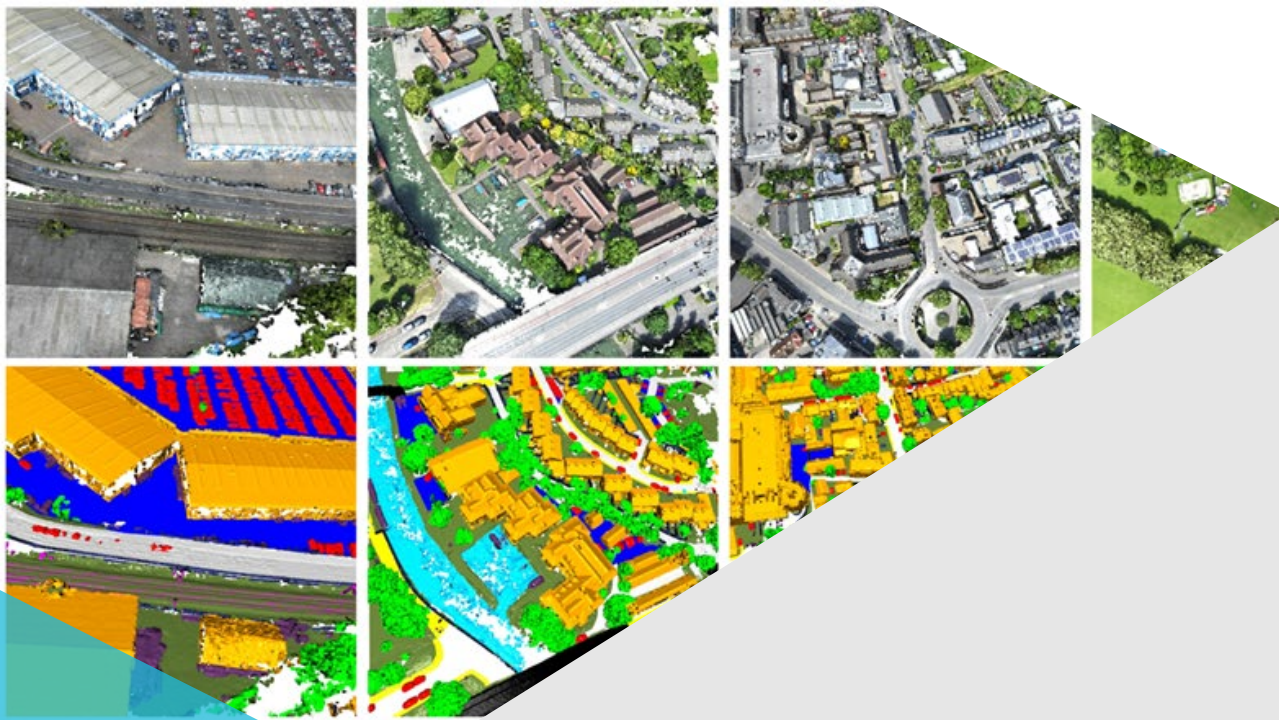




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GeoSCITY



# From semantic segmentation of LiDAR point clouds to 3D objects for digital twins

Prof. Roland Billen | PhD, Ing. Zouhair Ballouch

# Who are we?

## Geospatial Data Science and City Information Modeling

### GeoScITY

The “Geospatial Data Science and City Information Modeling” Lab is a research group specialising in spatial information modelling. Its activities cover both theoretical aspects (qualitative spatial reasoning, spatial ontologies, etc.) and operational developments (use of AI methods in geospatial data processing, development of spatial data infrastructures, etc.). Research focuses mainly on urban applications, from the territorial to the building scale, without excluding other themes such as digital heritage.

