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Scientific Conferenence

WISE CITY – THEORY AND PRACTICE

Warszawa, 23-24 may 2024

The potential of 3D models in managing complexity in cities - case studies of European cities

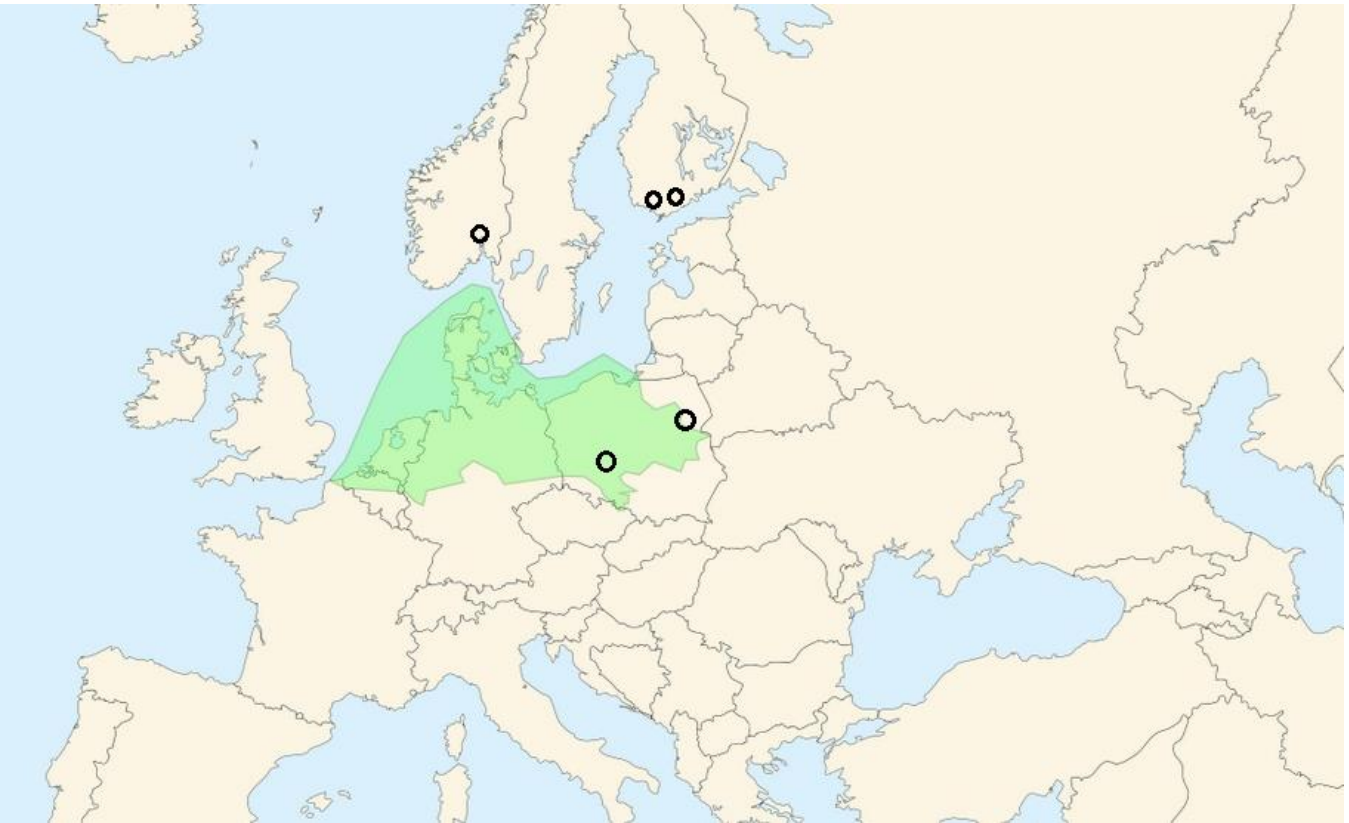
Presentation plan

1. **Introduction - City management: teoretical foundation; 3D City models, SCDT; While Nordic cities?**
2. **Materials and methods - Participant observation, interviews, online survey questionaire**
3. **Results of research - Poznań, Lublin, Turku, Helsinki, Oslo**
4. **Discussion of research results - Smart cities or wise cities ?**
5. **Summary - The need to develop wise cties and need to continue reserarch**

1. Introduction

The aim of the research is to assess: the quality of created 3D city models, the possibility of updating and developing them and using their potential to manage complexity in cities on the example of cities:

Poznań, Lublin, Turku, Helsinki, Oslo



1. Introduction

City management - theoretical basics

3D City models & Smart City Digital Twins

Why Nordic cities ?

1. Introductions. City management- teoretical basics

CITY AND DEVELOPMENT

Prof. I. Mironowicz (2013)

The term state in ancient times was used to **refer to cities**. "The first community of a larger number of families to meet needs that go beyond the current day is a rural commune.

"**The first community** created from a larger number of rural communes that has already reached the end of comprehensive self-sufficiency is a state; **it comes into being to make life possible, and it exists to make life good**." *Arystoteles, Stagiryta (384-322 p.n.e)*

Prof. P. Lorens (2005)

writes about defining the principles of sustainable development in relation to space management. P. Lorens draws attention to the need for a more **active spatial policy in Poland**.

The city is a natural creation

„The city comes into being to make life possible, and it exists to make life good.”

The city is natural creation.

Aristotle, Stagirite

1. Introductions. City management- teoretical basics

CITY MANAGEMENT CONCEPTS

GEOGRAPHY

Prof. Z. Hojnicki writes about the need to shift the attention of the research field of geography to the issue of the possibility of geography's contribution to solving the main problems of understanding the spatial organization and func- tion tion of a complex system: geographical environment - society, which is divided into subsystems: geographical environment and spatial socio-economic system, with different spatial organization, etc.

