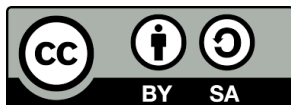


Semantic City Models

- creation, use and examples

Ariana.kubart@ocellus.se



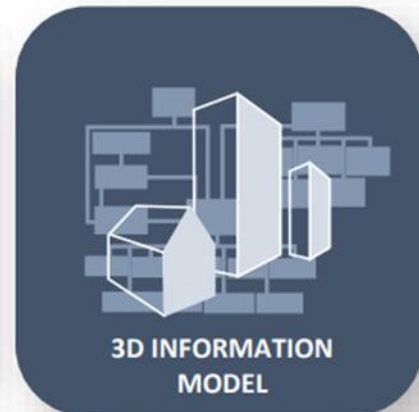
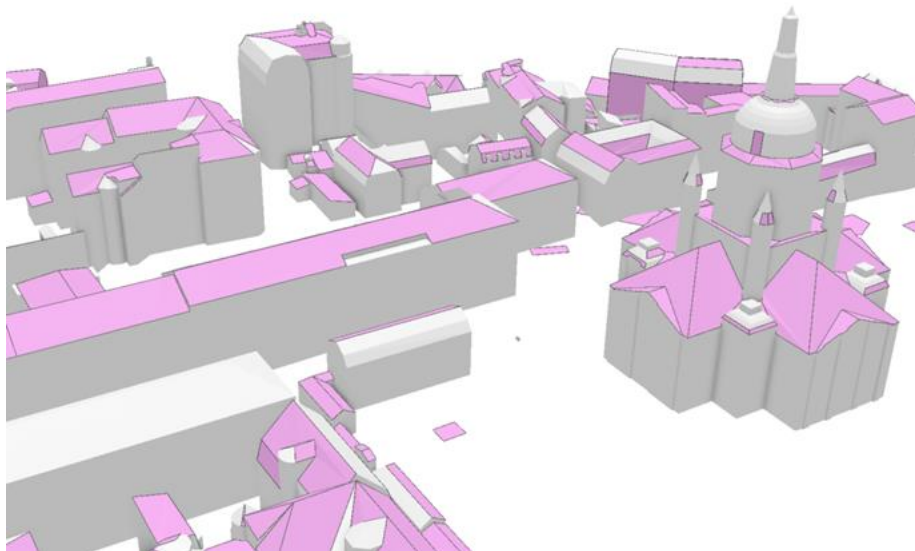
Learning outcomes

At the end of this lecture, the learner is expected to be able to:

- Explain the semantic part of the city models and differences compared to graphical 3D models
- Summarize the main steps of semantic model creation
- Name examples of existing models as well as of their possible applications

What is Semantic City Model?

Model with distinguished objects representing real-world things: the houses, streets, trees and others

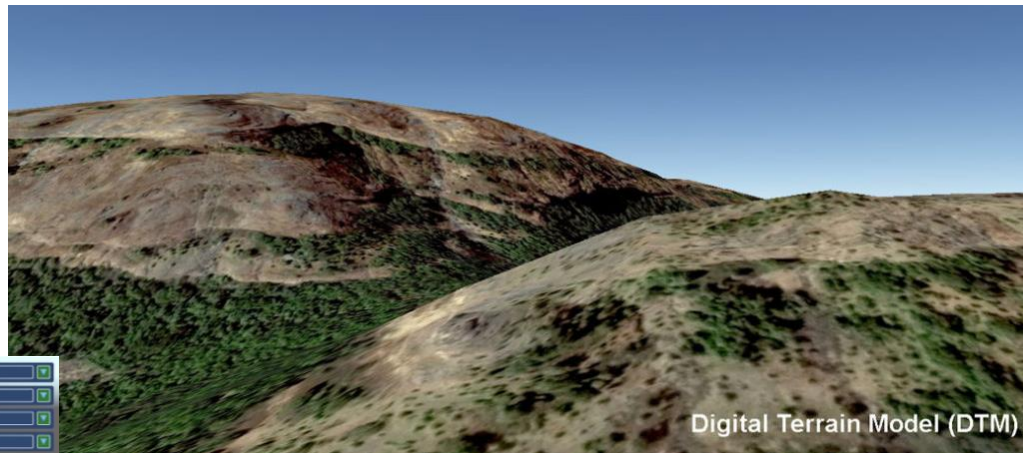


Up: from Helsinki3D_Kalasadama_Digital_Twins
<https://www.hel.fi/en/decision-making/information-on-helsinki/maps-and-geospatial-data/helsinki-3d>

Left: semantic city model of Stockholm
Downloaded from: [Dataportalen \(stockholm.se\)](https://dataportalen.stockholm.se)

Objects in the Semantic Models

- Natural objects – digital terrain model, vegetation, water bodies...