[LEARN MORE](#)



*Acquisition, processing and display of geographical data "from territory to building scale"*

[www.geoscience.uliege.be](http://www.geoscience.uliege.be)



# City Digital Twin

## Some recent projects



**SEM 3D**



**Cerbere**



**TrackGen**

## Some on-going or recent PhD Thesis

*Semantic segmentation of aerial LiDAR data using deep learning*

*Towards a 3D property valuation with BIM-CIM based data*

*City digital twins: levels of data integration*

*Change detection using mobile LiDAR point's cloud*

*From consistency to flexibility: shifting the structure*



# 3D semantic objects for urban applications (SEM 3D)



SEM 3D

## Scientific objectives

- Implementation of procedures for extracting semantically enriched urban 3D objects based on data from airborne or ground-based sensors (LiDAR and spectral) using Deep Learning (DL) type artificial intelligence (AI) techniques.

## In practice...

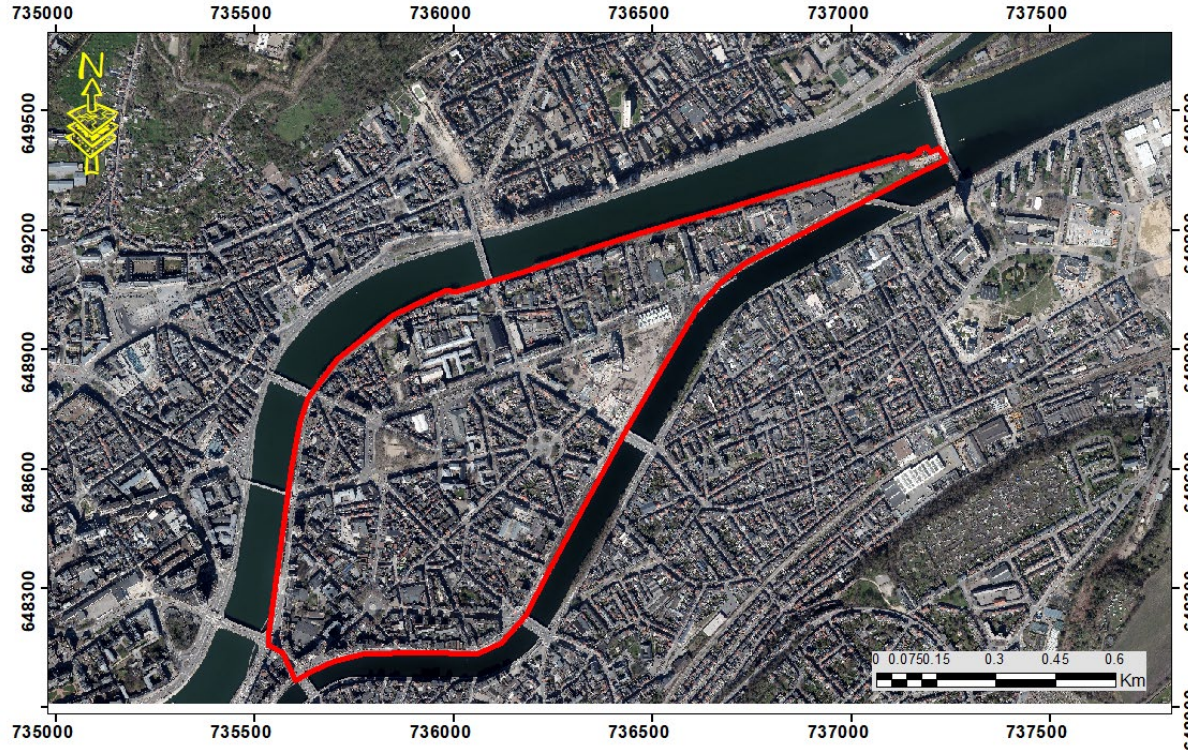
- *Enabling the City of Liège to improve urban management using 3D objects (buildings, trees, roads, etc.) obtained from data made available by the Walloon Region.*



