# Smart Cities: Visualization

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# Presentation Overview

- Smart Cities
- Types of data in Smart City
- Visualization of Smart City data
- Potential standard
- Application of SC24 Standards

# Smart City

- Applies advanced ICT (IoT, Cloud, Big Data etc) to manage city assets and utilities
- Provides efficient, secure urban services through smart systems (eg transport) and infrastructure (buildings, homes)
- Reduces environmental impact, enhances sustainability with emerging technologies

# Smart Cities

- Barcelona – Smart City department
- Amsterdam – Smart City program
- Stockholm – broadband cover, on line gov, collects data from vehicles, sensors etc
- Songdo (송도/松都)

# Smart City Objects

- Digital Twin
  - Model of real city – eg Tokyo, Amsterdam, New York
  - Future city to be developed
- Static Components
  - Buildings, roads, parks, water bodies
- Animated Components
  - Cars, people etc included
- Semantic data
  - Legal, noise etc

# Smart City Components

- **Physical, Geometric Objects**
  - Static
    - Buildings, Roads
    - Open spaces – parks, gardens, sports
    - Water bodies – rivers, lakes
  - Mobile Objects (if animation needed)
    - Cars, aircraft, ships
    - Humans, individual and crowds
    - Robots (eg drones)
- **Semantics**
  - Legal: ownership, road rules, security…
  - Feature: noise levels, pollution, network traffic, smart city indicators..
- **Sensors**

# Physical / Geometric

- **CityGML**
  - Defines classes and relations for geometric, topological, semantic and appearance properties of **cities**
    - LOD 0: footprint
    - LOD 1: blocks with roofs
    - LOD 2: texture and roofs
    - LOD 3: architecture model of exterior
    - LOD 4: interior models
  - CityGML models can be visualized with X3D


- **Industry Foundation Classes ISO 16739**
  - Building Information Modelling
  - Building models – geometry, topology, semantics

# Semantic Data

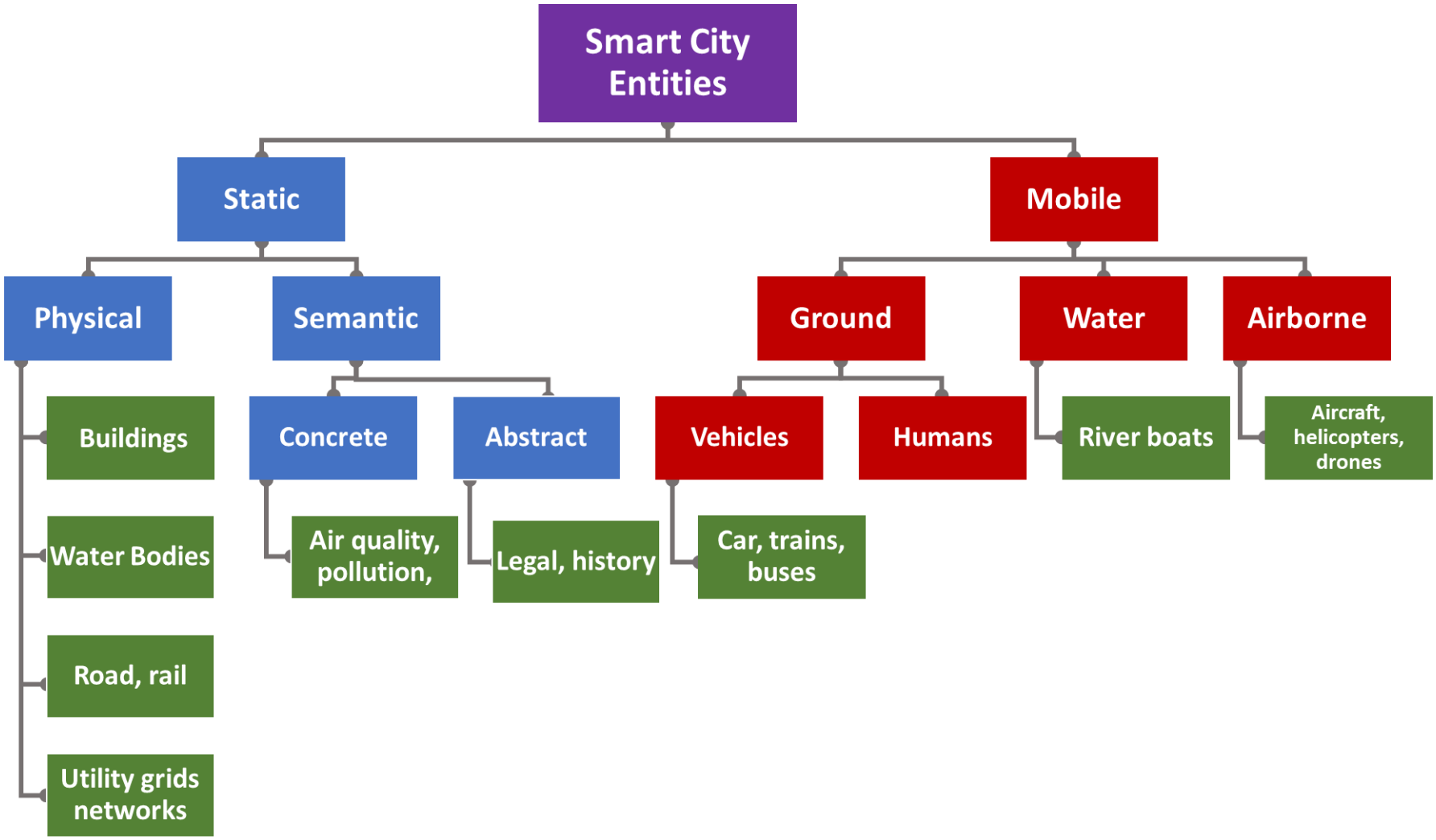
- **CityGML**
  - limited semantics
  - Focus on building details
  - Can / has been extended to include other features

