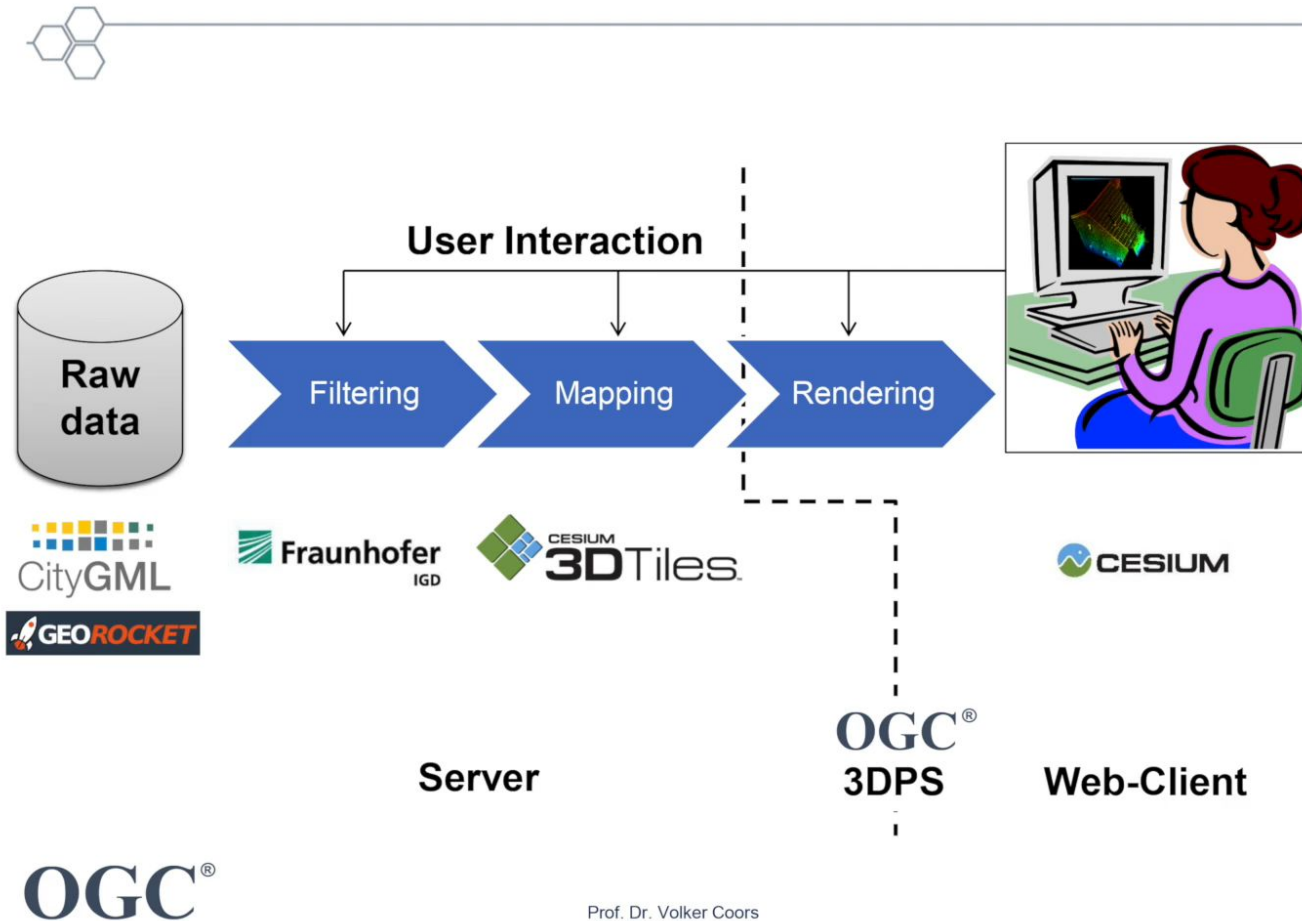


3D Portrayal Service

<https://github.com/engeospatial/3DPS>

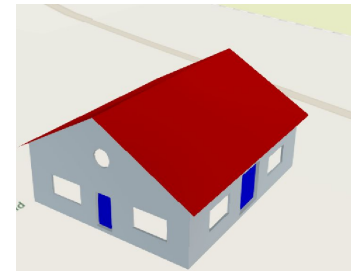
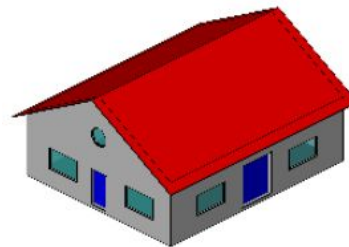
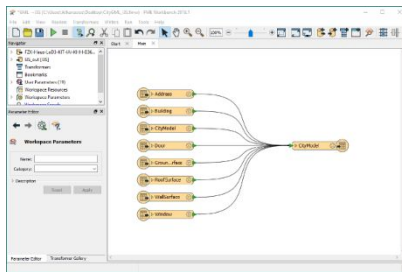
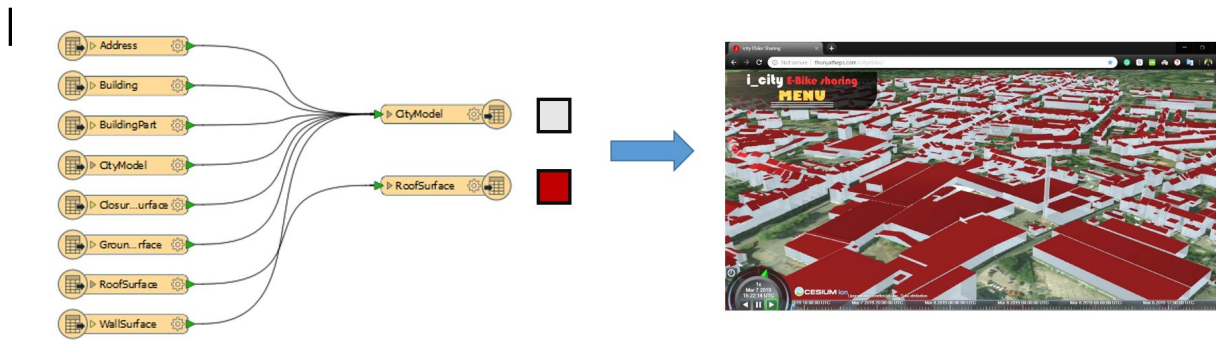


Experiment #2



Prof. Dr. Volker Coors

FME to generate 3D Tiles & I3S



<http://193.196.37.89:8085/app/>

Building Blocks

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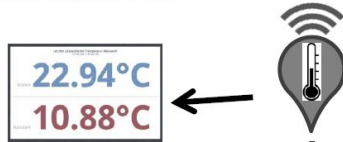
Smart Villages –