ECONOMIC GEOGRAPHY AND URBAN POLICY

Prof. A. Noworól distinguishes the following concepts in the context of economic geography and urban policy:

broadly understood: **public management** (field of management sciences)

narrowly understood: **territorial management**

The specificity of city management is situated **between public management and territorial management** (offices, public organizations etc)

1. Introductions. City management- teoretical basics

PUBLIC MANAGEMENT

Prof. B. Kożuch (2004)

"**Public management** is a detailed discipline of management science, the main object of research of which is the management of individual organizations in the public sphere, primarily public institutions and macrosystems, or macro-organizations, such as the national economy and the state, as well as mesosystems, e.g. regions and individual spheres of public life".

Kożuch details the scope of public **management according to the criteria of the areas of socio-economic life**, distinguishing:

1. Management in the economic sphere (infrastructure for business activities, public finance management, production management - maintaining the sector of state and municipal enterprises;
2. Public safety management;
3. Public health management;
4. Education management;
5. Culture management.

Territorial unit as a territorial organization.

1. Introductions. City management- teoretical basics

PROCESS MANAGEMENT

Peter M. Senge (2012)

„The Fifth Discipline"

1) theory and practice of **learning organizations** personal mastery,
2) mental models,
3) shared vision,
4) team learning,
5) systems thinking - these are five disciplines, the mastery of which will allow you to build a learning organization, **thanks to which you can achieve a lasting competitive advantage.**

Senge outlines how organizations can address the learning disabilities that threaten productivity and hinder success.

Learning organizations apply new, expansive ways of thinking and unleashing their aspirations to support their people in achieving goals that people truly identify with.

1. Introductions. City management- and digital twins

MANAGEMENT OF SYSTEMS & DIGITAL TWINS

Prof. M. Edger from University of Cambridge.

Profesor has explained how important a **systemic approach** to creating digital twins is and has explained the definition:

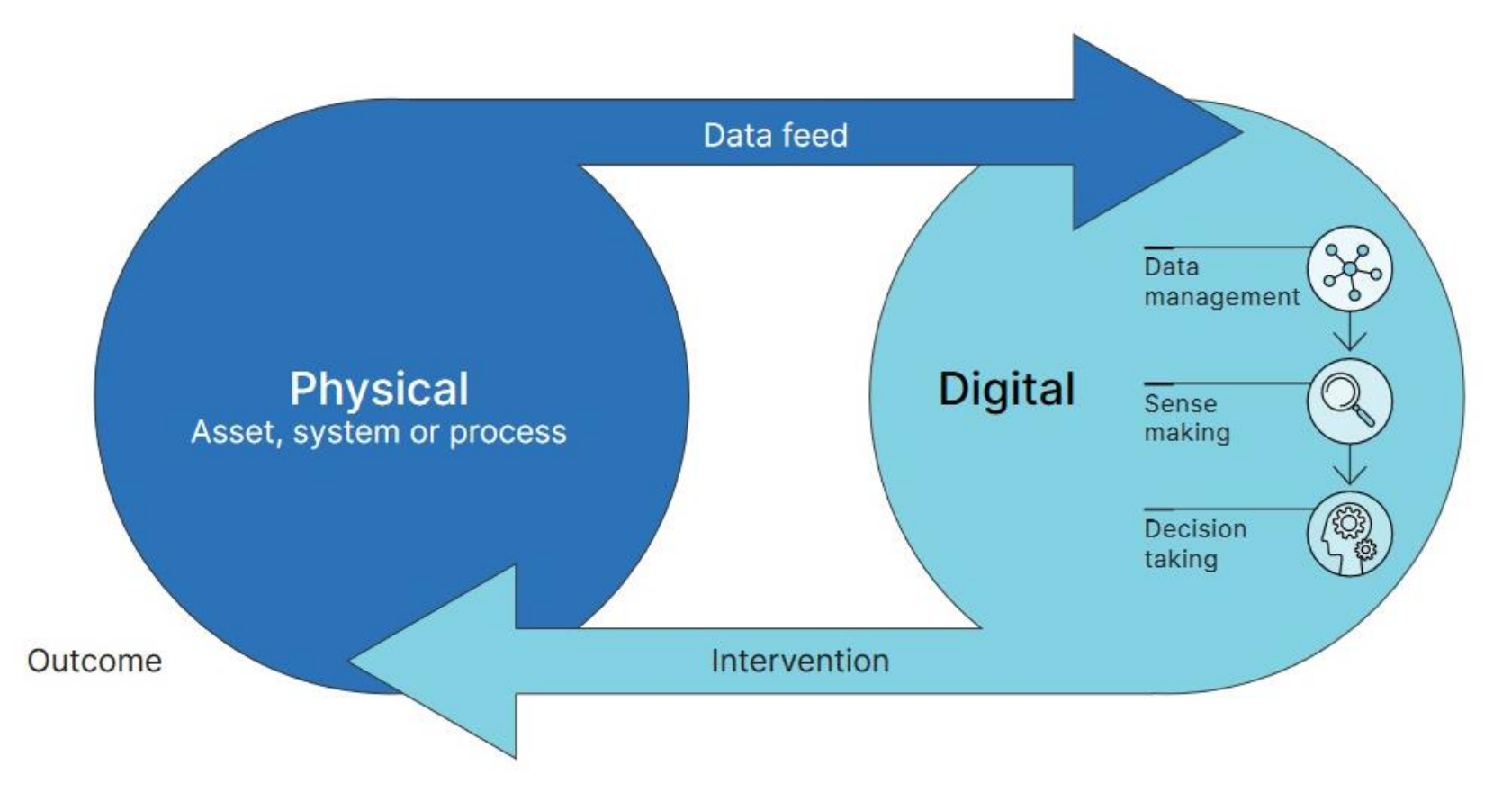
"A digital twin is a digital representation of a physical asset, process or system. It is distinguished from any other digital model by its dynamic connection to the physical twin. A digital twin unlocks value by supporting improved decision making". (Workshop, Turku,2024)

Gemini Principles" published by CDBB in 2018.

„A digital twin is a digital representation of a physical asset, **process or system**. It is distinguished from any other digital model by its dynamic connection to the physical twin. **A digital twin unlocks value by supporting improved decision making**”

Gemini Principles
By CDDB 2018.

