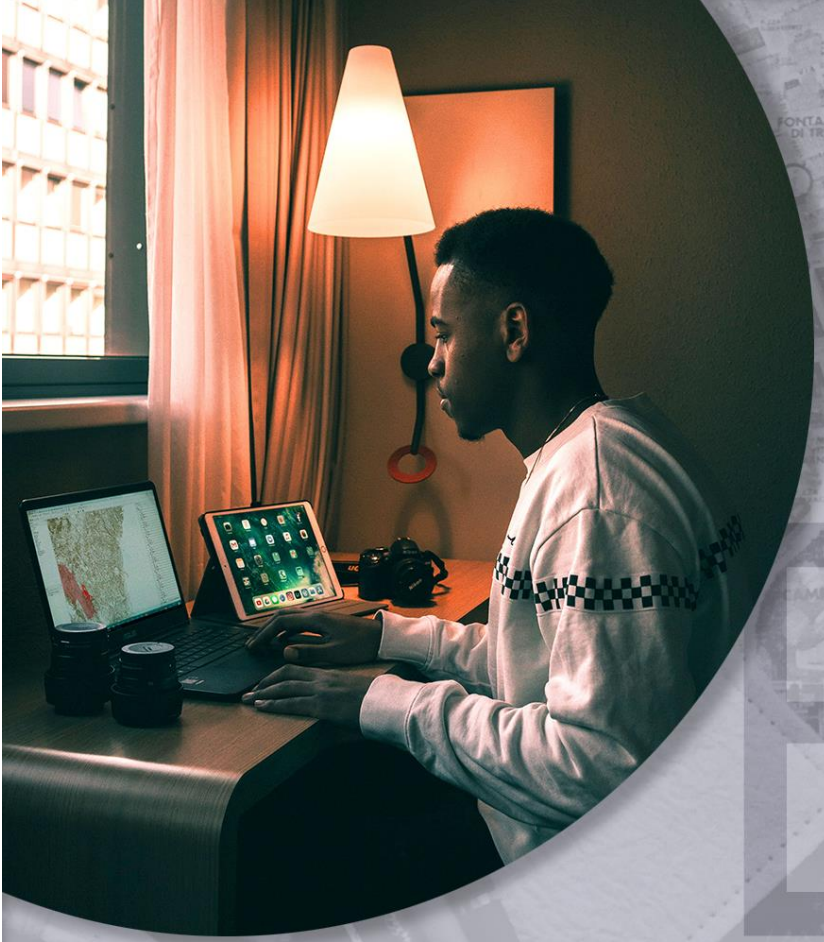

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1.2 Semantic City Models
April 2025

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Semantic City Models
- creation, use and examples

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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

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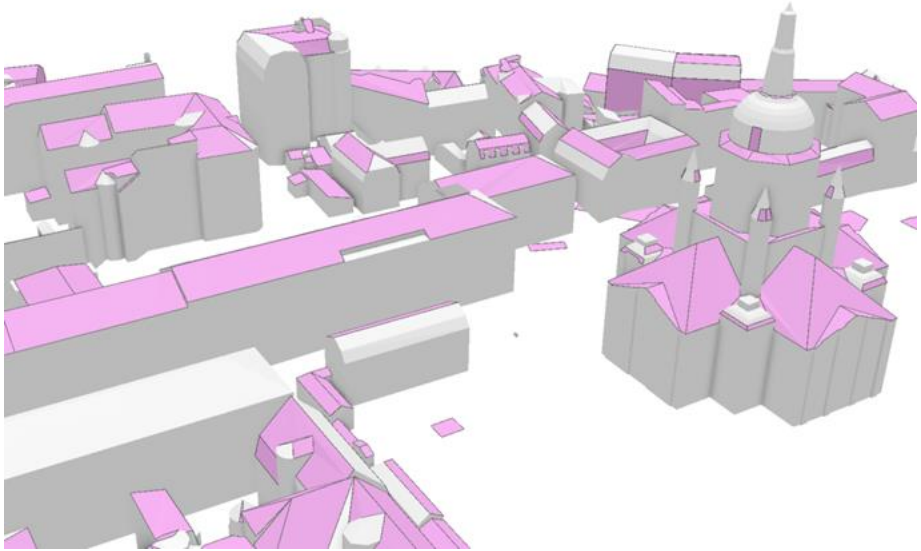
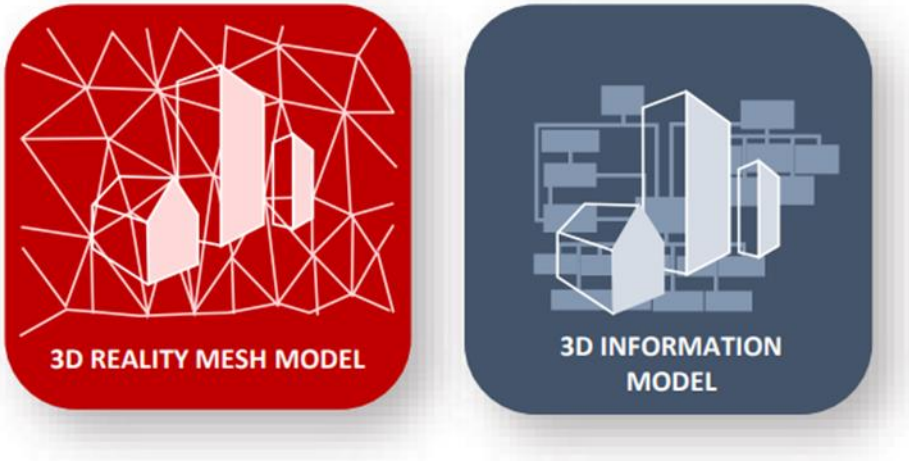
What is Semantic City Model?