Unsere Anwendung

Partnerkommune



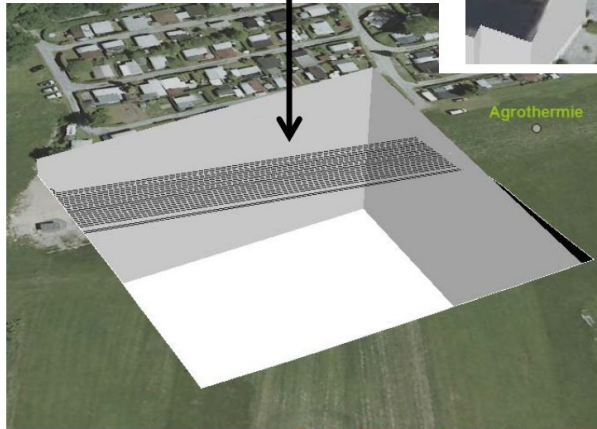
Echtzeitdaten



Sensor



Statistikdaten

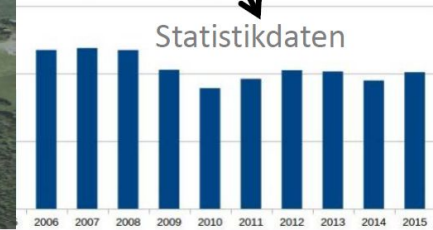


Agrothermie

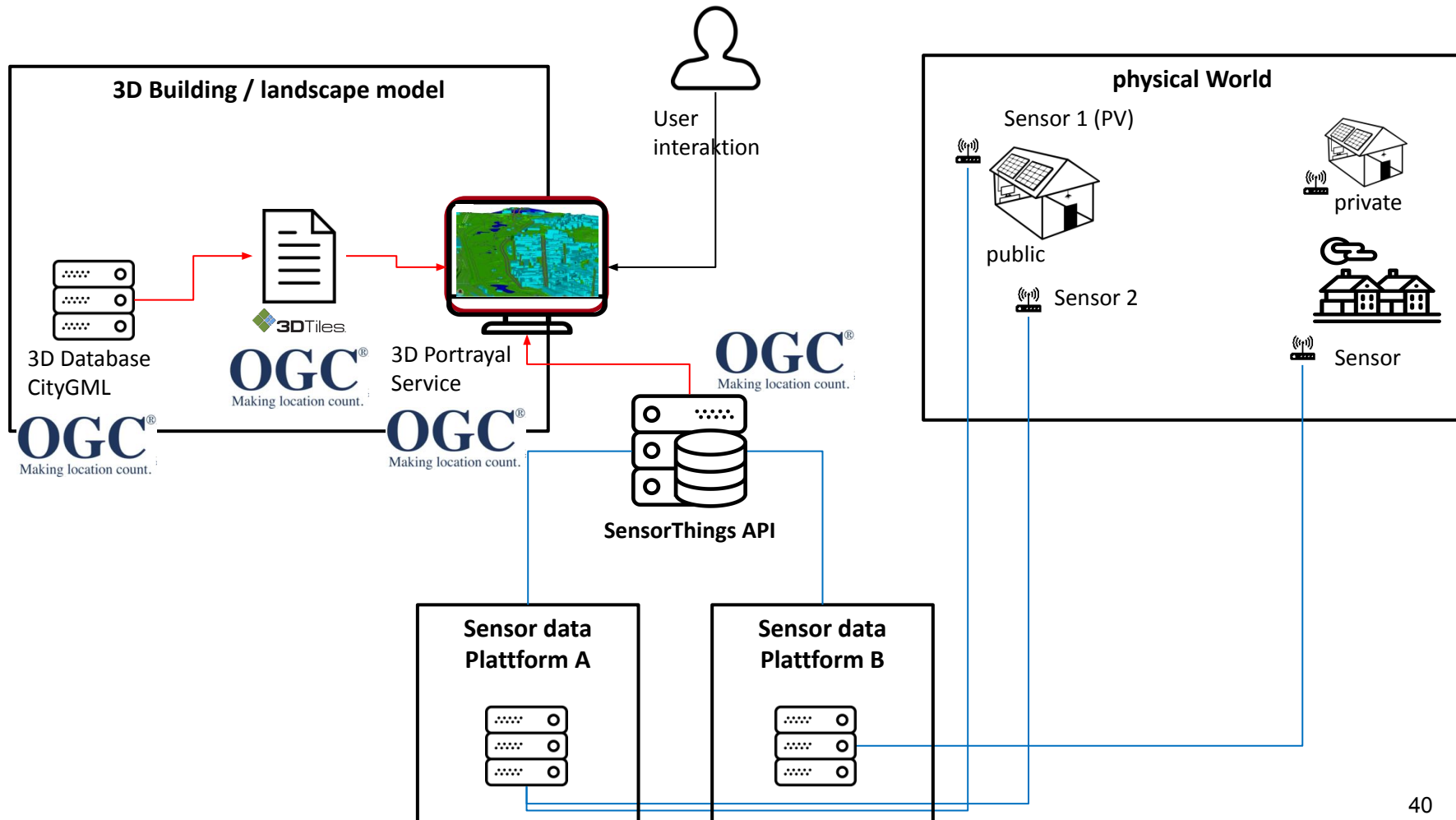