Digital Terrain Model (DTM)

Digital Terrain Model, DTM; source: digital-terrain-model-dtm-1024x569.jpg (1024x569) (pigeonis.in)

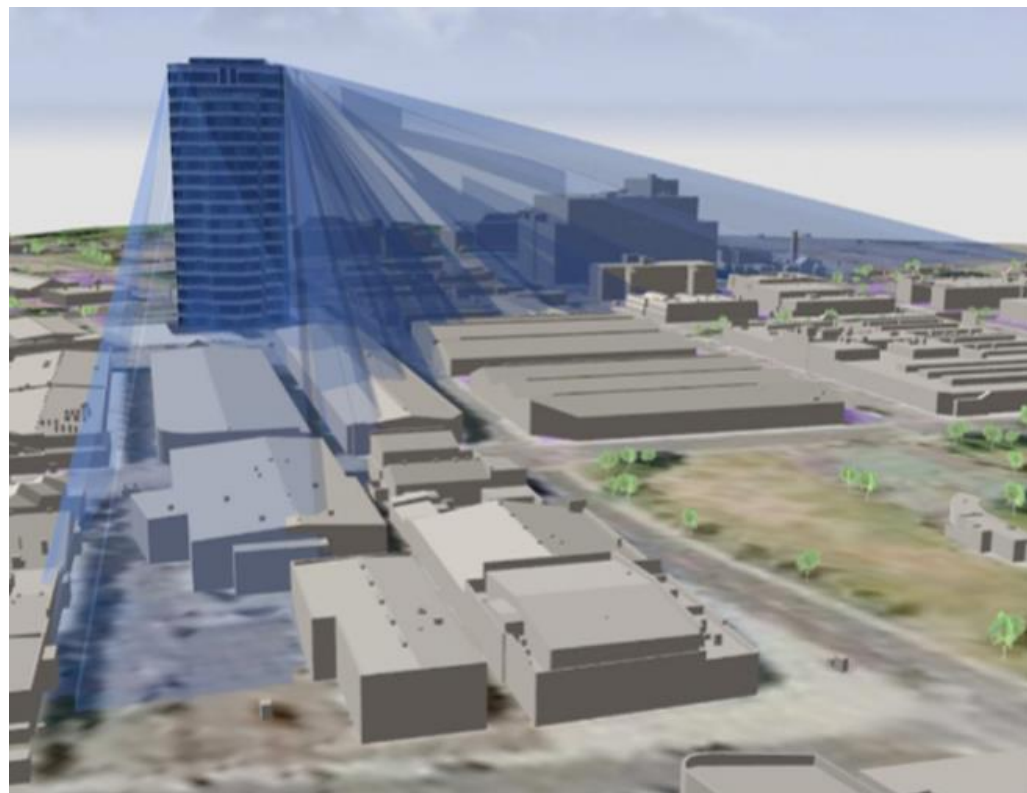
- Man-made objects – houses, bridges, street furniture...
- All objects can have attributes



Man-made objects and vegetation; source: Biljecki et al (2015)
Applications of 3D City Models: State of the Art Review

Creation of City Models I

- 3D models – successor of 2D maps
- Possible to increased computation capacity
- World is 3D – 3D models more realistic than 2D
- Certain analyses not possible in 2D, e.g. shadow-cast or air-pollution



Shadow-cast analysis, 3D necessary for it, from: Applications of 3D City Models: State of the Art Review