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





Up: from Helsinki3D_Kalasatama_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)

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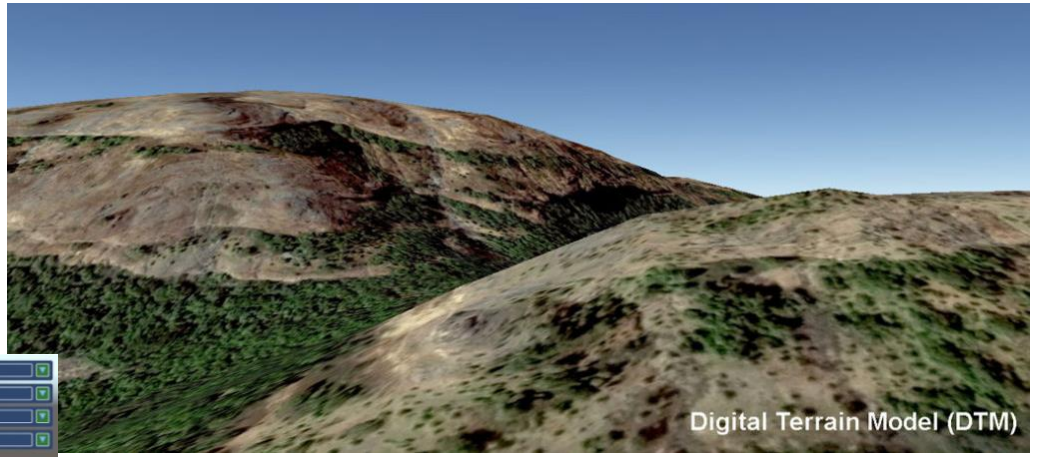
Objects in the Semantic Models

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



Digital Terrain Model, DTM; source: [digital-terrain-model-dtm-1024x569.jpg (1024×569) (pigeonis.in)]

