Quality Control of 3D Geospatial Data

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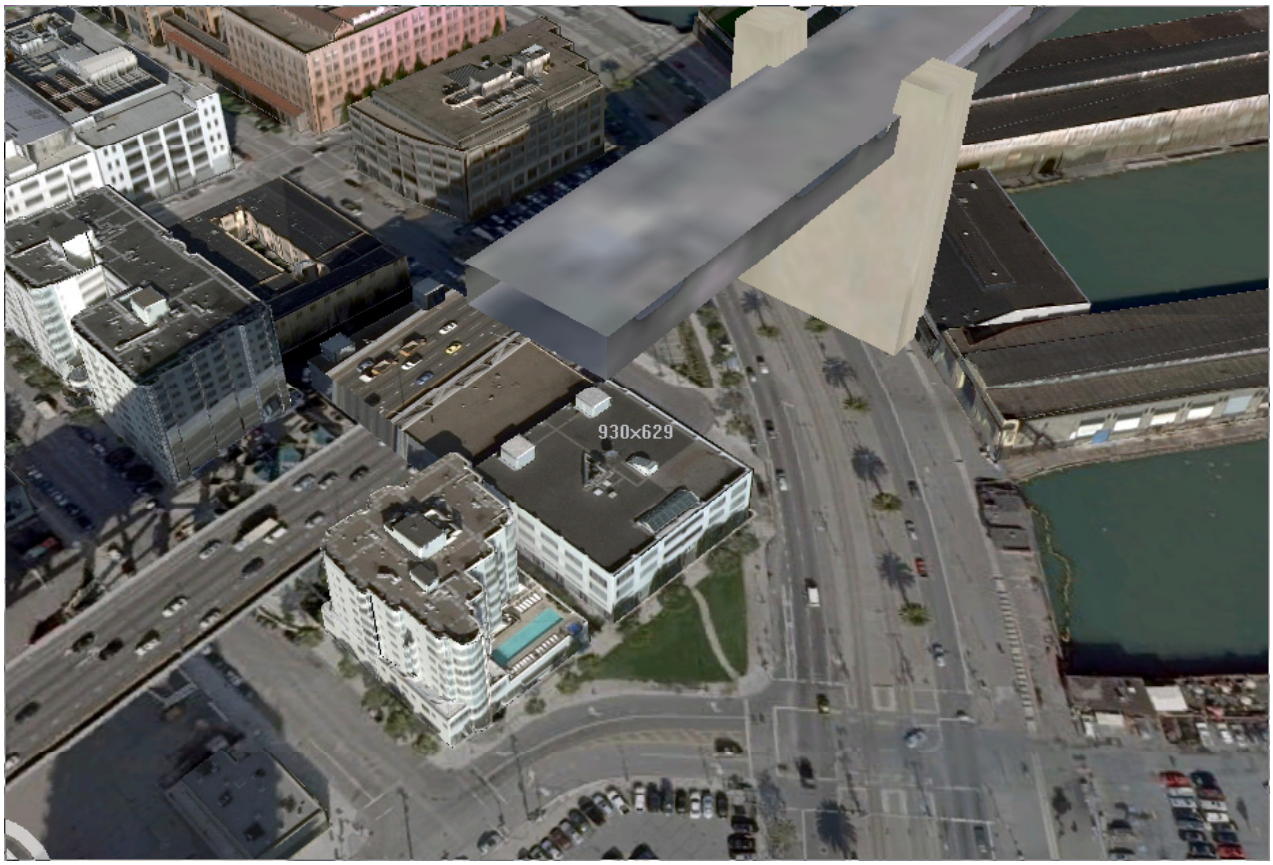
Motivation