Creation of City Models II

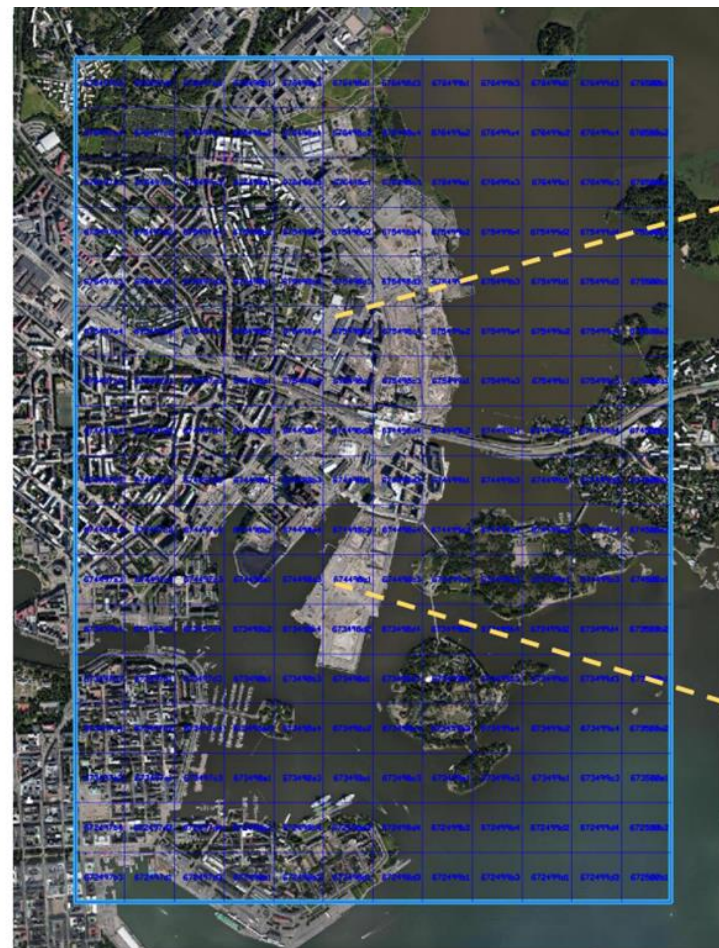
Combination of:

- aerial images (photogrammetry)
- point-clouds (LiDAR)
- 2D data (cadastres)

Data put together by specialised software

Followed by control and manual adjustment

Tiling of aerial images in Helsinki city model, from: The Kalasatama Digital Twins Project



3D City from Aerial Photos I

- 2D images from different viewpoints
- Partly overlapping
- Automatically bind together and triangulated

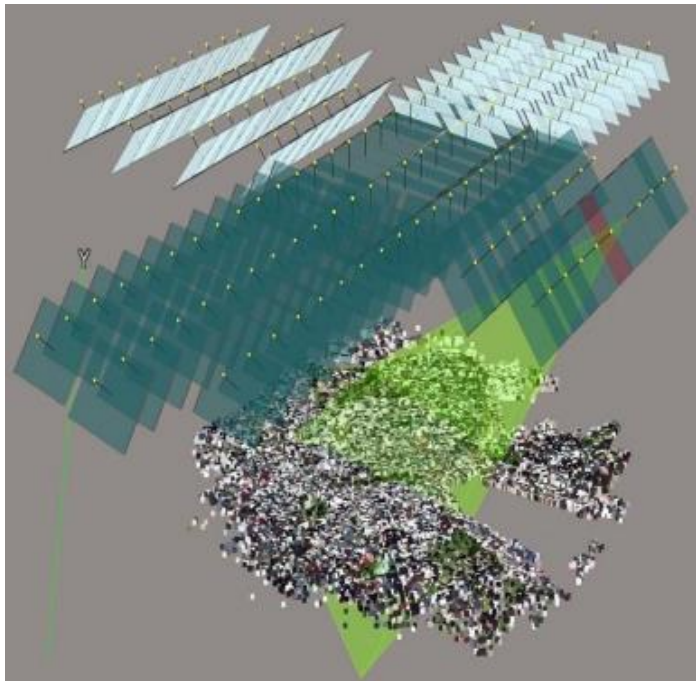


Vertical and oblique aerial photography (up)
and tilling into mesh 250x250 meters (right)

Source: The Kalasatama Digital Twins Project. The final
report of the KIRA-digi pilot project, 2019

3D City from Aerial Photos II

- Binding together by finding common features in the overlapping images (down)



- Ground control points (right)