“**A system of systems approach** applies systems thinking to the **built and natural environment**. A system is a connected collection of interrelated and interdependent parts; a complex whole that may be more than the sum of its parts. It is influenced by its environment, defined by its structure and purpose, and expressed through its function”. *Gemini Principles” by CDBB in 2018*



2. Research methods –

Including SCDT WORKSHOPS organized by Finland Futures Research Centre, University of Turku in Gdańsk 2023 and Turku 2024

2. Research methods

- **Analysis of the literature and the state of research**
- **Analysis of smart city rankings by Prof. Bartoszczuk**
- **Consultations of *Infosolutions* employees from Wrocław, (creators of the 3D model of Poznań)**
- **Participant observation: SCDT Workshops in Gdansk 08.09.23, in Turku 02.11.23 and 05.03.24**
- **Questionnaire interview: 12 open questions**
- **Online survey questionaire: 64 questions (using 47 of Lei, Stouffs, Biljecki, qualitative criteria (2023)**

Urbanisation | Aging population

Scarcity of space | Pollution

Infectious diseases | Decarbonisation

Reliable & affordable Energy

Traffic / Mobility / Accessibility

Legacy infrastructure / heritage

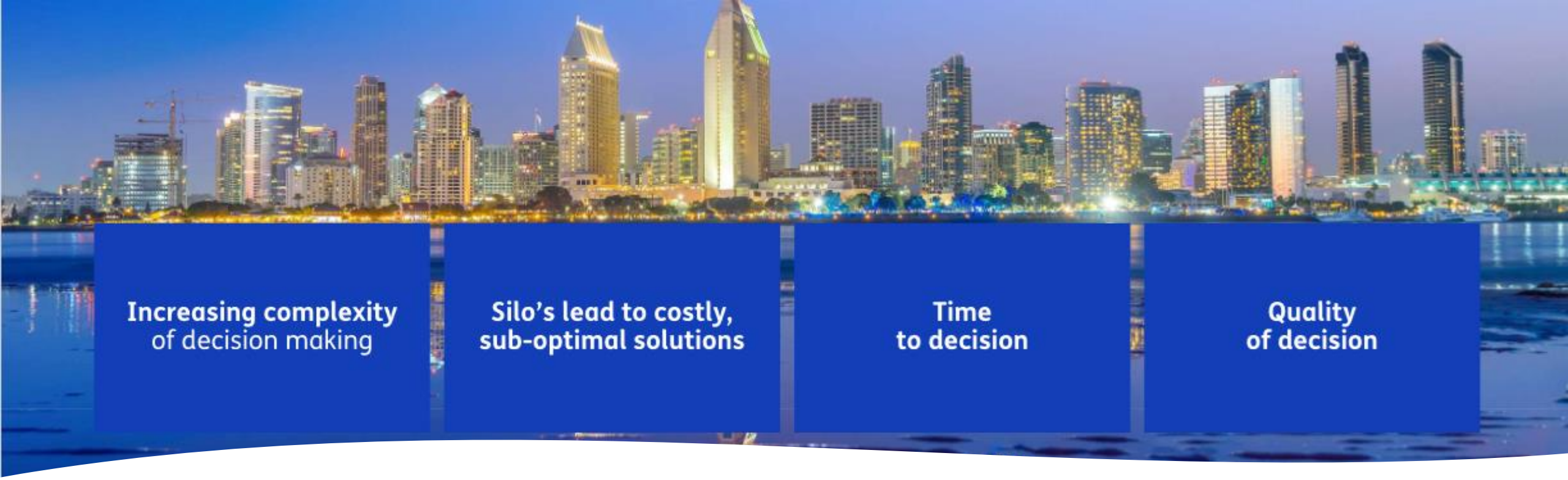
Inclusion | Crime

a complex organism

connected

2. Research methods – Participant observation

- **KEY WORKSHOPS** - **05.03.24, University of Turku, Finland**
- **KEY SPEAKERS:** **Bart Vuijk (TNO) & prof. Mark Edger**



2. Research methods – Participant observation

- **KEY WORKSHOPS** - **05.03.24, University of Turku, Finland**
- **KEY SPEAKERS: Bart Vuijk (TNO) & Prof. Mark Edge**

2. Reseach metods – Questionaire interview

1) Whether the input data for building the model is created in the open, international City GML standard ?
2) How up-to-date is the data contained in the 3D Model?
3) the development of the 3D Model planned?
4) Is the city model generally available?/ What is access to 3D Model data?
5) What cind types of services are available only to office employees?
6) What kind *services* are currently connected to the 3D model of the City of ?
7) How many services are connected to the 3d model ?
8) What type services/ data are available to employees inside the office?
9) What technological challenges have been overcome to make the 3d city model the best in the world (…)?
10) What purposes is the 3D city model currently most used for?
11) Has the fact of having a 3D city model, digital twin changed the city management model, (managing urban processes) in terms of for example, the creation of new units ?
12) Has the fact of having a 3D city model, digital twin changed the city management methods as "proces management" - "learning organization"

2. Research metods - Online survey questionaire

The survey was aimed at City Halls/or Units responsible for providing and maintaining 3D city models in Poznań, Lublin (Poland) and cities from Nordic Smart City Network: Turku, Helsinki (Finland), Oslo, Bergen (Norway), Copenhagen, Aarhus (Denmark), Stockholm (Sweden), Reykjavik (Iceland).

The survey contains six categories of questions:

Category 1 - Data portal (Lei, Stouffs, Biljecki, 2023)

Category 2 - Basic Information (Lei, Stouffs, Biljecki)

Category 3 - Thematic Content, *Types of thematic features in the CityGML, OGC Standard* **(Lei, Stouffs, Biljecki)**

Category 4 - Attribute content (Lei, Stouffs, Biljecki)

Category 5 - Selected criteria from: Smart City Index Master Indicators: 1) Online services; 2) Infrastructure: WiFi Coverage; Sensor Coverage; Integrated health + safety operations 3) Open Government: Open data, Open Apps; Privacy; 4) Entrepreneursip & Innovation: R +D.

Category 6 - Challenges for 3D model data as a platform for digital twins of cities (Inspiration from Stoter, 2020).