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

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

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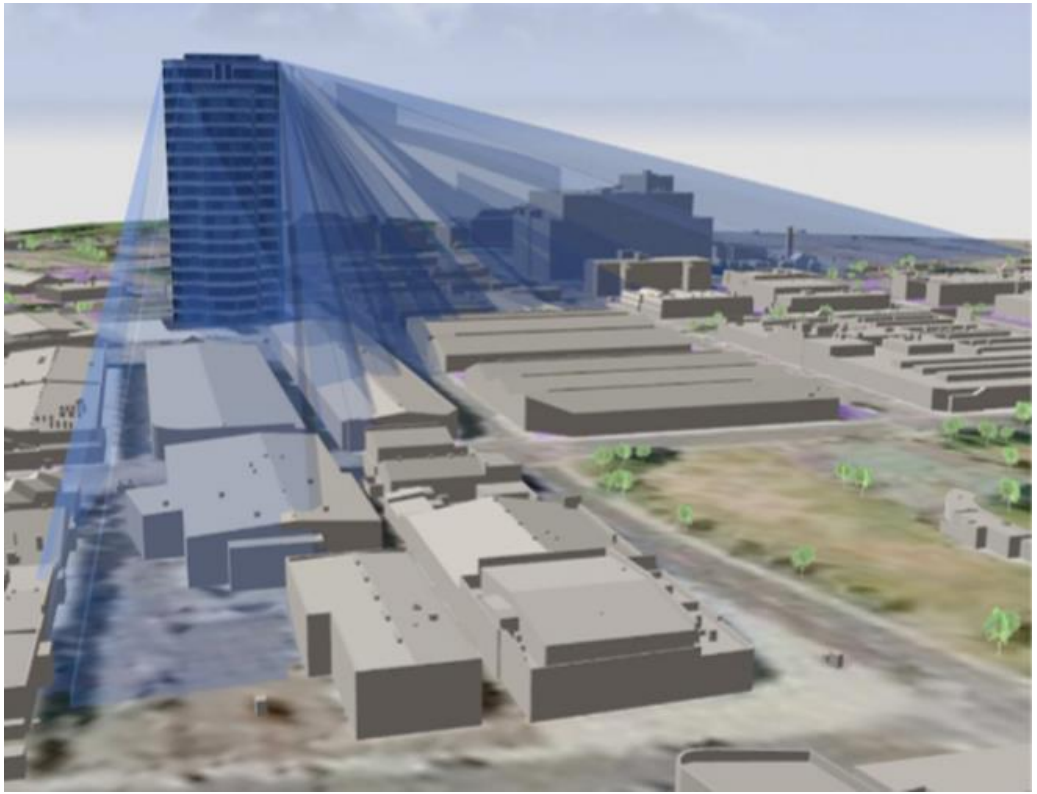
Creation of City Models I

- 3D models – successor of 2D maps
- Possible to increased computation capacity

- World is 3D – 3D models more realistic then 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

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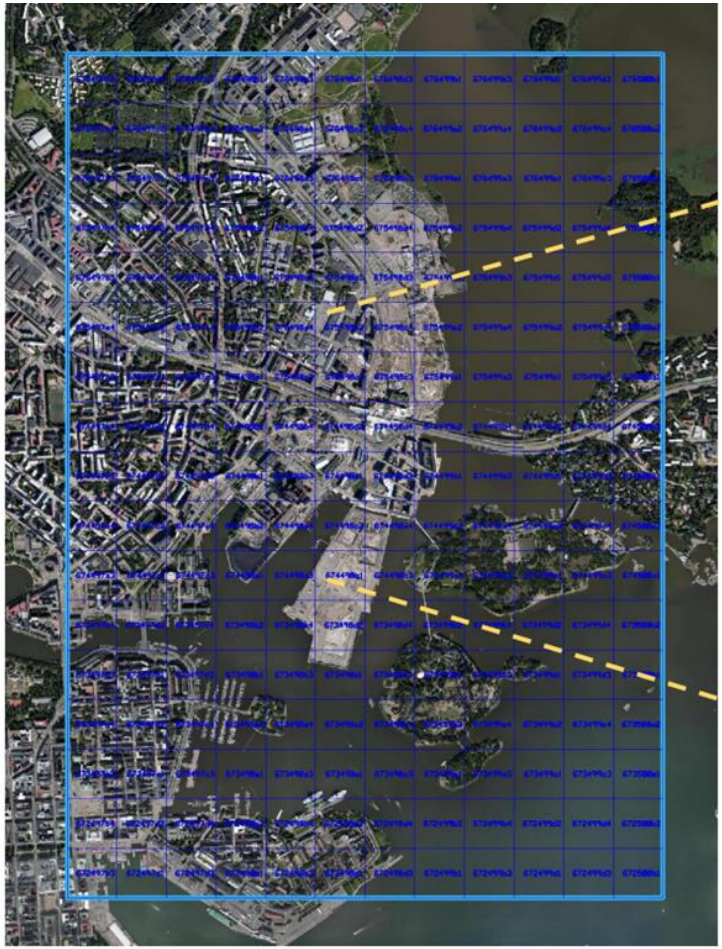
Creation of City Models II