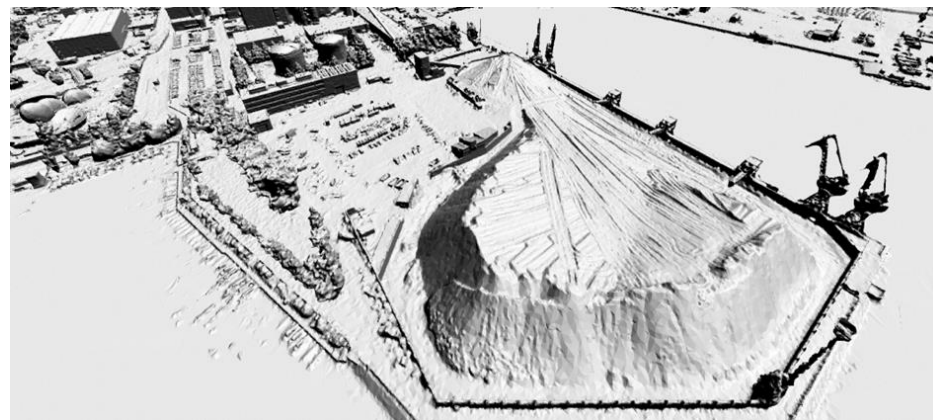
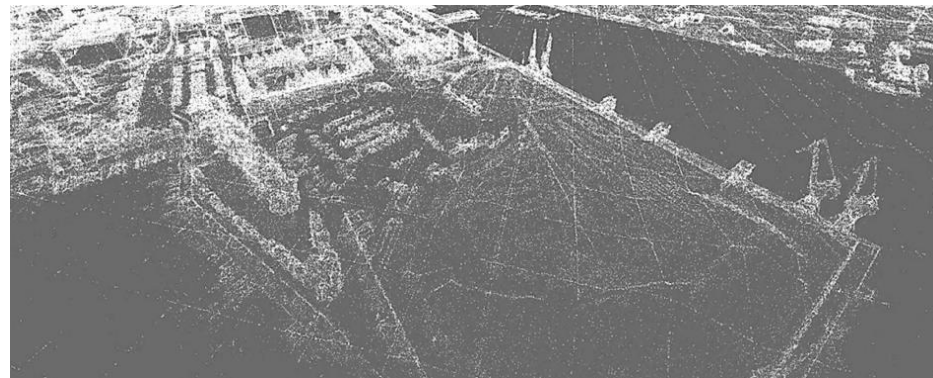
Source: The Kalasatama Digital Twins Project. The final report of the KIRA-digi pilot project, 2019



Example of Helsinki model

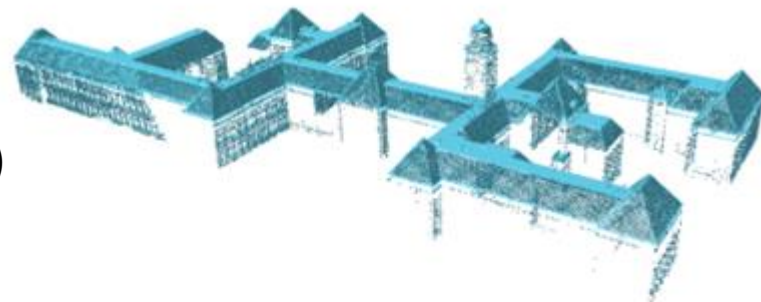
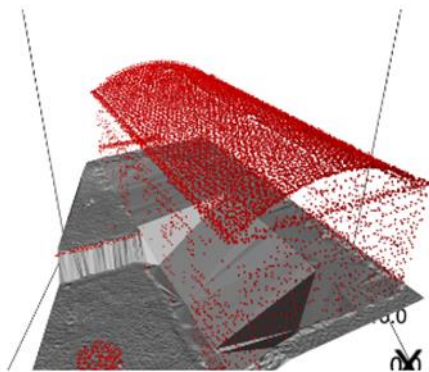
Three steps in creation:

- 1) point-cloud from aerial-images (right up)
- 2) mesh model without visible triangles (right down)
- 3) final photorealistic model (left down)