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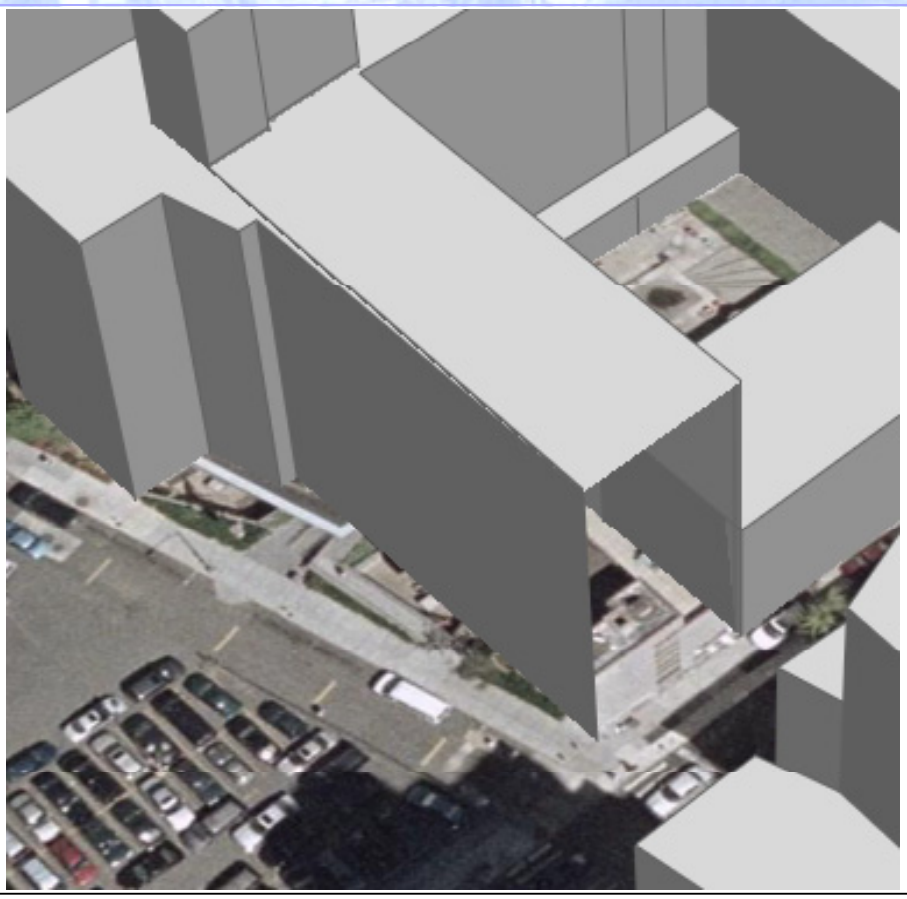

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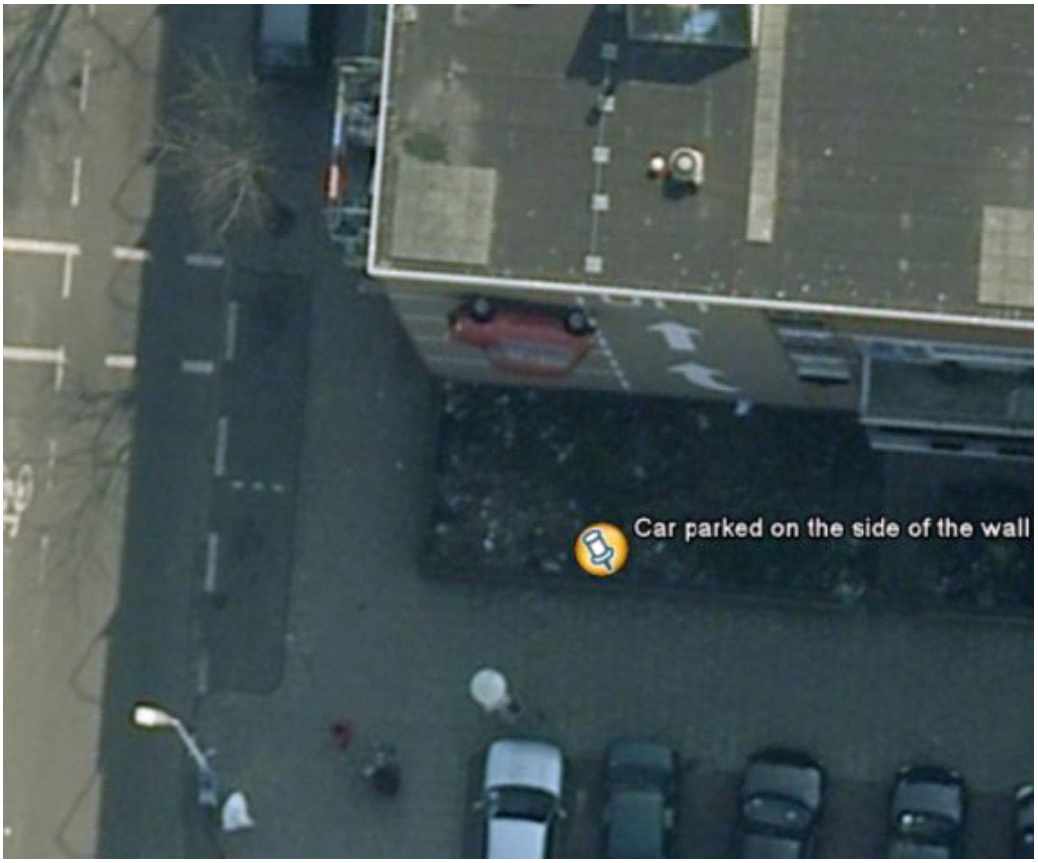