Research  
Innovation  
award  
BeGEO 24

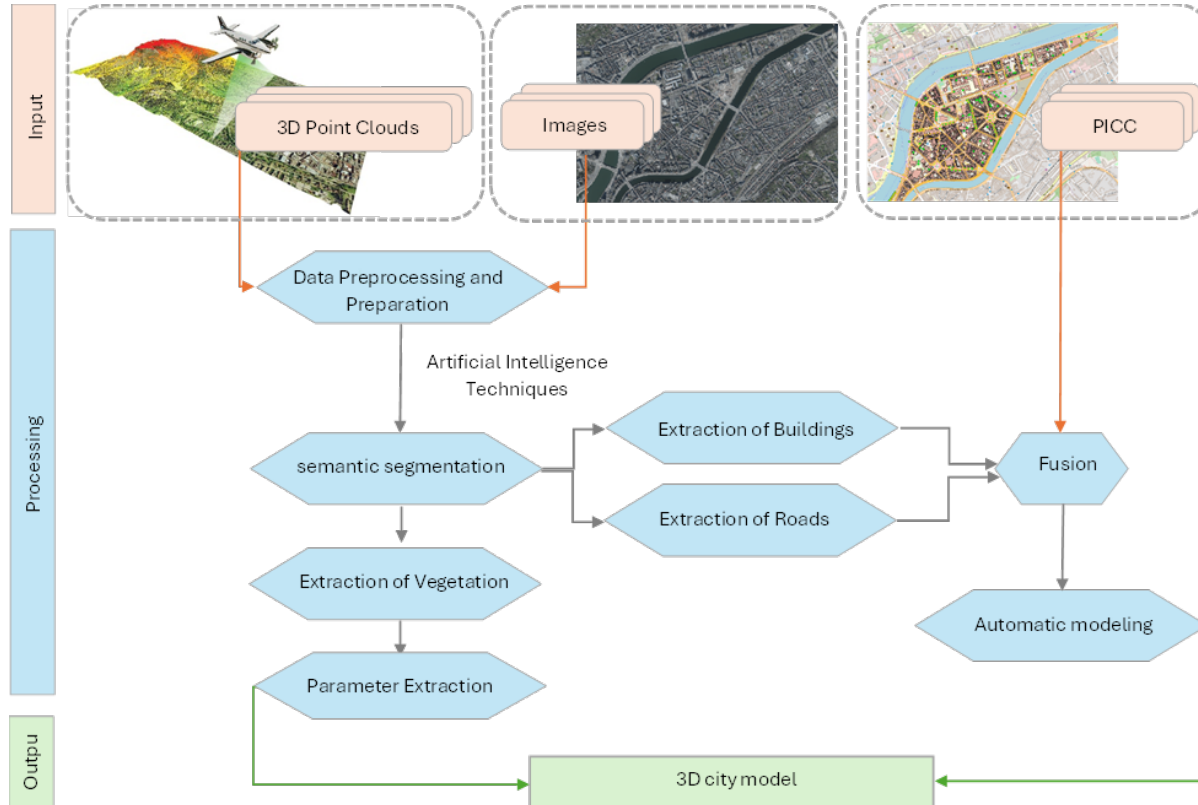


# SEM 3D – case study



Outremeuse island – City of Liege, Belgium

# SEM 3D - The general workflow

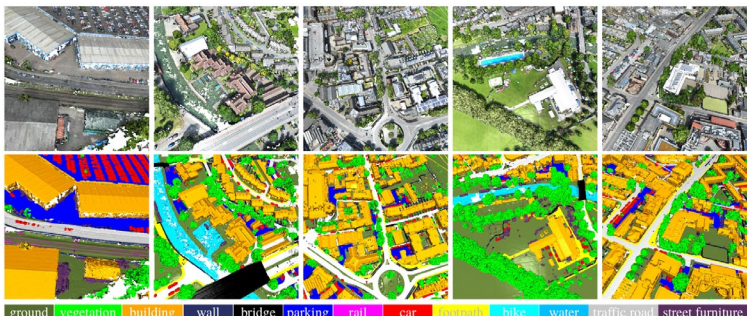


## NOTATION

- Data
- ⬡ Processing