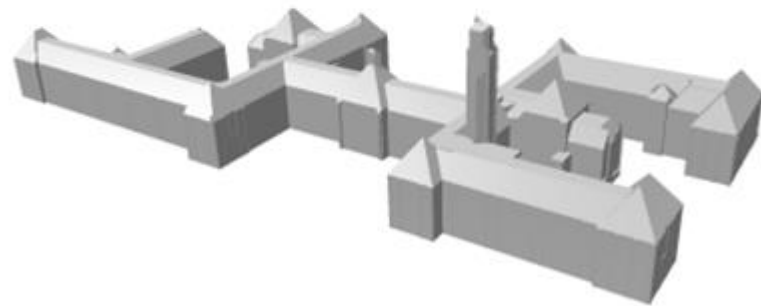


3D city from laser scanning I

- Mesh-models even from point-clouds
(right (a) a point-cloud, (b) reconstructed building)
- Can be photorealistic (down)
- Smaller areas, more details (vs. aerial images)



(a)



(b)

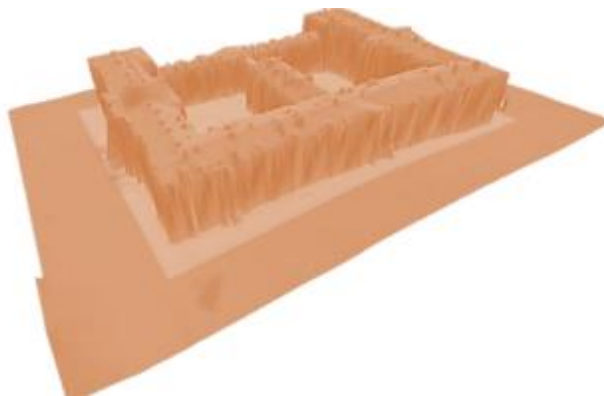
Source: 3D Book (left),
<https://www.rock.estate/blog/a-tour-of-3d-point-cloud-processing> (right)

3D city from laser scanning II

DTM – elevation of building footprint

DSM – building height and roof shape

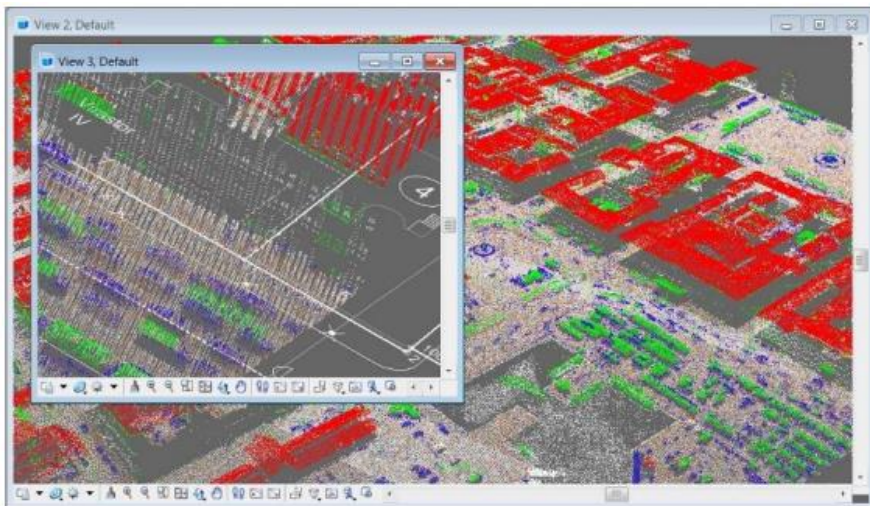
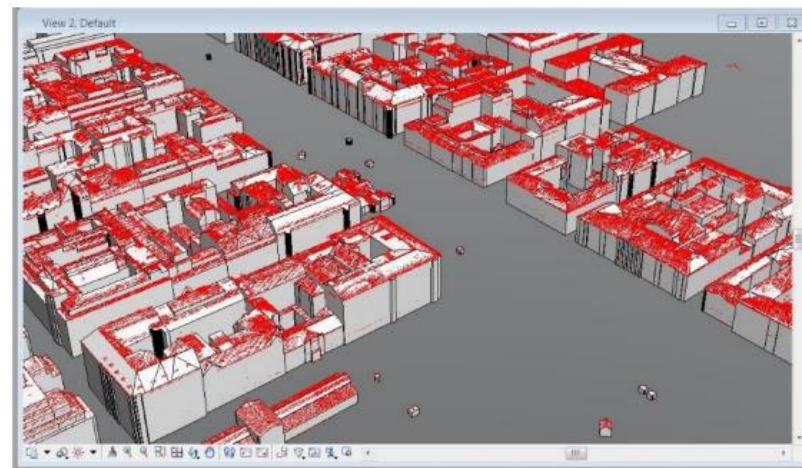
2D map – footprint