- **Industry Foundation Classes ISO 16739+**
  - Building Information Model
  - Building models – geometry, topology, semantics

- **SEDRIS (ISO)**
  - Has all components needed for city modelling (DRM, SRM, EDCS)
  - military focus but can be extended
  - Needs visual presentation (X3D?)

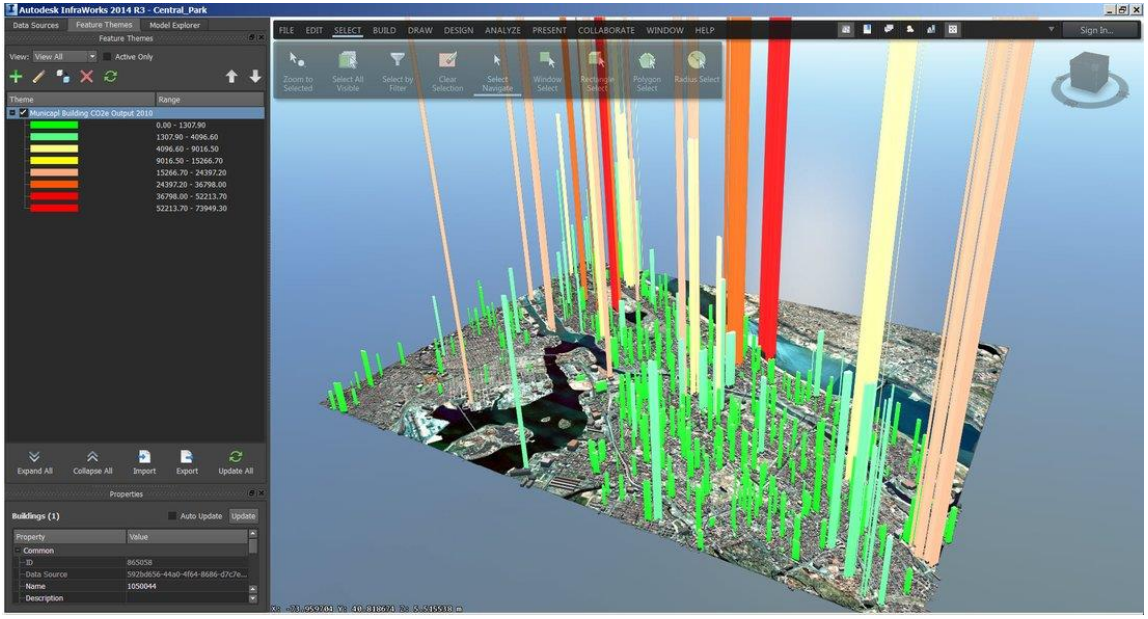
ISO/TC 184/SC 4 Industrial data

# Taxonomy of (Smart) City Entities



# Visualization for Semantic Data

- Example from:
  - http://fortune.com/2014/06/13/the-new-metropolis-the-new-urban-pioneers/
  - Autodesk modelling
  - Energy use and Greenhouse Gas emissions from New York buildings
  - Emissions represented as towers with color / height describing emission type and magnitude



# European Research in 3D City Modelling

European Cost action TU0801 – Semantic enrichment of 3D city models for sustainable urban development


1. Billen, R., et al. (2014) *3D City Models and urban information: Current issues and perspectives*, edp Sciences Les Ulis, France
2. Métral, C., et al. (2014) A repository of information visualization techniques to support the design of 3D virtual city models. In: *Innovations in 3D Geo-Information Sciences*. Springer 175-194
3. Métral, C. and Falquet, G. (2014) Prototyping Information Visualization in 3D City Models: a Model-based Approach. In: *3DGeoInfo 2014 Conference,* Dubai: Nov 2014
4. Metral, C., Ghoula, N. and Falquet, G. (2012) An ontology of 3D visualization techniques for enriched 3D city models. Usage, usability, and utility of 3D city models–European COST action TU0801 02005
5. Bazargan Harandi, K. (2011) *Abstract information visualization in interactive 3D virtual environments: conceptualization and usability evaluation*. [PhD] University of Geneva, Geneva, Switzerland

# 3D City Model Formats

| | X3D | COLLADA | KML | Shape | CityGML | IFC | DXF |
|---|---|---|---|---|---|---|---|
| GP: General purpose<br>IM: Information model | GP | GP | GP | GP | IM | IM | GP |
| 3D Geometry | + | + | • | • | + | ++ | • |
| Georeferencing | + | • | • | + | ++ | • | |
| Appearance | ++ | ++ | • | | + | • | |
| 3D Topology | • | • | | | · | • | |
| Semantics | • | • | • | • | ++ | ++ | |
| Levels of Detail | + | + | • | | ++ | • | |
| Links/embedding | + | ++ | ++ | | ++ | | |
| Extensibility | + | ++ | + | | ++ | • | |
| Fast Rendering | ++ | ++ | + | + | + | •/+ | + |

Kolbe, T. H. (2012) BIM, CityGML, and related standardization.
In: *2012 Digital Landscape Architecture Conference,* Bernburg/Dessau, Germany

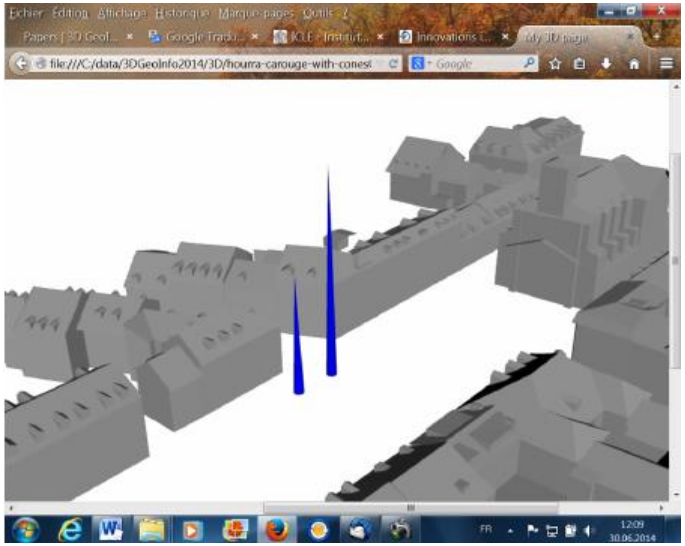
# Visualization Techniques

Ontology of visualization techniques proposed:

1. representation of 3D visualization techniques
   - Data description concept
   - Visualization technique concept – data, location, rendering, attributes etc
2. evaluation module
   - applies metrics based on user and system performance to assess utility of particular technique while considering user context