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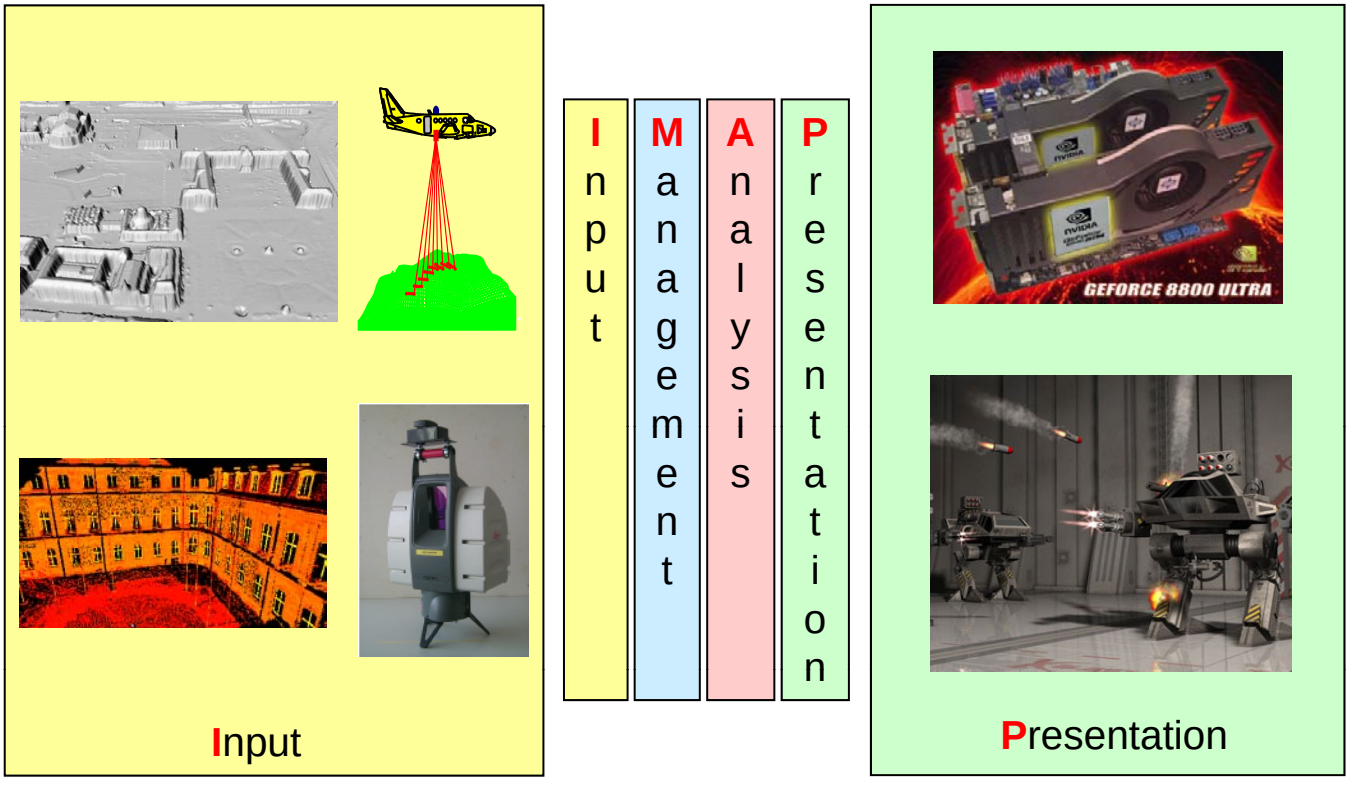
Introduction