Urban Challenges

- Urbanisation
- Aging population
- Scarcity of space
- Pollution
- Infectious diseases
- Decarbonisation
- Reliable & affordable Energy
- Traffic / Mobility / Accessibility
- Legacy infrastructure / heritage
- Inclusion
- Crime

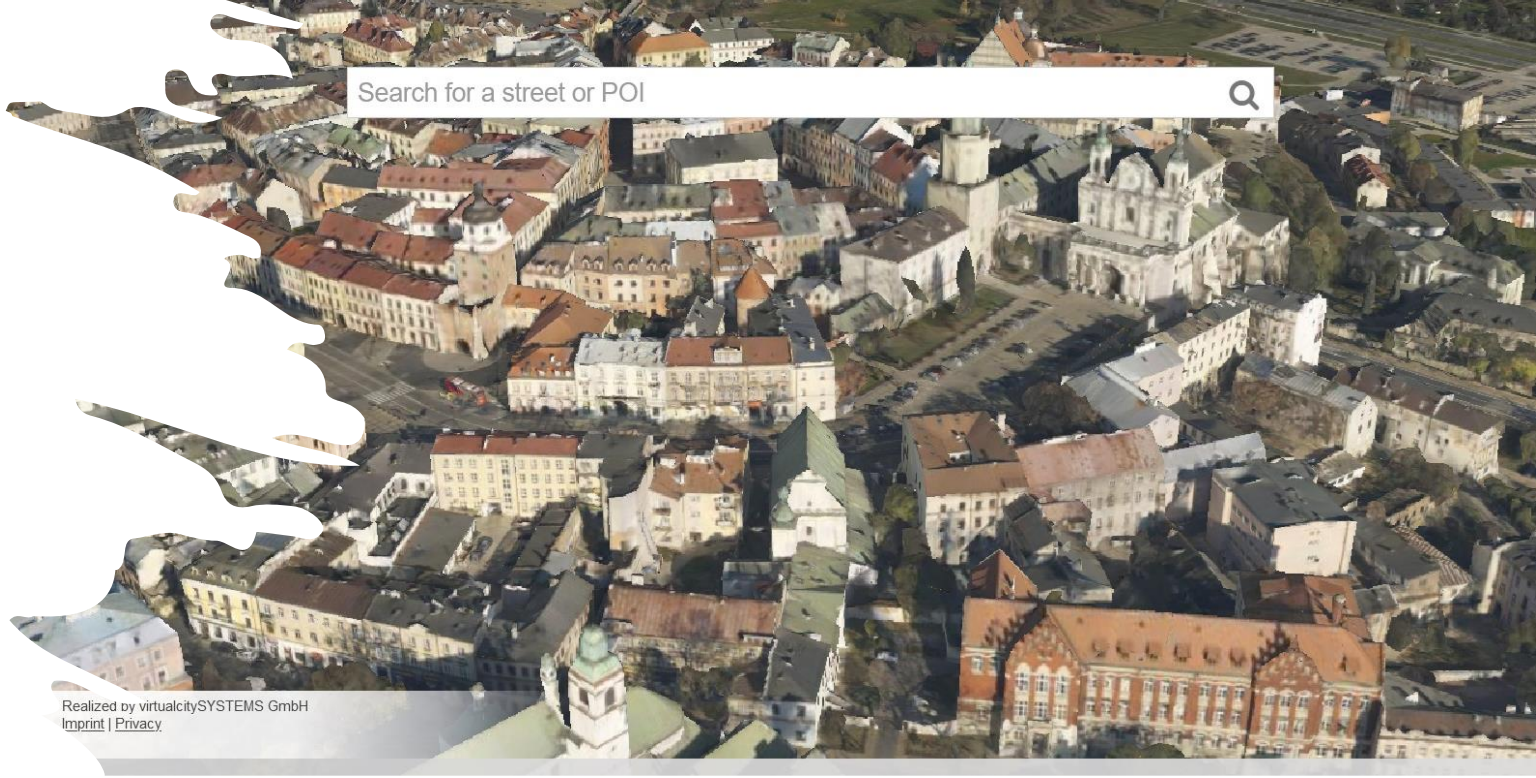
City: a complex organism