*Metral, C., Ghoula, N. and Falquet, G. (2012) An ontology of 3D visualization techniques for enriched 3D city models. Usage, usability, and utility of 3D city models–European COST action TU0801 02005*

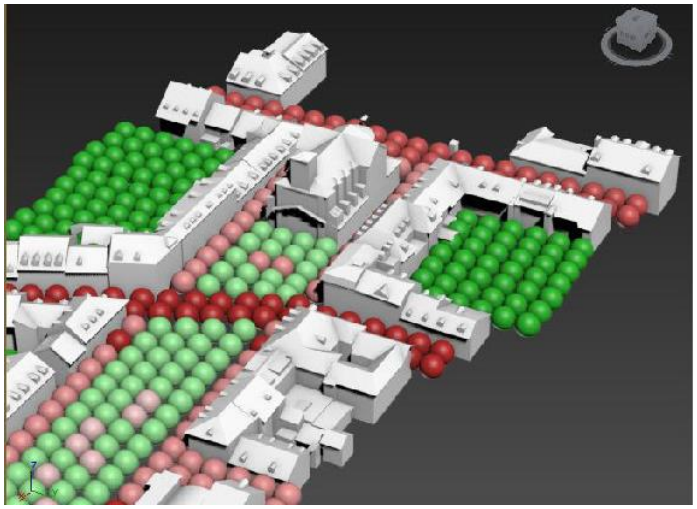
# Semantic City Visualization Examples (1)