- IMAP model of a Geoinfomation System:



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3D Applications

- Already available
  - Virtual Globes
  - Architecture, city planning and landscape planning
  - Telecommunication
  - Civil protection
  - Computer Aided Facility Management (CAFM)
  - Cultural Heritage
  - …
- Soon available
  - Location Based Services (LBS)
  - Mixed Reality Games
  - …

Daniela Nicklas, Nexus - A Global, Active, and 3D Augmented Reality Model

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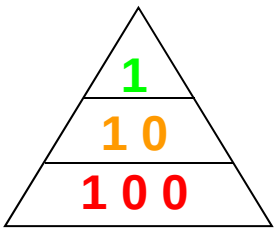
Costs of Data Acquisition

- Pyramid of costs



Hardware
Software
Data

- Data are the most expensive part in a GIS
- Quality control is needed in order to guarantee that investments are based on a sustained basis

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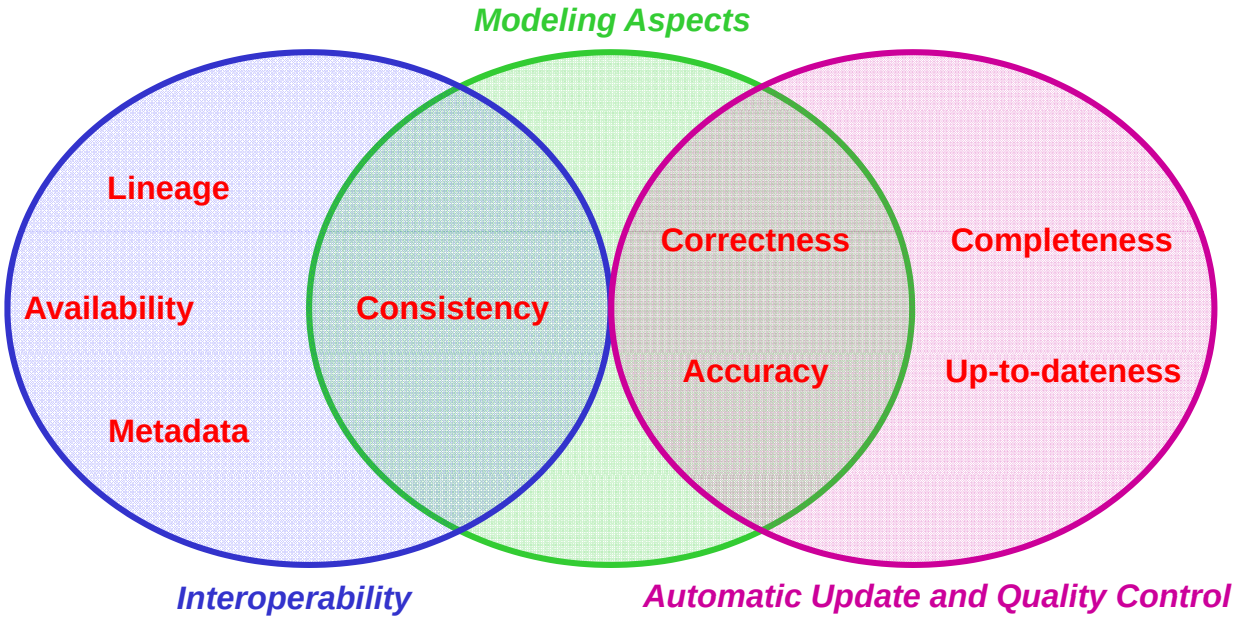
Quality

- Data quality requirements are dependent on the application (fitness for use)
- Quality is defined in (ISO 2000) as the totality of characteristics of a product that bear on its ability to satisfy stated and implied needs
- In the GIS world, these characteristics are traditionally called “Elements of Spatial Data Quality”