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

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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

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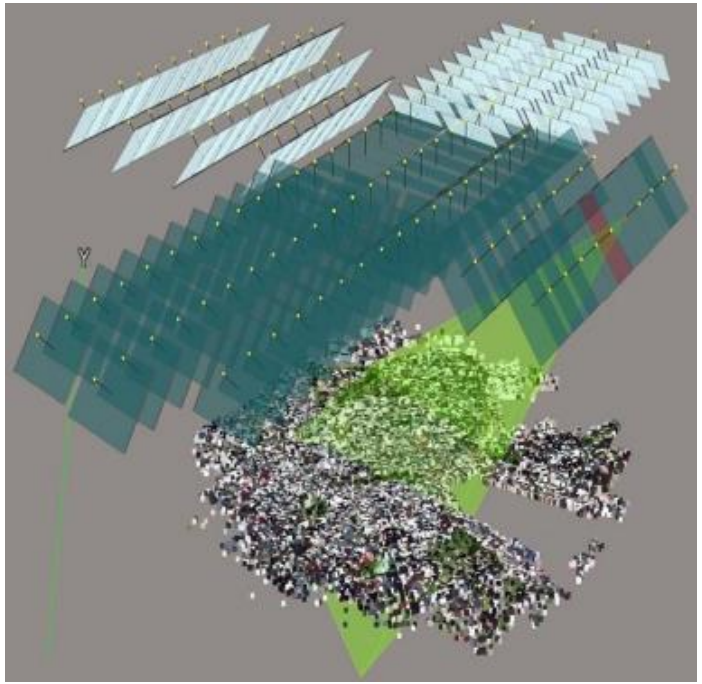
3D City from Aerial Photos II

- 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

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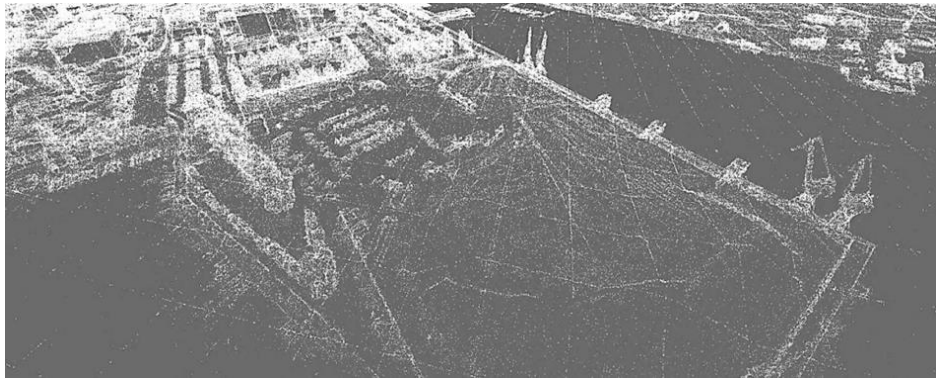
Example of Helsinki model

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)



Source: The Kalasatama DT Project

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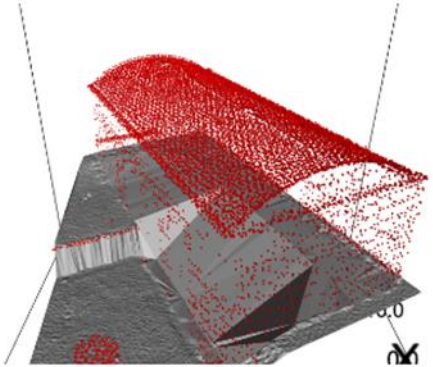
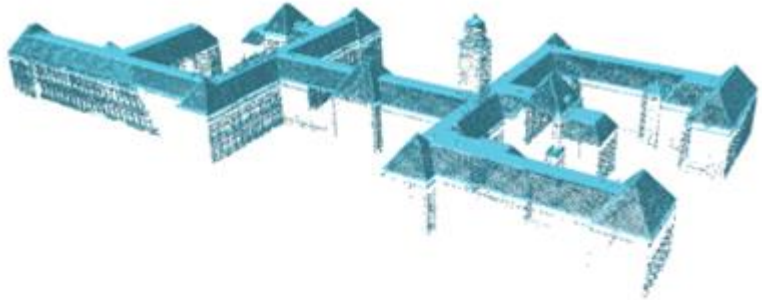
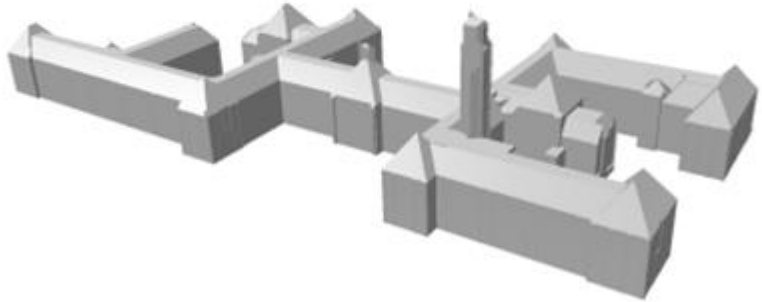
3D city from laser scanning I