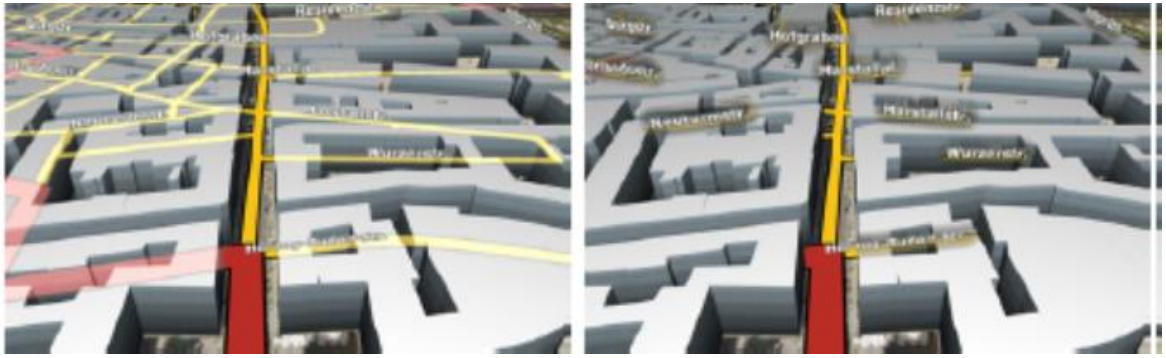
**Pedestrian traffic as cones**

**Traffic conditions – 4D real time visualization**

# Semantic City Visualization Examples (2)

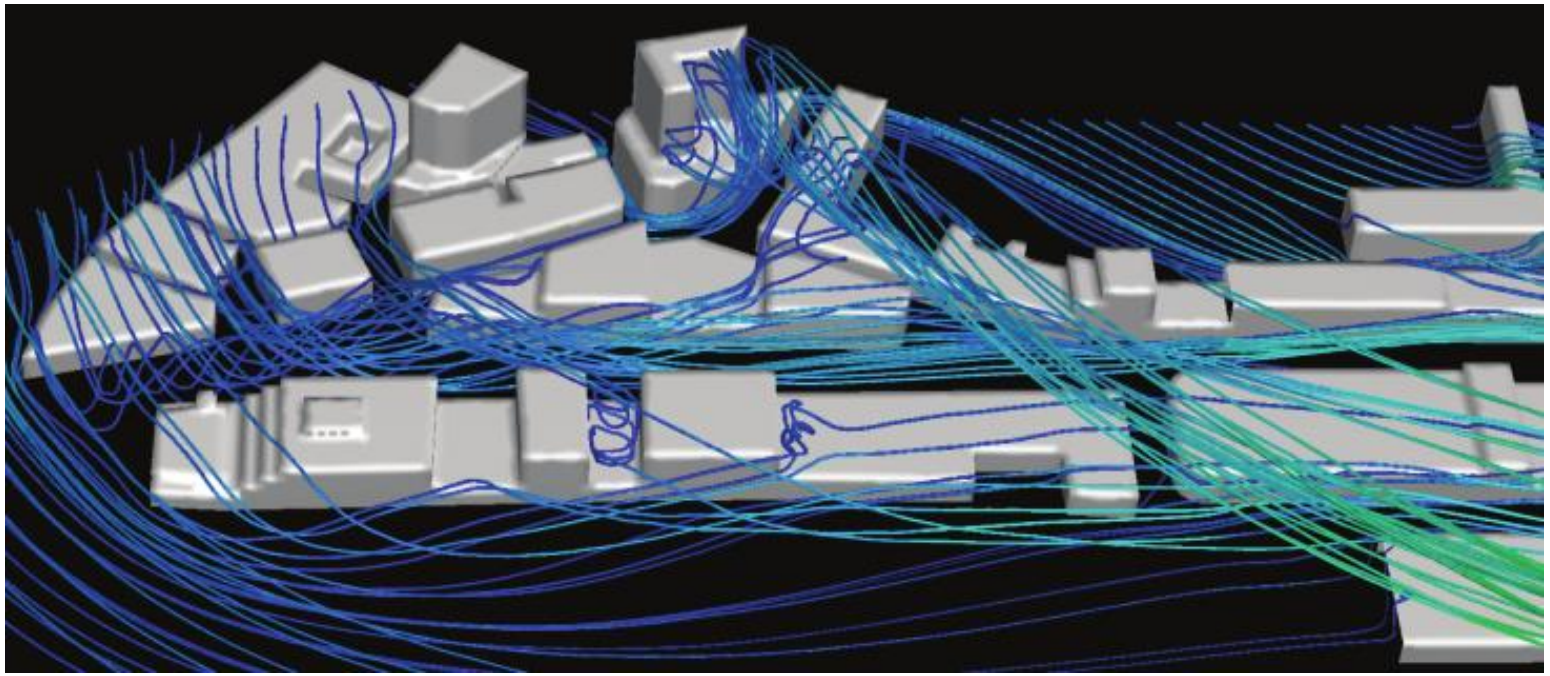


**Air quality represented as colored spheres**



**Two techniques for traffic flow:**
**Transparency Labels on left, Glowing Roads on right**

# Semantic City Visualization Examples (3)



**Wind flow in Portuguese city Aveiro**

# What to Visualize?

- Geometry and appearance (3D)
- Physical property
  - Scalar (eg air quality)
  - Vector (eg wind)
- Semantic property
  - Concrete (eg population density)
  - Abstract (eg ownership)
- Other
  - Wifi coverage?

# Visual Data Types

1. 1D data - linear data – eg text
2. 2D data – planar data, eg map
3. 3D data – 3D objects, eg building
4. Temporal data – items with start/finish time
5. Multidimensional data – data not primarily spatial
6. Tree data – tree structures
7. Network data – items with links

Shneiderman, B. (1996). The eyes have it: A task by data type taxonomy for information visualizations. Visual Languages, 1996. Proceedings., IEEE Symposium on. Boulder, Colorado, US, IEEE: 336-343.

# Use Cases for Smart Cities

- 29 use cases identified in 2015 review
  - More than 400 references!
- 25 visualization use cases
  - 3D visualization model required
  - Visibility analysis, shadowing, routing
- 4 non-visualization use cases
  - 3D model visualization not required
  - Solar irradiation, energy demand, building types

Biljecki, F., Stoter, J., Ledoux, H., Zlatanova, S. and Çöltekin, A. (2015) Applications of 3D city models: State of the art review. *ISPRS International Journal of Geo-Information* **4** (4) 2842-2889

# Guidelines for Visualization

- Review 3D city modelling
- Review visualization techniques
- Physical and semantic data for Smart Cities
- Develop Use Cases
- Develop guidelines
  - Represent abstract data, scalars, vectors
- Application of SC24 standards