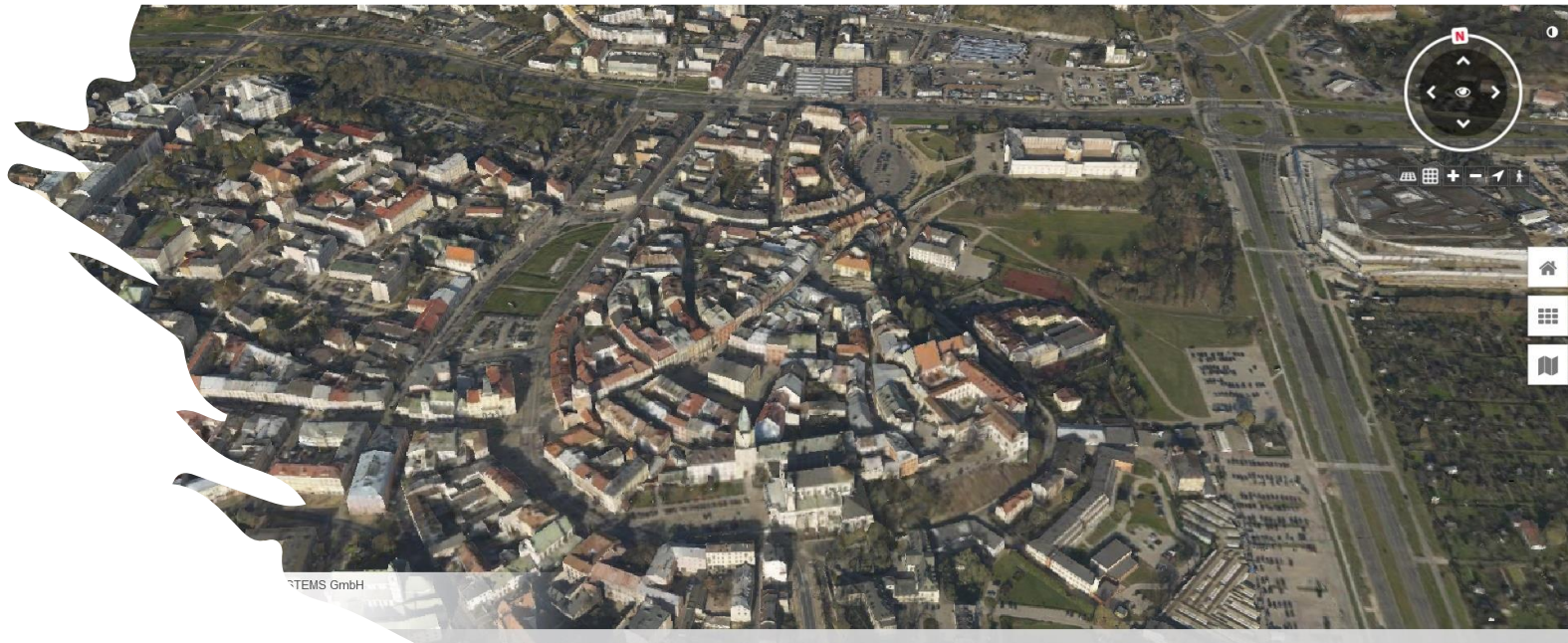
All things interconnected

3. Results of reserach

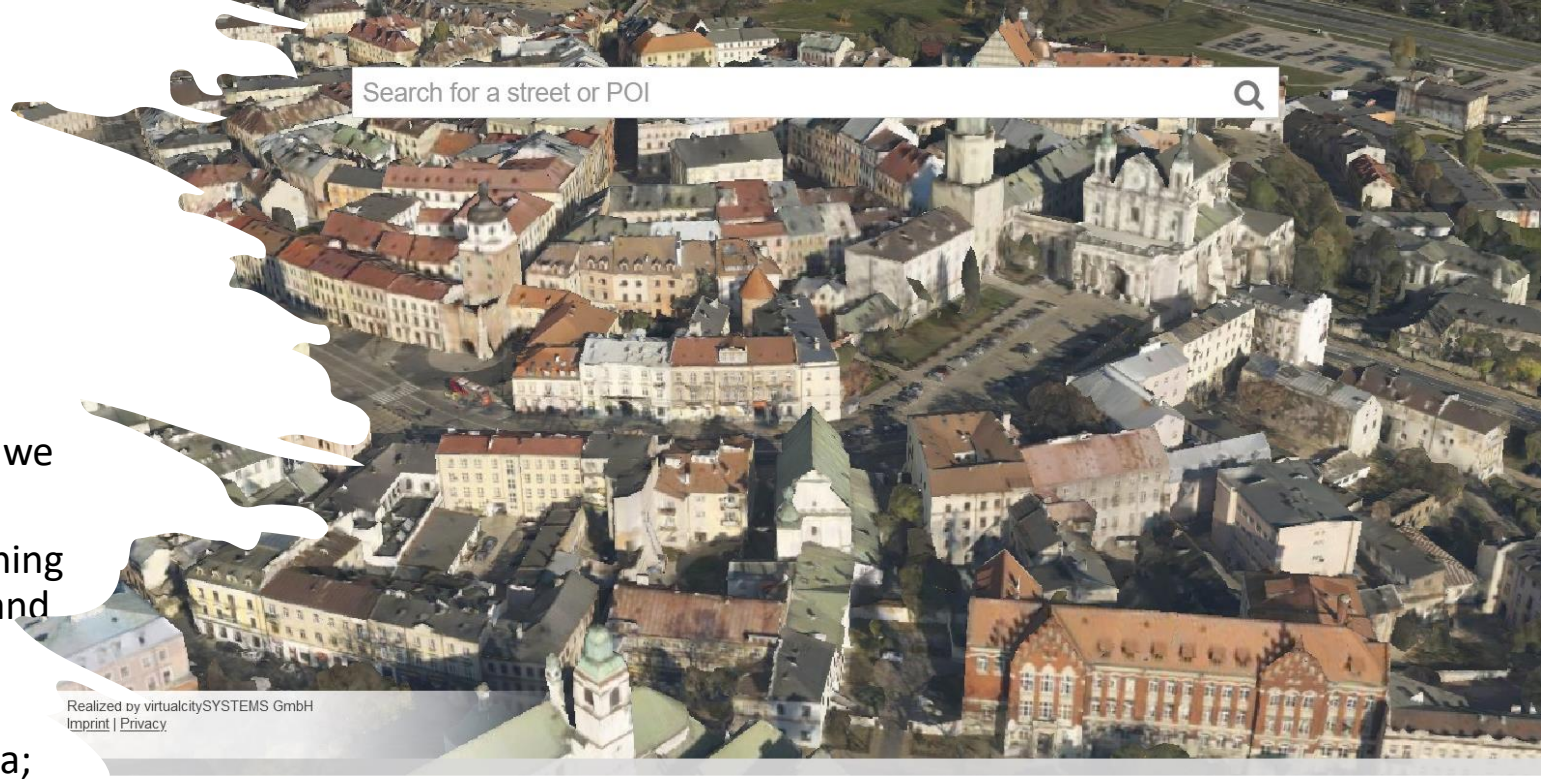
3. Results of the research
- Lublin, Poland

- Hilly terrain
- Area is ~ 147 square kilometers
- About 340 000 inhabitants
- The prevailing height of buildings 3-4 floors
- Middle Europe
- European Union