- ▭ Output

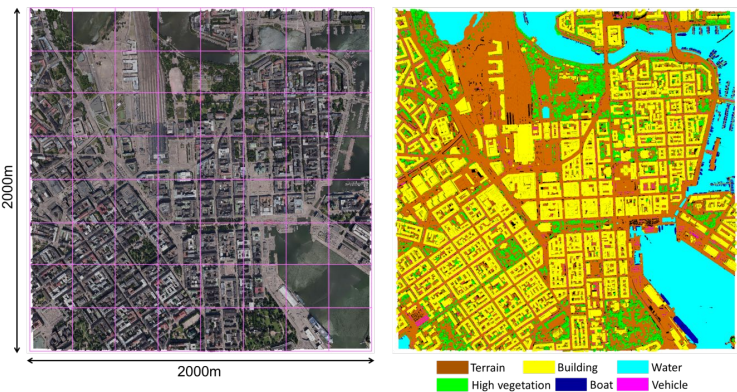
# SEM 3D - Point classification

## Training sets 1

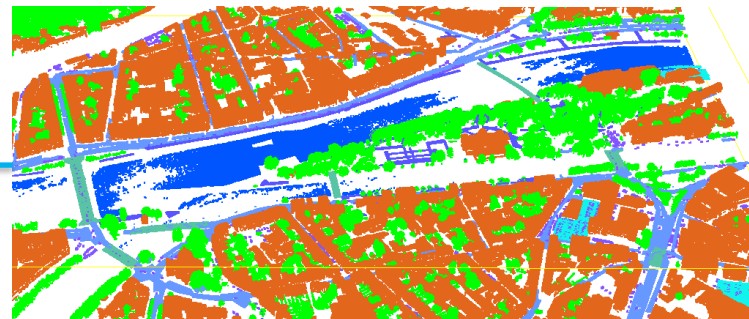


### SensatUrban dataset

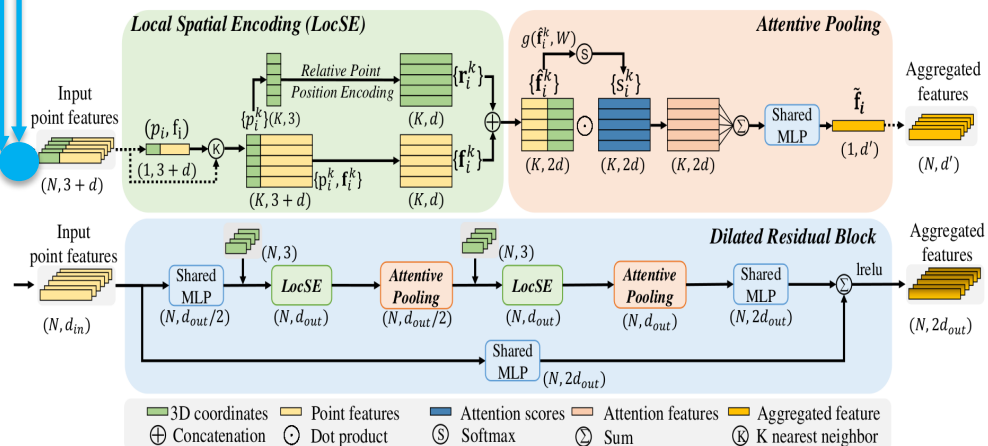
## Training sets 3



## Training sets 