Sensor

Statistikdaten

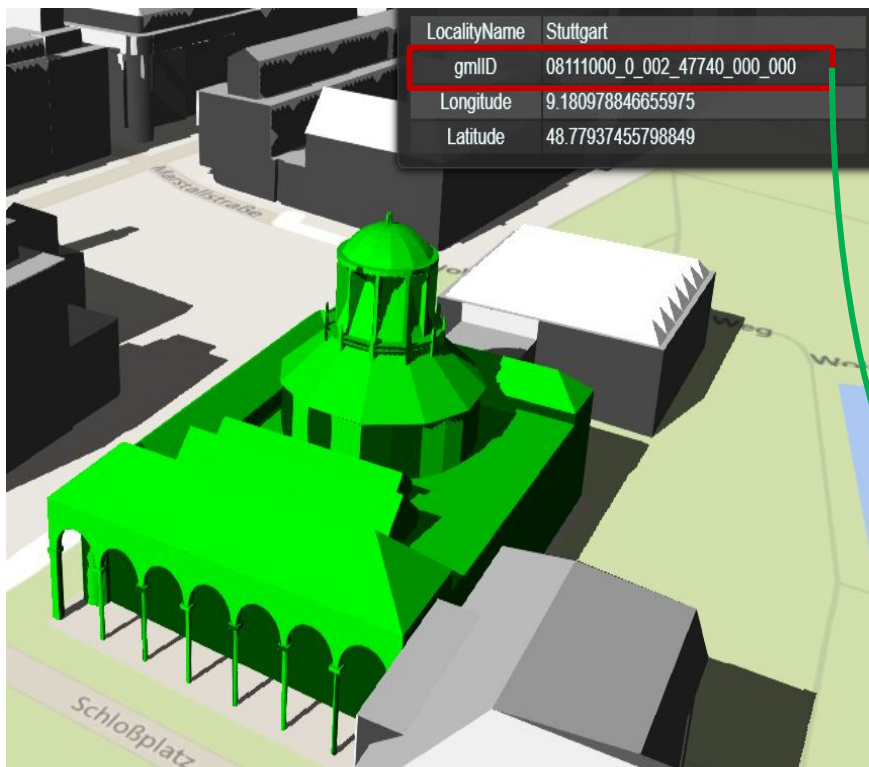


Connecting Sensors

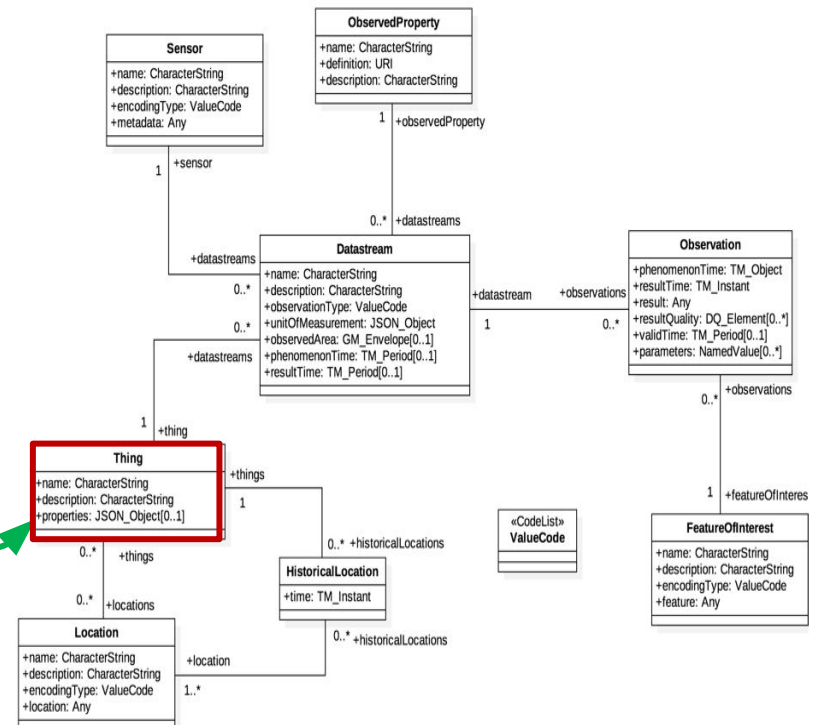


Connecting Sensors and 3D City Model

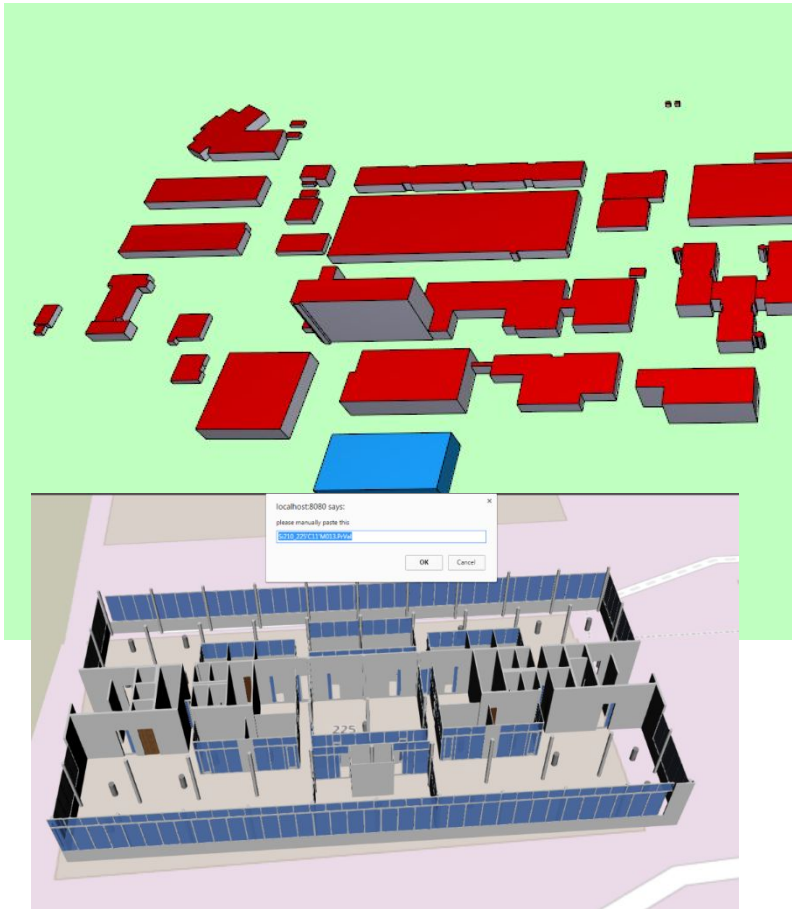