# Where are the Sensors?


**Sensor XYZ**
**UV radiation**

# Where is Free Wifi?

# What is Weather?

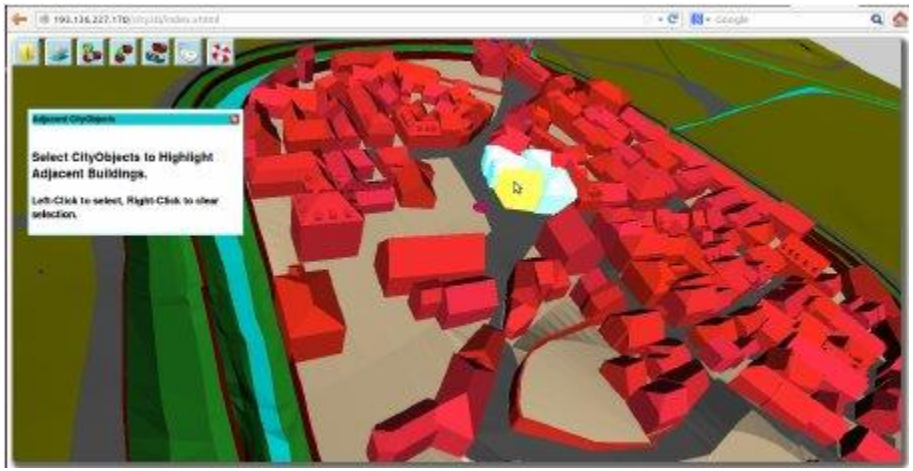
# SEDRIS Smart City

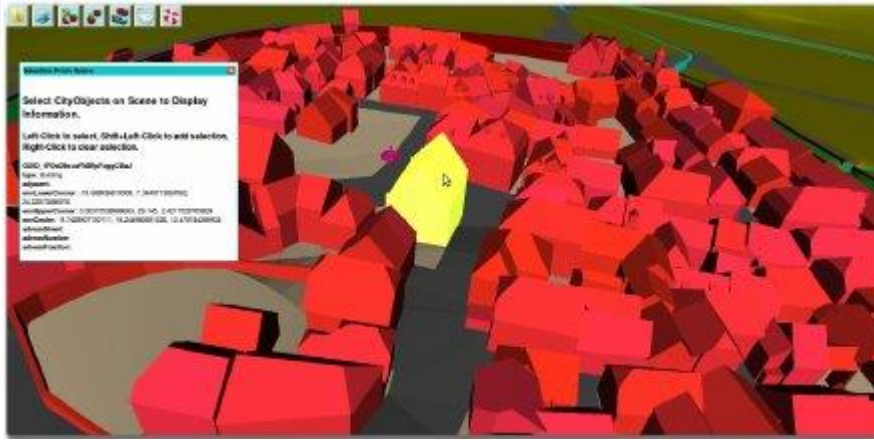
- **Parts 1, 2, 3** and **C Language Binding**
- **Spatial Reference Model (SRM)**
  - Position, orientation, reference frames
- **Environmental Data Coding Specification (EDCS)**
  - Identification/registration of objects
- **Data Representation Model (DRM)**
  - Relationships between objects and data

# X3D Smart City

- X3D can be used to render CityGML models
- http://www.web3d.org/sites/default/files/attachment/node/1853/edit/X3D%20An%20Open%203D%20Digital%20World%20-%20March%202015.pdf

# X3D City Model


*Rodrigues, J. I., Figueiredo, M. J. and Costa, C. P. (2013) Web3DGIS for city models with CityGML and X3D. In: Information Visualisation (IV), 2013 17th International Conference, London, IEEE*

# Potential SC24 Standard

- Guidelines for Smart City Visualization
  - Define rules for visualizing SC objects
  - Based on European work as guide
  - Rules for physical objects (eg buildings)
  - Rules for semantic objects (eg air quality)
  - Application of SC24 standards – X3D, MAR, SEDRIS

# Outline

# Discussion

- SC24 standards (X3D, SEDRIS, H-Anim) most suited to physical/geometric *sensor-based* (eg visual) representation
- X3D visualization of CityGML models achieved
- Different techniques required for semantic visualization of both *sensor* (eg wind flow) and *non-sensor* based attributes (eg ownership)
- OGC has considerable expertise in city modelling
- Potential visualization guidelines standard