- DTM and DSM – Digital Terrain and Surface model (up)
- Terrain and surface models from one building area (left)

3D city from laser scanning III

Base map and point-clouds for an area (down)
Roof shapes of buildings from the data (right up)
Geometries of created 3D buildings (right down)



Source: The Kalasatama DT Project

Final 3D semantic model

- Adding semantic info
= attributes
- Available e.g. in
cadastres



Examples of graphical semantic model of
Stockholm – city center and a residential area

<https://smartstad.stockholm/2020/03/09/over-100-000-byggnader-i-stockholm-som-3d-modeller-i-stadsbyggnadskontorets-nya-databas/>

Abstraction in 3D models

- Removing unnecessary parts, e.g. interiors
- Semantic models – high abstraction level, unique IDs
- Mesh models – low abstraction, less computer space, faster to create and read, cheaper



[Helsinki 3D | City of Helsinki](https://www.hel.fi/en/decision-making/information-on-helsinki/maps-and-geospatial-data/helsinki-3d)

<https://www.hel.fi/en/decision-making/information-on-helsinki/maps-and-geospatial-data/helsinki-3d>

Examples of 3D city models I

- Semantic models - mainly public sector
- High-graphic models – often commercial, Open Street Map
- 1st free model – Berlin 2015



[VisualizationBerlin – 3DCityDB Database](#)

Examples of 3D city models II

Many cities provide
3D models to browse

Data itself usually not
for free to download

Exceptions:

[Cities/regions around
the world with open
datasets \(tudelft.nl\)](#)



Semantic model of Zagreb, Croatia

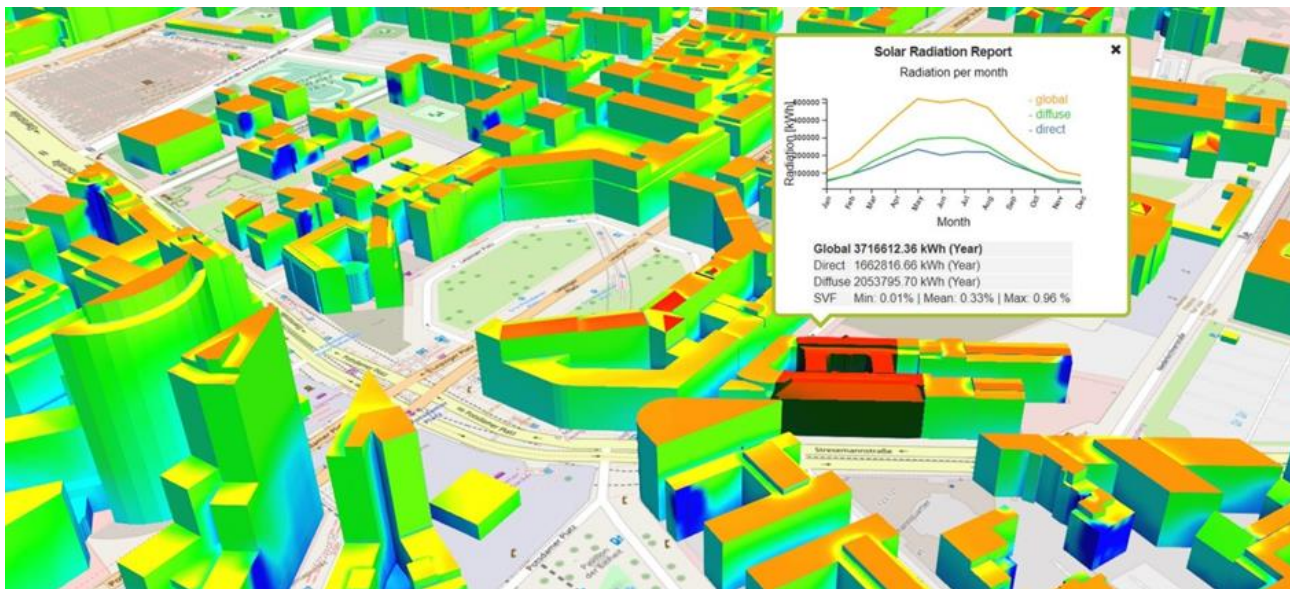
[ZG3D: 3D model Grada Zagreba \(gdi.net\)](#)