2



### Liège dataset



## Deep learning model



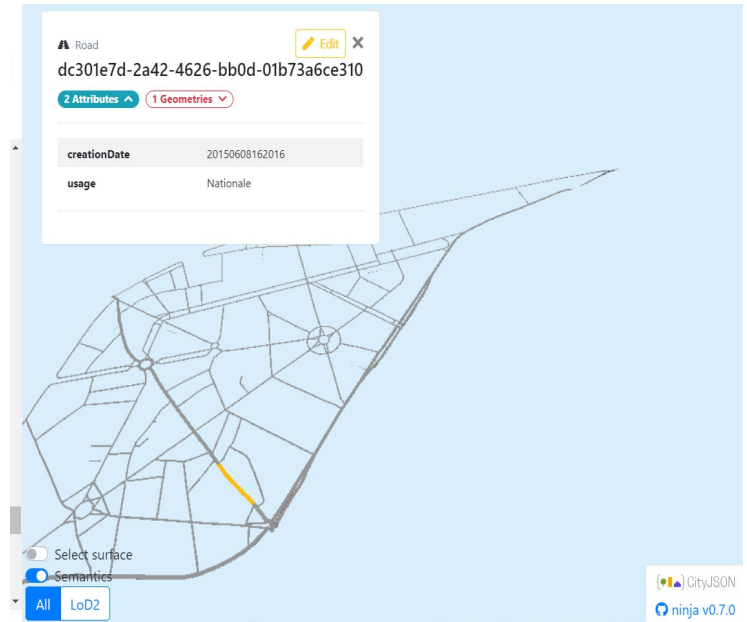
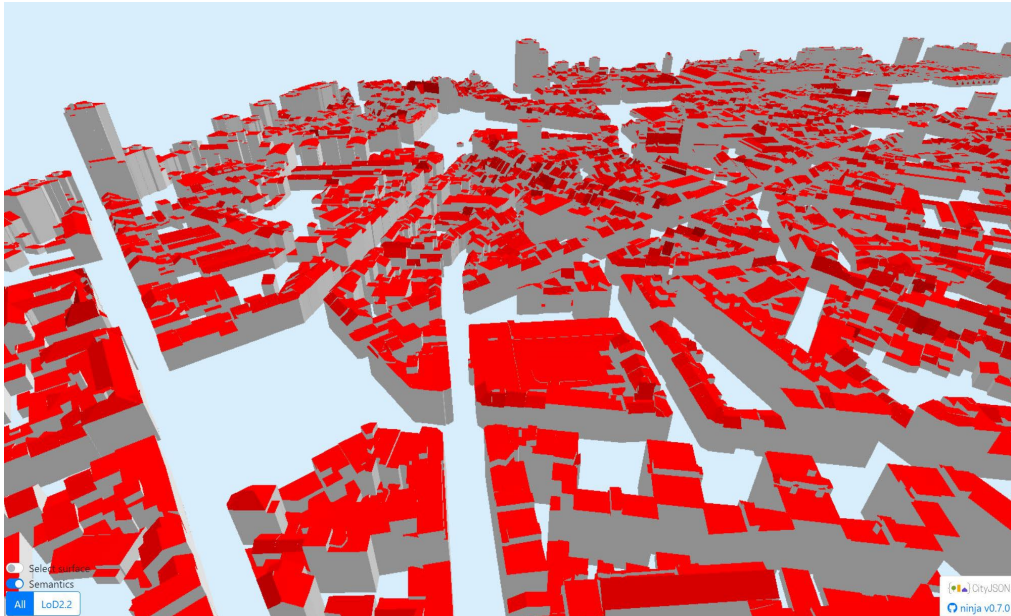
# SEM 3D – Point classification

- ▶ 3D classification of points into several categories using deep learning techniques (AI)