3. Results of the research - Lublin, Poland



1) **Yes, the City GML standard was used to create the 3D model**;
2) It depends on the layer. LOD2 is 2023, but we have some historical layers;
3) There are no plans to change well-functioning software. However, in terms of acquiring and processing new, available data, yes;
4) Access to the 3D model is via the website, but there are options for downloading data;
5) Services connected to the 3D model include several that support urban design;
6) **Services connected to the 3D model;**

https://geoportal.lublin.eu/mesh/#/
https://geoportal.lublin.eu/chmura/#/

https://geoportal.lublin.eu/lod/#/

https://geoportal.lublin.eu/3d/#/

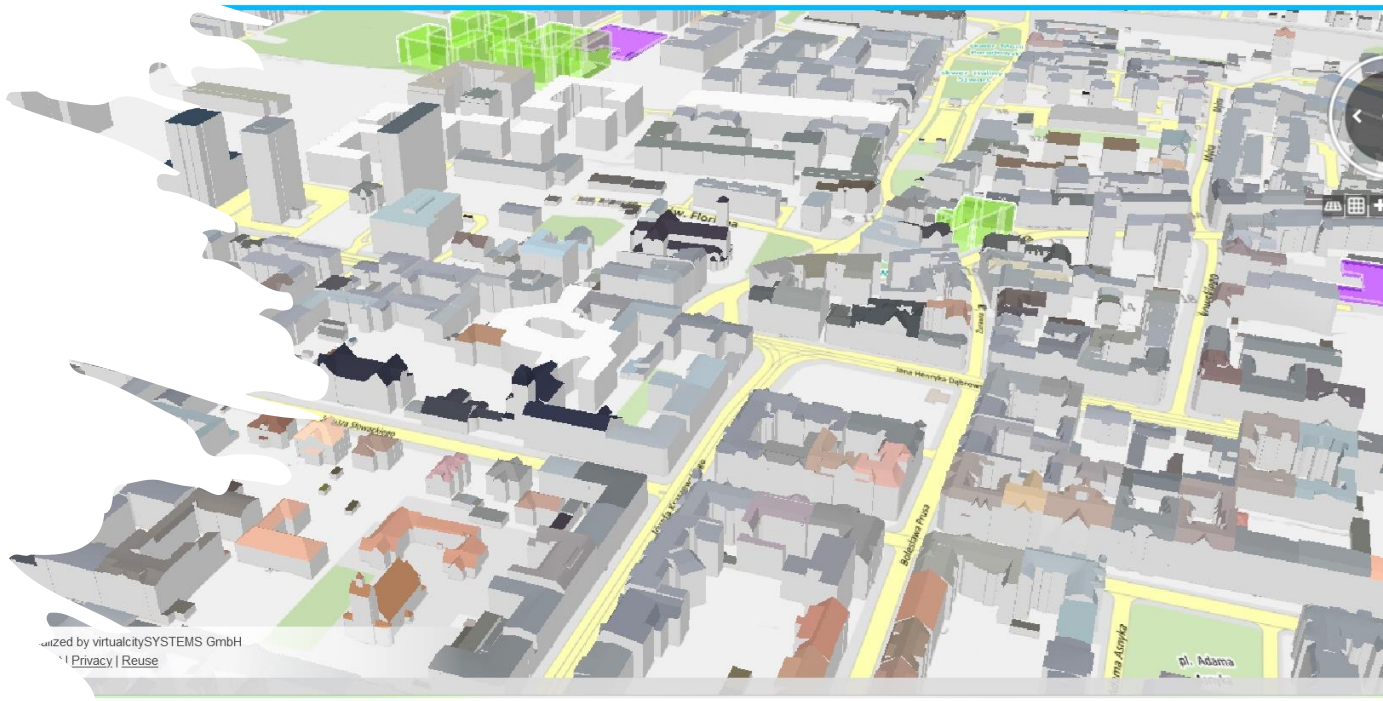
7) Four (4) services
8) The above-mentioned services are available to office employees and resident;
9) The challeng we overcome is updating the data and combining it with conventional 2d services like https://geoportal.lublin.eu/
10) The 3D model is used for: **urban planning, shadow analysis, height analysis;**
11) In the 2021 it was innovative, there were some new created, but while the time passed the **City Hall is more focused on 2d solutiins and analysis rather than 3D approach;**
12) Not quite – this kind of practices where implemented in 2d portals – mainly because the **public interest was focused on more simple solutions.**

3. Results of the research - Poznań, Poland

- Hilly terrain
- area is ~ 261 square kilometers
- about 540 000 inhabitants
- The prevailing height of buildings 4-5 floors
- Middle Europe
- European Union

3. Results of the research - Poznań, Poland

1) **Yes, the City GML standard was used to create the 3D model;**
2) Data on buildings, including those under construction, and planned ones, are updated on an ongoing basis; spatial planning, green;
3) **The 3D model has been ready and developed since 2018**
4) Access to the 3D model is via the website, but there are options for downloading data;
5) Services connected to the 3D model include several that support urban design;
6) Services connected to the 3D model: IoT sensor data - position of buses and trams, parking occupancy, smog data on air quality, bicycle counters, water gauges, Aquanet rain gauges, SIP data search (streets, addresses, plots), 3D Model data download service (download portal)
7) A dosen services; including **greenery database**;