3D City Model in CityGML



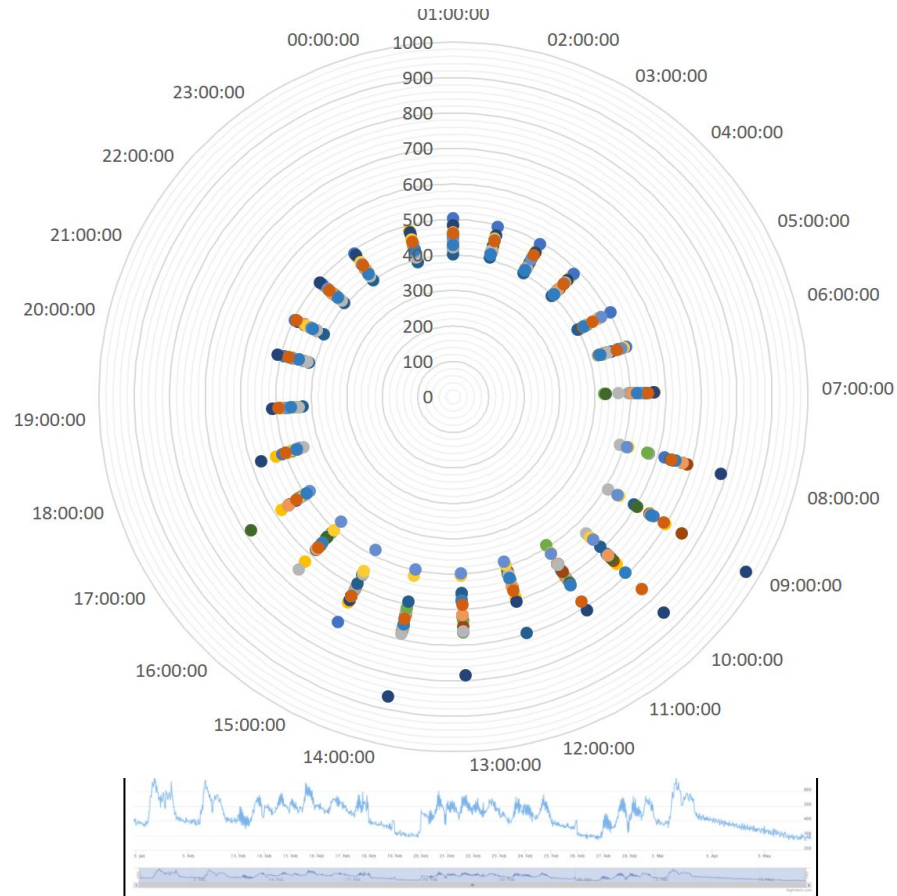
SensorThings API



Linking Sensor data and 3D City Models from CPS



Building interior and sensors



CO2 measures (ventilation system)