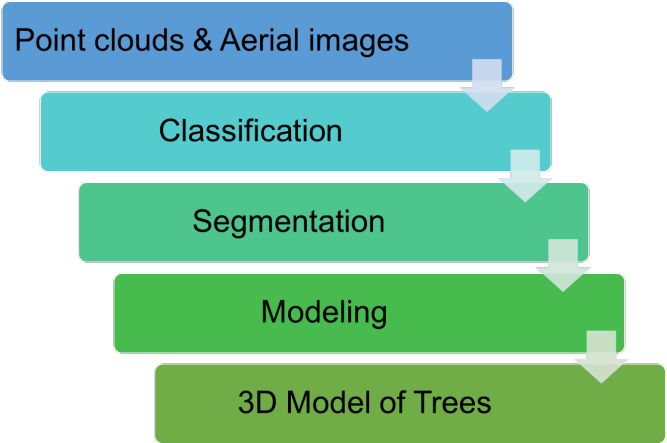
# SEM 3D – Creation of 3D city models

- ▶ Based on classified points and 2D vector data
- ▶ Building and road

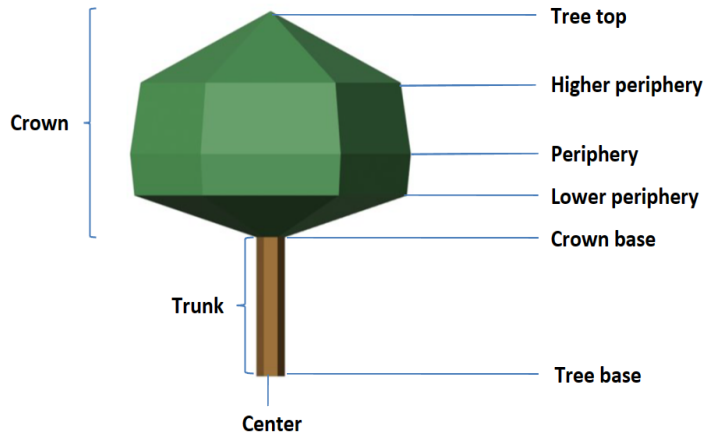


# SEM 3D – Creation of 3D city models

## ► Vegetation



General Workflow for Tree Modeling



Tree construction parameters

### Detail levels





# SEM 3D – Creation of 3D city models

## ► Vegetation

City Objects **1476 total**

Download
Close

- 81.0 LoD2
- 82.0 LoD2
- 83.0 LoD2
- 84.0 LoD2
- 85.0 LoD2
- 86.0 LoD2
- 87.0 LoD2
- 88.0 LoD2
- 90.0 LoD2
- 91.0 LoD2
- 92.0 LoD2
- 93.0 LoD2
- 94.0 LoD2
- 95.0 LoD2
- 96.0 LoD2
- 97.0 LoD2
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- 99.0 LoD2
- 100.0 LoD2
- 101.0 LoD2
- 102.0 LoD2

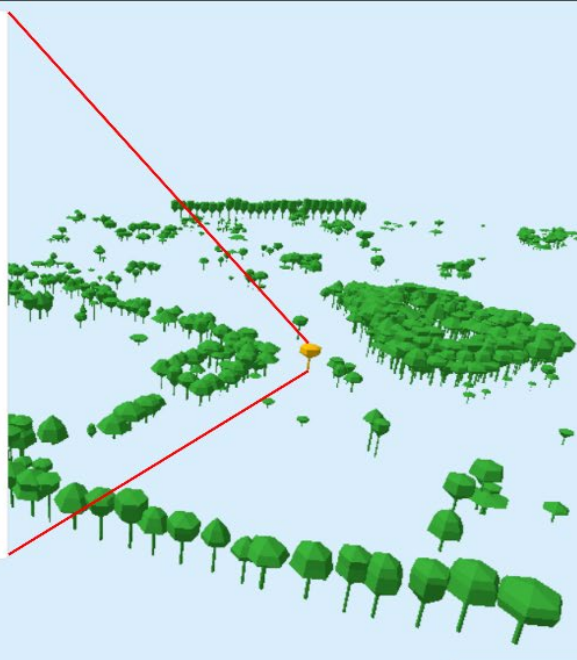
✎ Edit ✕

9 Attributes
1 Geometries

Point Count	504
Height Crown Base	11.009249591827393
Periphery Height	17.60192883014679
Periphery Radius	5.7267604936348855
Lower Periphery Height	14.30558921098709
Lower Periphery Radius	5.800224881881194
Higher Periphery Height	18.39505586862564
Higher Periphery Radius	4.171733283181835
Tree Top	19.18818290710449

Select surface  
 Semantics

All LoD2



CityJSON  
ninja v0.7.0

# SEM 3D – Creation of 3D city models

## ➤ 3D city model of Outremeuse district



## ➤ Validation results of all city objects

File	Validation of geometry	Validation of the schema
<b>Buildings.json</b>	93,2% valid	100% valid
<b>Roads.json</b>	87% valid	100% valid
<b>Vegetation.json</b>	100% valid	100% valid