- 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)

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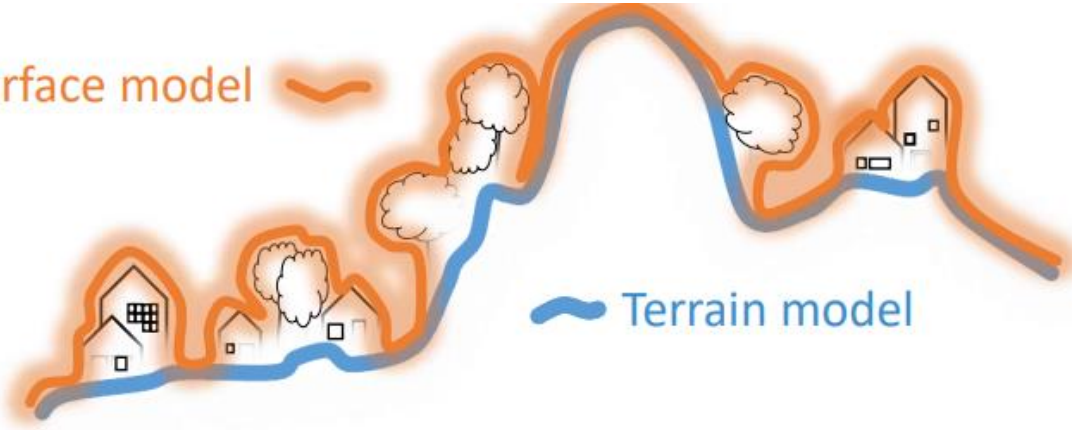
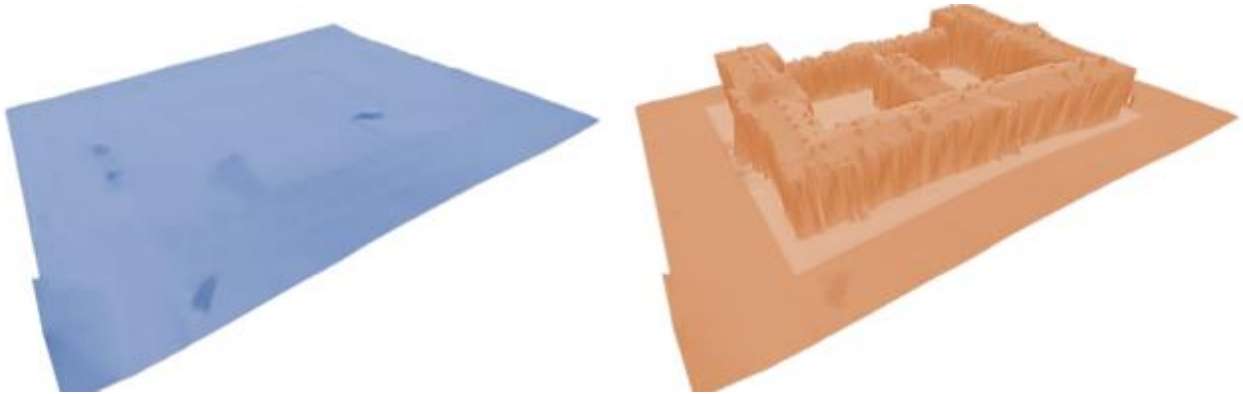
3D city from laser scanning II

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)