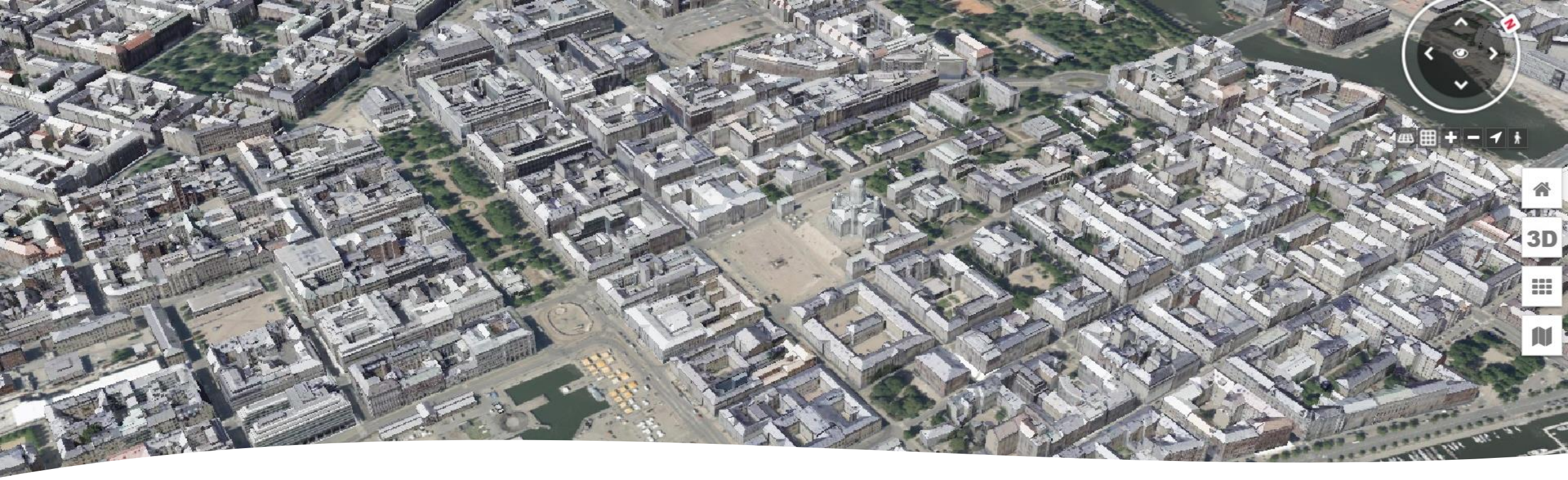


9) The challenges we overcome are:Integration of services and multiple data sets, new data sets – e.g. greenery, BIM model, underground infrastructure, small architecture, central data connection, providing interactive tools for working with the model, system interoperability – ability to download data and place data after logging in, mobile version of the system
10) The 3D model is used for: **urban planning,spatial planning, comperative analysys (biologically active surface), green growth, acoustic maps, Poznań lighting design; (architectural offices, property appraisers, students;**
11) **Yes, the model improved the work of departments in the city, especially those reakted to urban space, greenery d.b.;**
12) **Yes, the model in departments, being the basis influenced procedures making decisions regarding (…)**

3. Results of the research
- Poznań, Poland

11) **Has the fact of having a 3D model of the city, a digital twin, changed the methods of city management as "process management" – Poznań City Hall "learning organization"? Yes, the model in departments, being the basis, influenced procedures making decisions regarding:** preparation of current/planned development models and issuing decisions - greenery database: creation of a new data flow regarding greenery management in the city. This applies to both work within the office and outsourced work) - providing cross-sectional analyzes about the city

Poznań City Hall



3. Results of the research - Helsinki, Finland

- Hilly terrain
- Area is ~ 715 square kilometers
- About 650 000 inhabitants
- The prevailing height of buildings 4-5 floors
- Northen Europe
- European Union

3. Results of the research
- Helsinki, Finland

1) **Yes, Helsinki urban information model is based on CityGML** More information available https://www.hel.fi/en/decision-making/information-on-helsinki/maps-and-geospatial-data/helsinki-3d
2) There are two versions of the city model, a) photogrammetric mesh model – it's updated in 2017 for the whole city area, b) an urban information model (CityGML) which is actively updated through the city GIS processes and its more up to date (…)
3) **Yes, the model 3D City will be developed** (…)
4) Access to the building models and photogrammetric mesh are available as open data. License is CC4.0. delivery is through WFS-api (CityGML), 3DTiles and as file downloads (OBJ, FBX, CityFML, SKP); https://kartta.hel.fi/3d/
5) Critical infrastructure like different underground networks (electricity, fiber etc), bridges.
6) City's GIS office could possibly have answers to this after clarification of the question
7) As the city model data is available as open data for download and viewing;
8) **City officials will have a dedicated version of the city model, which unfortunately cannot be described in more detail here;**
9) Helsinki digital twin is being developed **as a system of systems**, connecting parts through OGC standard API's and open formats like CityGML and 3DTiles.
10) The 3D model is used for: urban planning, spatial planning
12) **Not yet, usage of the city model is still in very early stages.**

9) What technological challenges have been overcome to make the Helsinki 3D model the best in the world in 3D city model rankings?

Helsinki digital twin is being developed as a system of systems, connecting parts through OGC standard API's and open formats like CityGML and 3DTiles.
This approach has a lot of potential in selecting most suitable tools for each part of the process, however this approach also requires a lot of integration work and comprehensive architecture design to function properly.

Helsinki City Hall

11) Has the fact of having a 3D city model changed the city management methods in the City Hall, a new approach to city development management ? new units ?

To create the Helsinki 3D city model originally in 2015, a dedicated team was created to Helsinki **city strategic department.** Since then, creating and developing city model has been a joint effort with this dedicated team, urban environment division (GIS office) and **city innovation company Forum Virium Helsinki;**