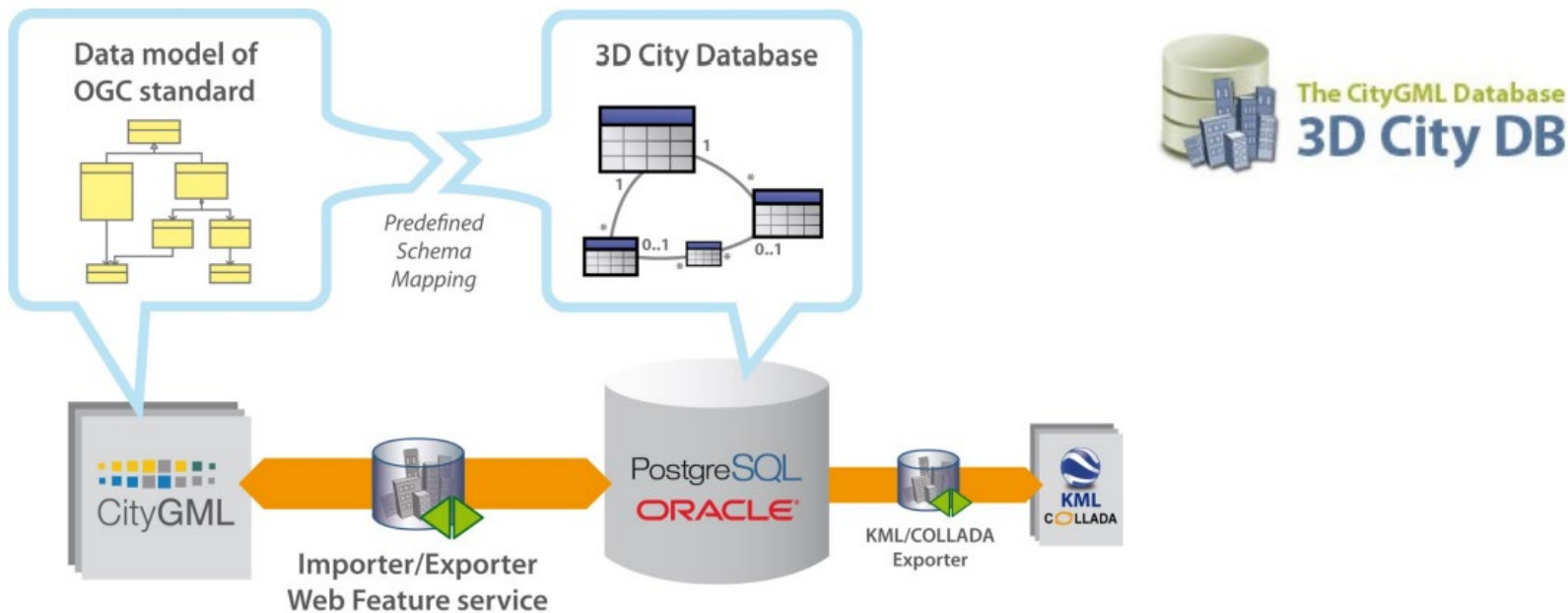
# Our R&D agenda en CDTs

- ▶ Optimize 3D urban object extraction procedures
  - More classes ... more objects ... more automation ... quality control
- ▶ Develop / improve DT data platform (static and dynamic data integration)
  - E.g. CERBERE Project