Source: The Kalasatama DT Project

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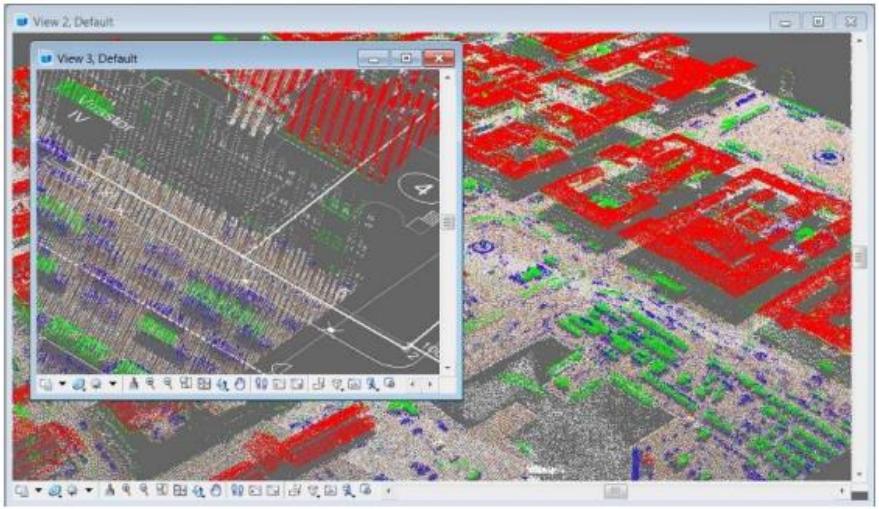
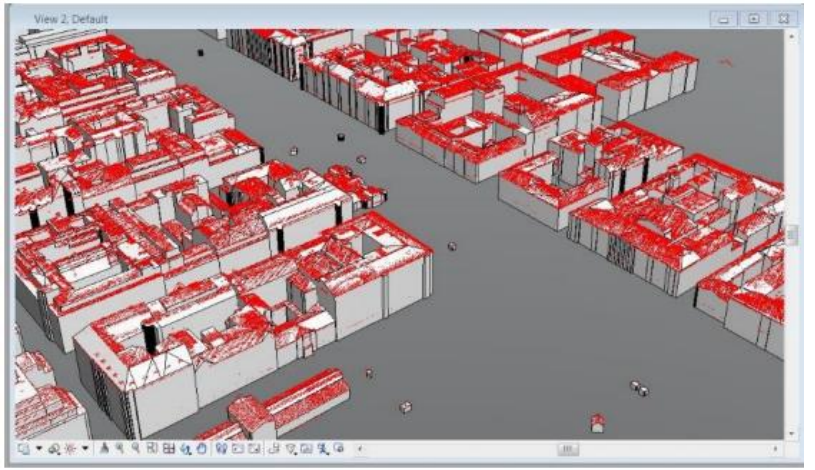
3D city from laser scanning III

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



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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/

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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

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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

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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)]

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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

Source: The Kalasatama DT Project

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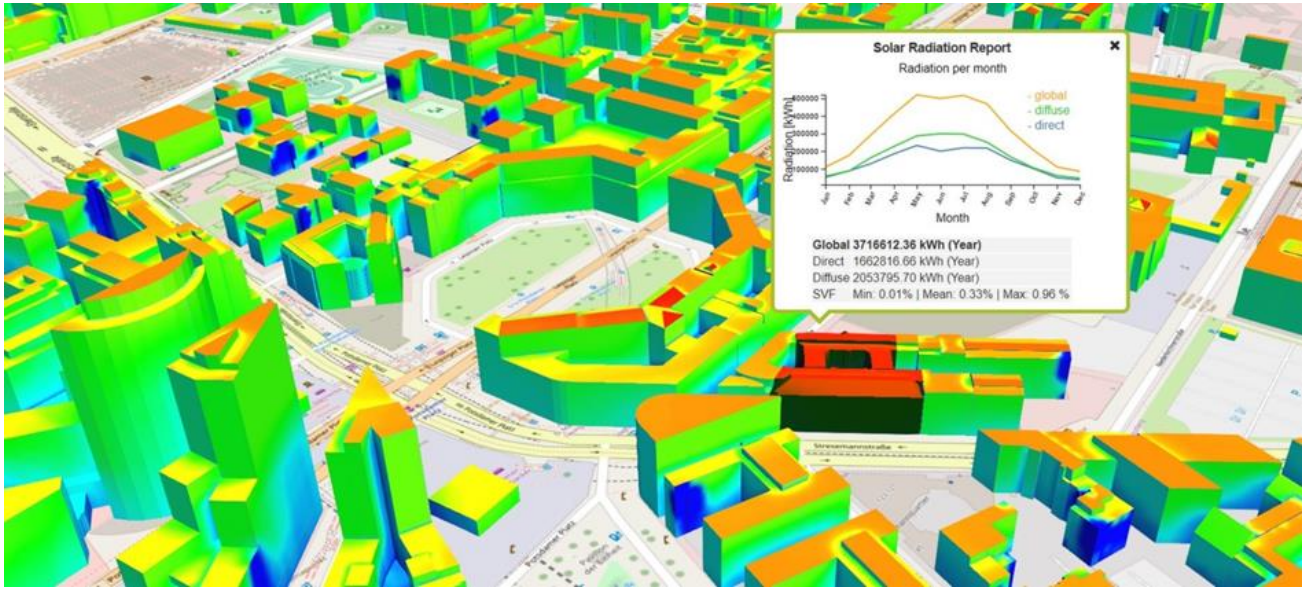
Analysis of solar radiation