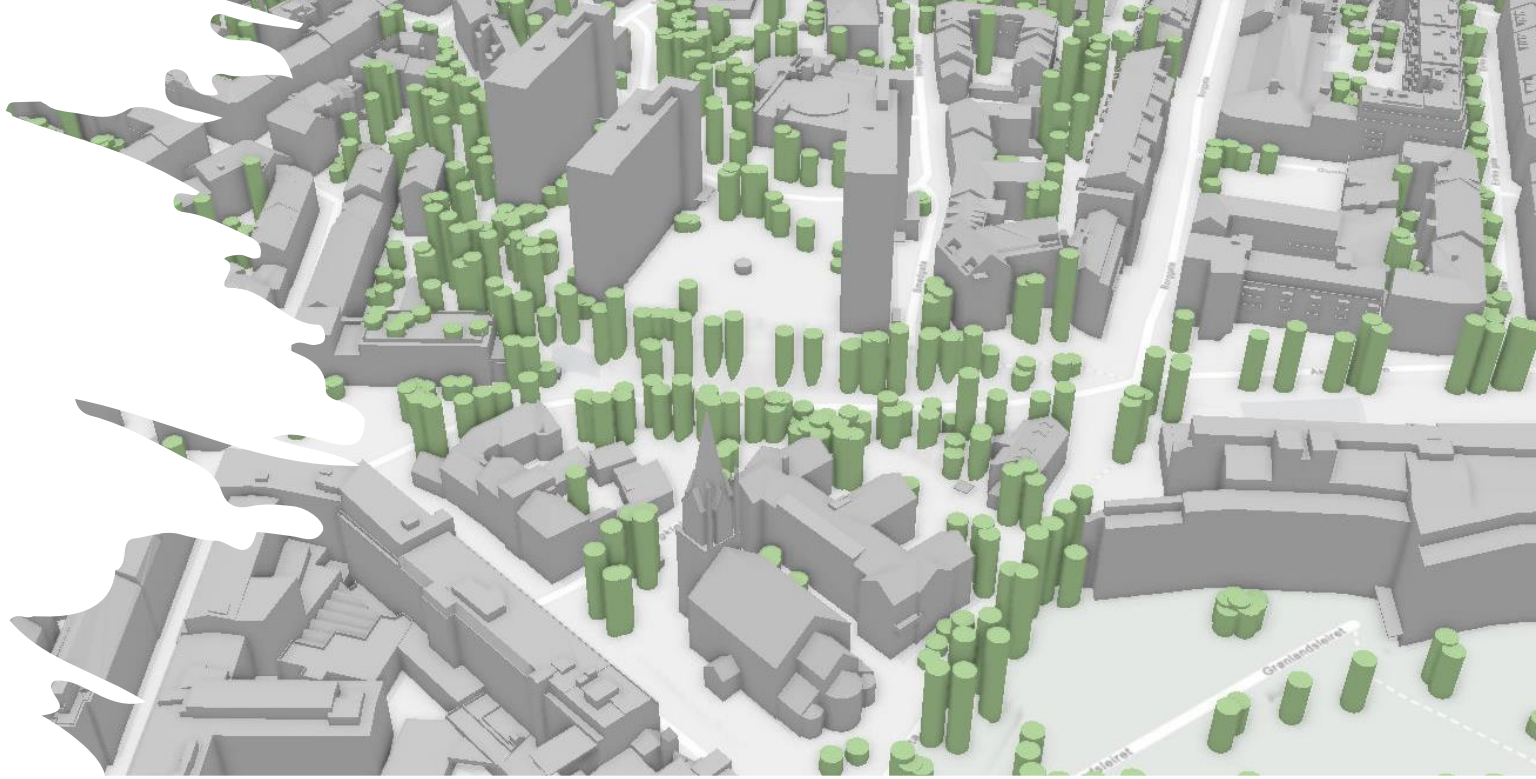
Helsinki City Hall

3. Results of the research
- Turku, Finland

- Varied terrain
- Area is 245 square kilometers
- About 190 000 inhabitants
- The prevailing height of buildings 2-3 floors
- https://opaskartta.turku.fi/ims/

3. Results of the research
- Oslo, Norway

- Variable topography, with mountainous areas and river valleys
- area is ~ 480 square kilometers
- about 700 thousand inhabitants
- The prevailing height of buildings 5-6 floors
- does not belong to the EU



All

3. Results of the research

Oslo, Norway

1) We have various models in different standards and use them according to needs;
2) Yes, they are up to date, updates as the planning prosess goes on.
3) Yes, for example, we are working with a 3D Reality Mesh model for the city;
4) Model 3D Oslo, so far only for internal use;
5) All available data is connected with the 3D city model;
6) I do not know how many services are connected
7) I do not know how many services;
8) Inside office: 3D - data of existing and planned buildings, landskape, infrastructure on the ground;
9) No answer to the question of what challenges were overcome
10) We are in process of drafting a new 3D strategy in city planning, which will conclude with a series of recommendations and action plans. At this moment it is too early to say how this will change the city management models and processes.
11) It is on its way to change the way we considering the ongoing plans
12) **Learning organization? It is on its way to do that, yes.**

3. Results of the research - Oslo, Norway

Oslo, Scenarios in ArcGIS Urban 2

Oslo, Gamblebyen 3D model mesh

3. Results od the research - Oslo, Norway

Analysis for urban design

– scenarios in ArcGIS Urban 2

3. Results od the research - Oslo, Norway

Analysis of <u>wind strength and directions</u>

4. Discussion of research results - Smart cities or wise cities?

- The research results indicate that in order for a 3D city model to be used as a base for digital twins of cities, it must meet OGC standards, e.g. City GML. This makes them a good base for digital twins of cities. All suveyed city halls have confirmed the compliance of the 3D city model with the standards OGC. Rightfully so, the 3D models of Helsinki, Poznań (Lublin is similar) are considered among the best in the world, also for their good quality, high detail and making them available free of charge to other users.

- 3D city models are most often used for urban design, spatial planning, social participation, and climate change prediction (Oslo, Helsinki, where great importance is attached to the analysis of wind strength and directions). 3D models have great potential in managing complexity in cities and building the resilience of cities. The following trends are observed: 1) creation of new units as **city innovation company Forum Virium Helsinki** (Helsinki) 2) recognition of the territorial unit city hall as a **"self-learning organization",** which is confirmed by the Poznań, Helsinki, Oslo. However, solving the problem of the lack of specialists in the field of digital twins is a big challenge. Common sense and the need for constant cooperation with companies and scientific units are still important when making decisions in cities.

5. Summary

1. Research on the characterization and evaluation of 3D city models represents a niche in research compared to other topics.
2. 3D city models created in accordance with standard as CityGML (OGC) enable their constant updating and transformation into digital twins (Helsinki, Turku, Poznań, Lublin, Oslo);
3. Currenntly, there are many aplications of 3D city models: spatial planning, urban planning, architectural and urban planning competitions, derailed inventory of urban greenery, analysis of wind forces and directions to predict the effects of climate change, for shadow analusis, height analysis, many other analyses answering the question what would happen if ?
4. In European Union cities, there is a trend of making 3D city models available to users free of charge.
5. There is a lack of specialits for complex analyses using digital twins, so it is difficult to say that the development of new technologies will change the approach to city management at this stage (Helsinki)

6. Summary

6. More advanced analyses related to the resiliance of cities are carried out in Oslo (wind directions and forces as well as sunlight durations and forces as well as sunlight duration in selected districts). Special reports in this regard are prepared on 2D maps. Oslo is a city located far to the north, so a lot of attention is paid to this type analysis.
7. Respondents from City Halls: in Poznań, Helsinki and Oslo confirmed that the creation of 3D city models changed the way of management in their organization. An innovative company, Forum Virium Helsinki was established in Helsinki. It can be considered that these are the beginnings of a new approach to managing such a territorial unit as a „learning organization”.
8. There is a need for continued resarch.