Applications using semantic 3D models

- Visualisation & city planning (see figure)
- Queried – depends on LoD and depth of semantic information
- Analyses and simulations – provide new semantic information
- Scenario testing



Analysis of solar radiation



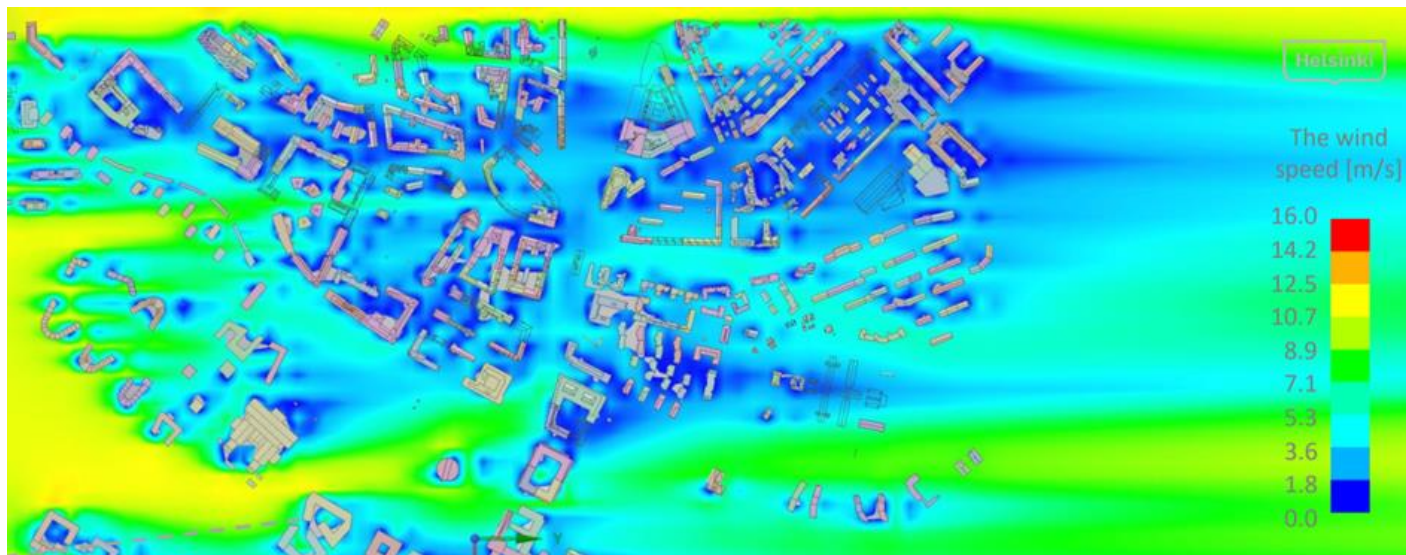
Possibility of many calculations:

- Solar energy production
- Best roofs for solar-cells
- % of house-consumption covered by solar-energy
- Money spent on electricity

[3d-stadtmodell_solarpotenzialanalyse-aspect-ratio-20-9-3.jpg \(2310x1040\) \(vc.systems\)](#)

Analysis of wind speed

- Slowing of the wind-speed in newly planned neighbourhood
- Estimating thermal-comfort during hot summers
- Spreading of air pollution