3d-stadtmodell_solarpotentzialanalyse-aspect-ratio-20-9-3.jpg (2310×1040) (vc.systems)

Possibility of many calculations:

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

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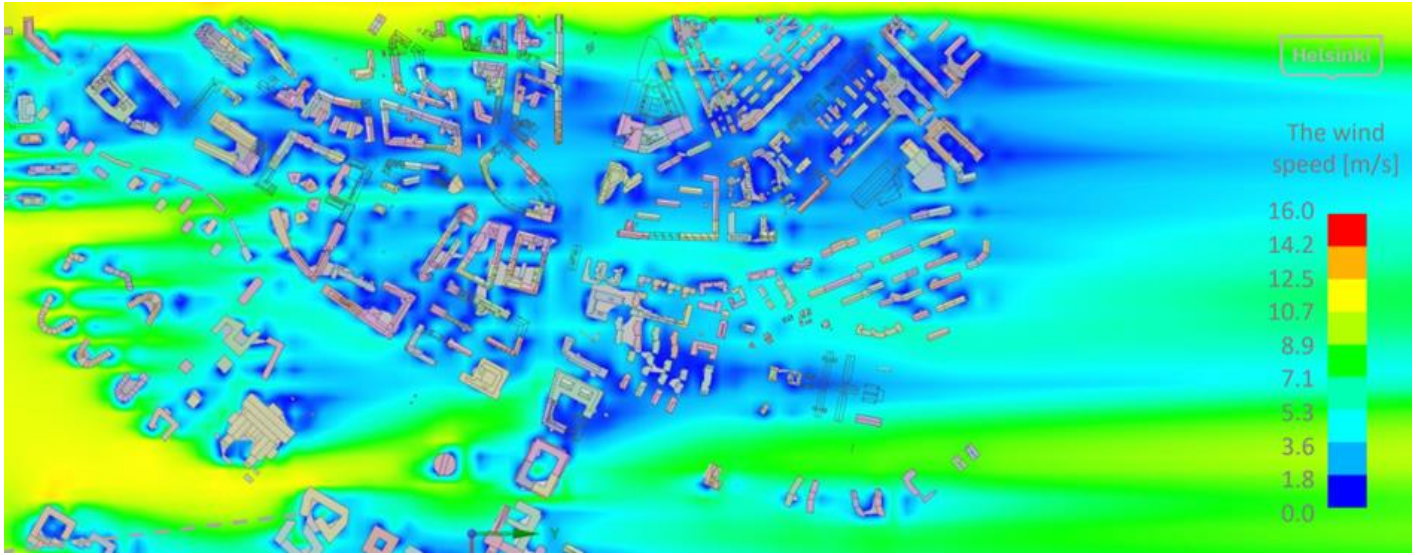
Analysis of wind speed