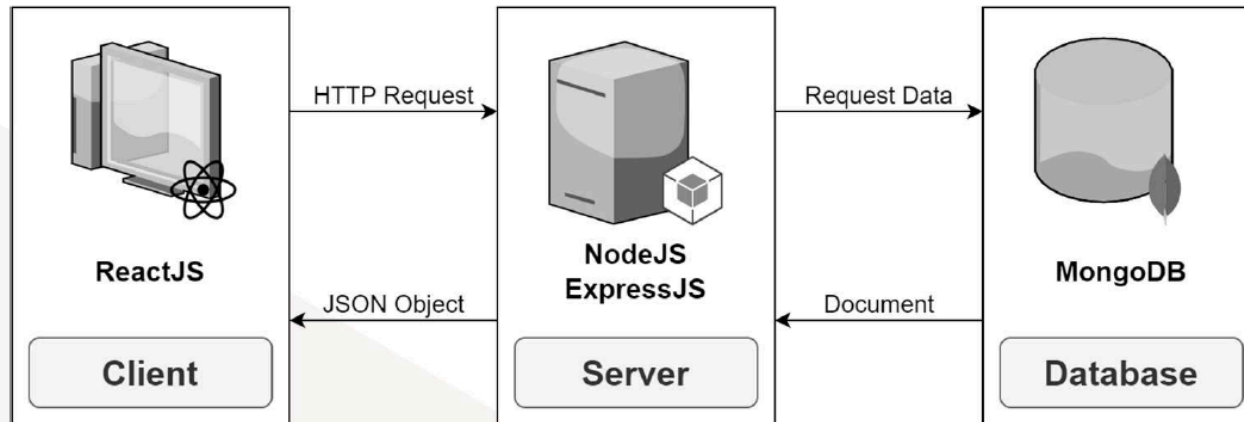
# CERBERE – 3D platform

- ▶ An alternative (or a complement) to the 3D CityDB solution



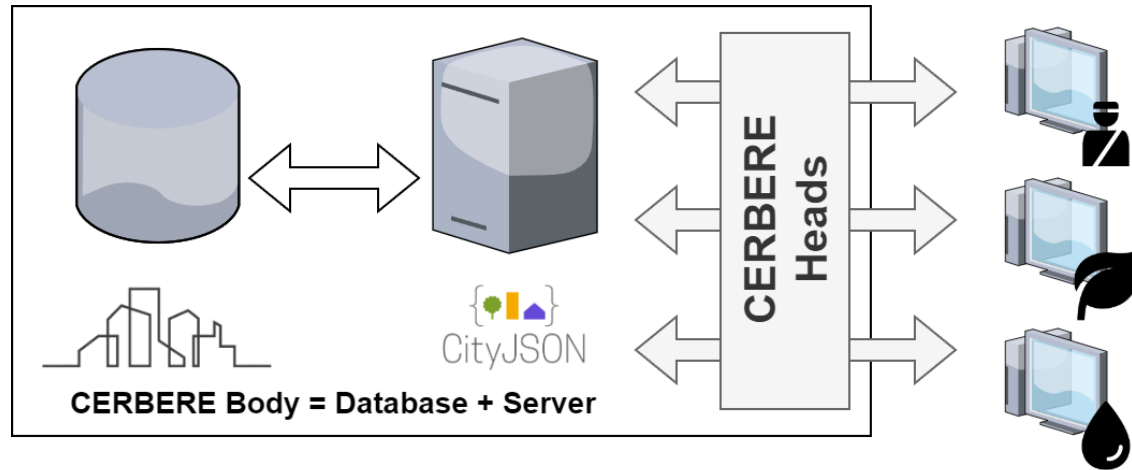
# CERBERE – 3D platform

- ▶ A MERN application (MongoDB, ReactJS, ExpressJS and NodeJS) to manage CityJSON files
- ▶ Guarantee of the logic and quality of the model passed from the database to the middleware



# CERBERE – 3D platform

- ▶ The middleware acts as an input and output filter, making it possible to handle all kinds of data from heterogeneous sources.







# Our R&D agenda en CDTs

- ▶ Optimize 3D urban object extraction procedures
  - More classes ... more objects ... more automation ... quality control
- ▶ Develop / improve DT data platform (static and dynamic data integration)
  - E.g. CERBERE Project
- ▶ Explore applications in energy, transport, urban greening, etc.
- ▶ Integrate Digital Twinning and Smart Cities programs.
- ▶ Explore Diverse Urban Contexts: engage with cities in Morocco, Rwanda, etc.

# References

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# Thanks for your attention



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