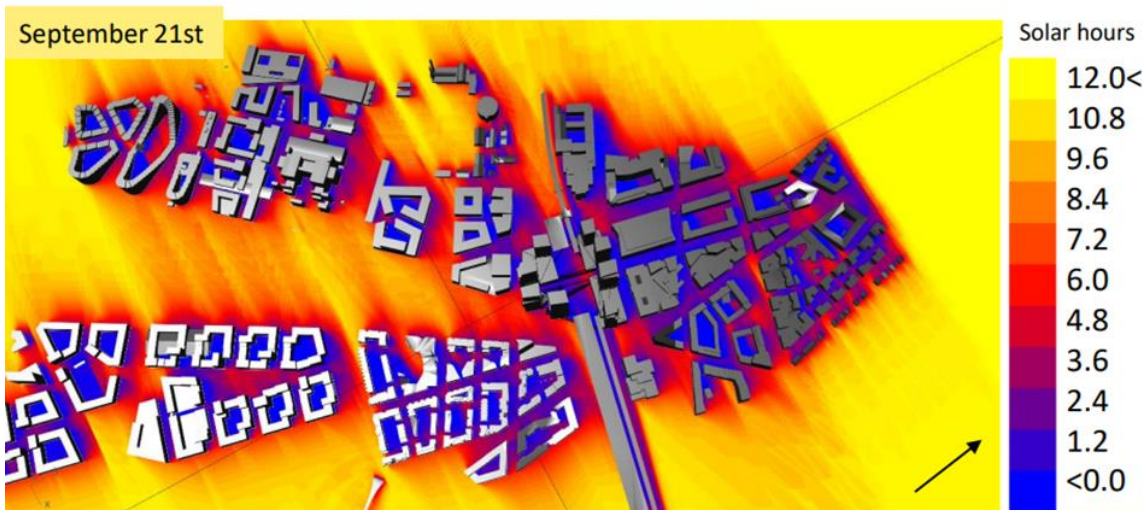


Stimulation of wind intensity on street level in Helsinki
The wind blows from the left side of the picture in 15m/s
Source: The Kalasatama DT Project

Sunshine and shadow analysis

- City planning

September 21st at 16:00

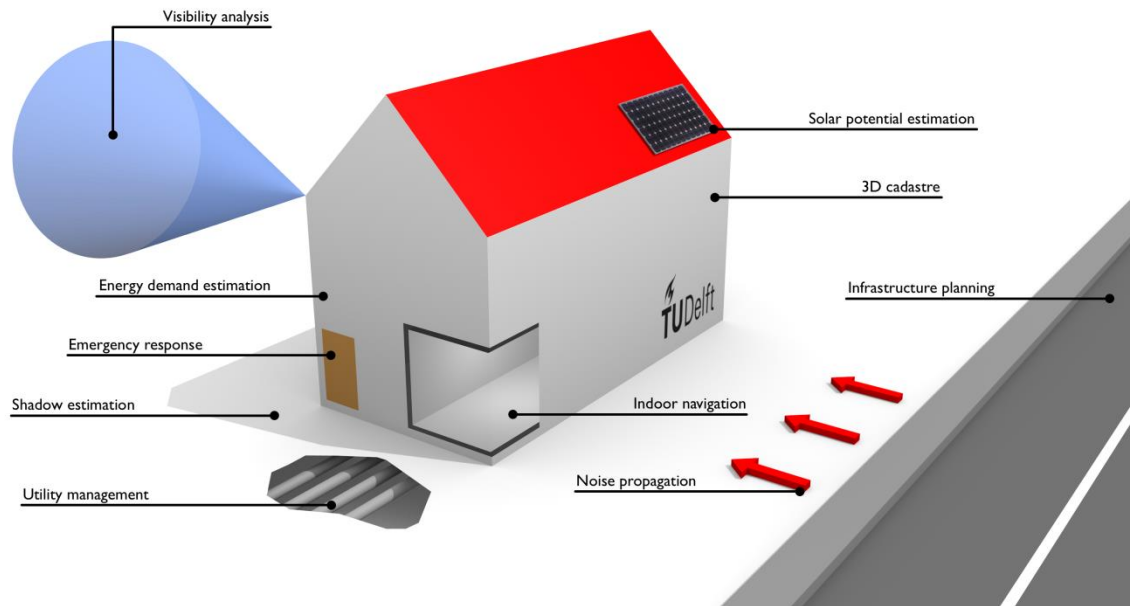


- Sunshine (up) and shadowing by planned-buildings (left) at autumnal equinox
- Similar computations for any time of the year
- Testing building-design and position

Source: The Kalasatama DT Project

Other applications

- Heavy-rain events and flooding
- Digital Twins, Smart Cities
- Data quality and harmonisation fundamental
- Biljecki et al. (2015):
Applications of 3D City
Models: State of the Art
Review



[Applications of 3D city models | CityJSON](#)

Thank you for your attention



<https://birgitproject.eu/>

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.