- 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

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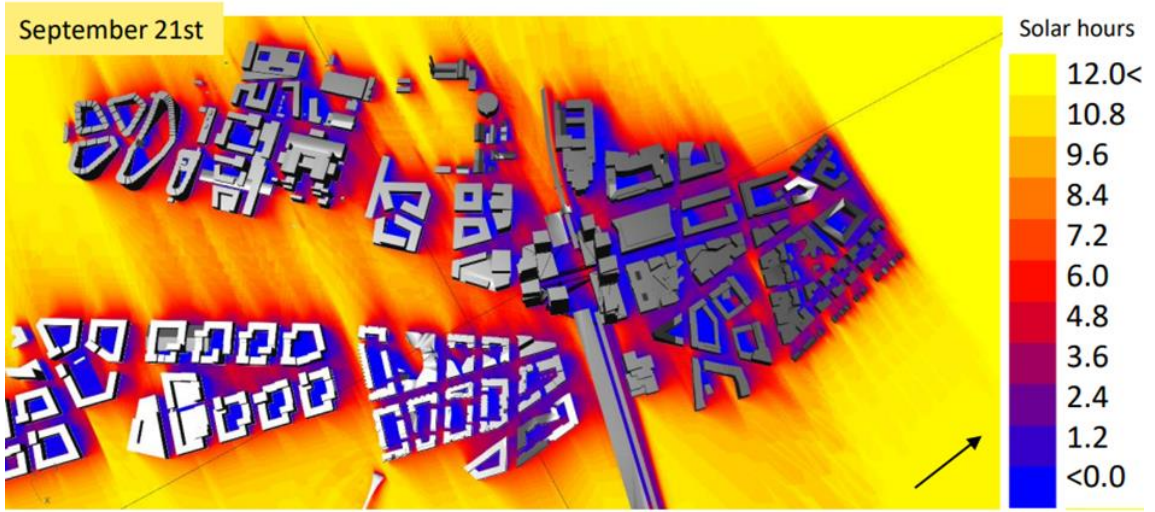
Sunshine and shadow analysis

- City planning



- 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

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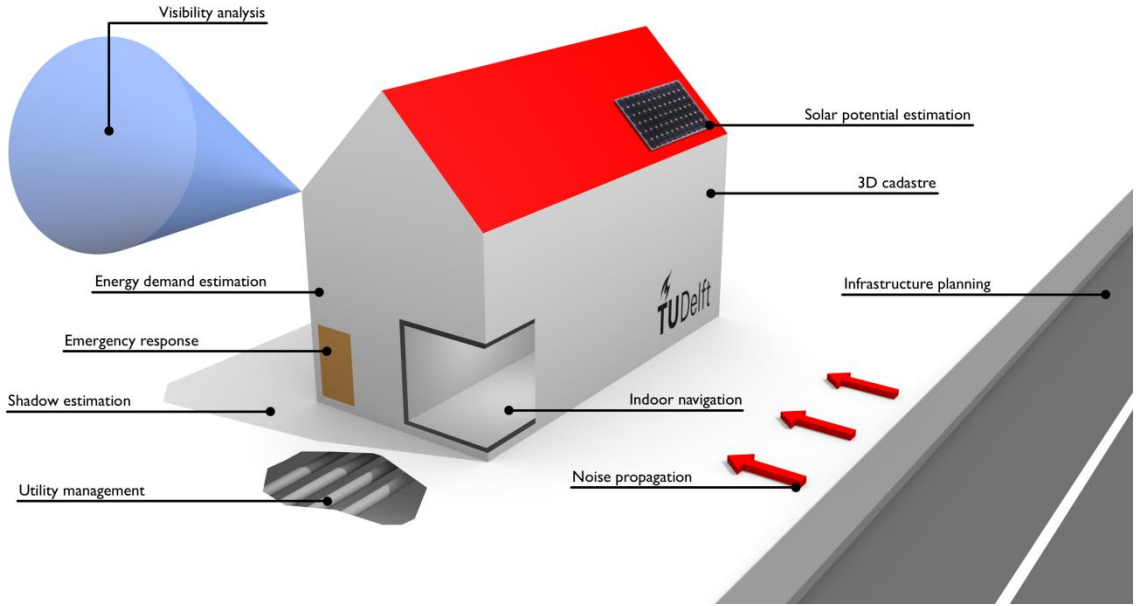
Other applications

- Heavy-rain events and flooding
- Digital Twins, Smart Cities

- Data quality and harmonisation fundamental

- Biljecki at 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/

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