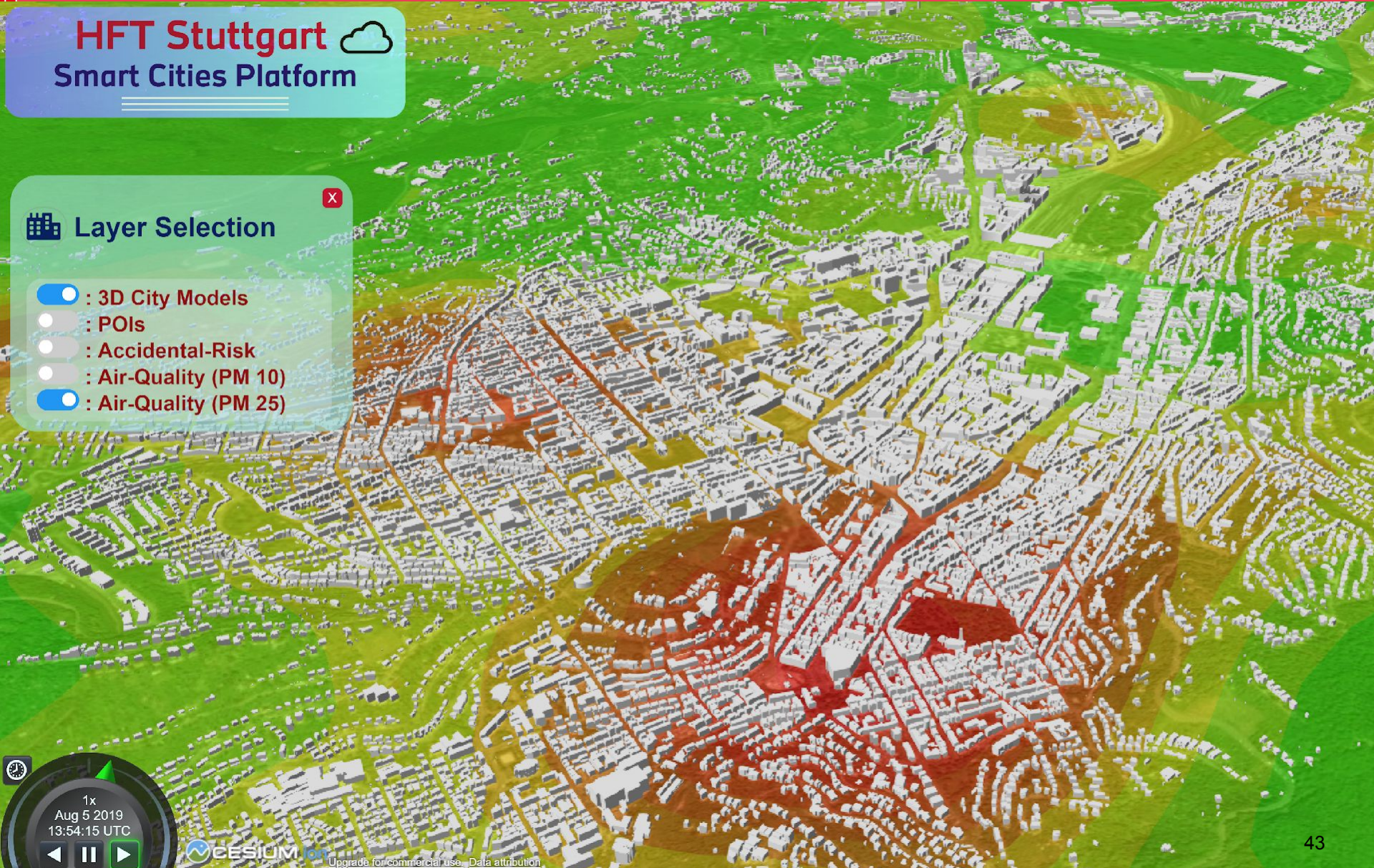
Hochschule für Technik Stuttgart

Environmental Sensors: Air quality

HFT Stuttgart 
Smart Cities Platform

Layer Selection

- : 3D City Models
- : POIs
- : Accidental-Risk
- : Air-Quality (PM 10)
- : Air-Quality (PM 25)



1x
Aug 5 2019
13:54:15 UTC