Elements of Spatial Data Quality

- **Lineage** contains information about the data producer, data sources and data processing methods.
- **Accuracy** describes the difference between the values in the database and the “true” values.
- **Availability** refers to the time and effort which is necessary in order to get access to the data
- **Metadata** are used for the documentation of the quality characteristics
- **Completeness** refers to the extent to which all objects are present in the database
- **Correctness** indicates whether the data is captured according the data model and how well the data match the real landscape.
- **Consistency** refers to the absence of apparent contradictions in a database
- **Up-to-dateness** contains information about the date when the data was collected or was checked

Elements of Spatial Data Quality



Interoperability

- Interoperability is the ability of software systems to exchange data and methods
- Standardized interfaces for the lossless exchange of information must be available in order to guarantee the security of investments
- In order to achieve interoperability, it is at first necessary that systems use standardized exchange formats

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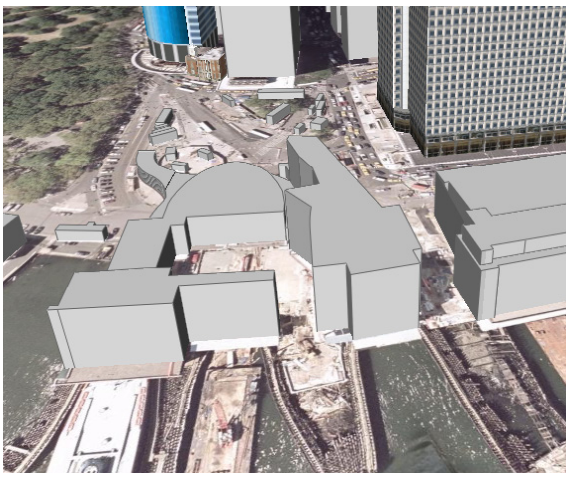
Exchange of 3D Geospatial Data

- **VRML** was developed as a standard for the exchange of 3D data in the internet
- **GeoVRML** is an extension of VRML and enables the georeferencing of objects and the representation of complex terrain models.
- **X3D** is an extension of VRML with more functionalities

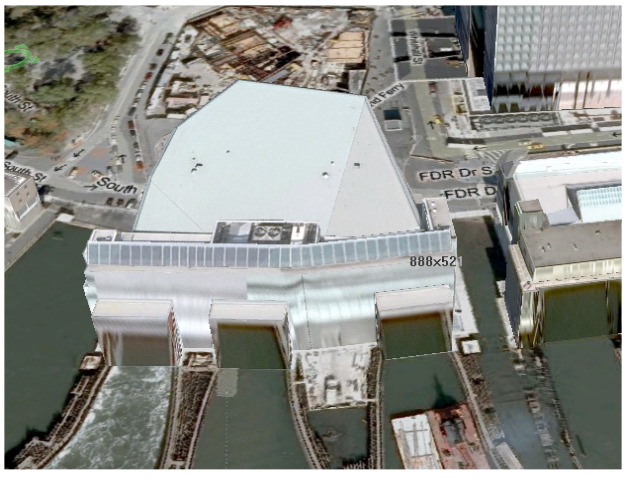
- **GML3** is a XML-based specification of the Open GIS Consortium (OGC). GML enables the exchange of geospatial objects with attributes, relations and geometries.
- **CityGML** is based on GML3 and defined especially for the exchange of 3D city models.
- **KML** exchange format for Google Earth and Google Maps with a similar syntax as GML

Syntactic vs. Semantic Interoperability

- A standardized exchange format does only guarantee syntactic interoperability and does not solve the problem of semantic differences between datasets.



Google



Microsoft

Modeling Aspects

- Geometric modeling in 2D is straightforward: spatial objects are represented in the vector world with points, lines and polygons and in the raster world with raster cells.
- Geometric modeling in 3D can be done with different modeling techniques …

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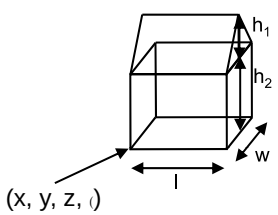
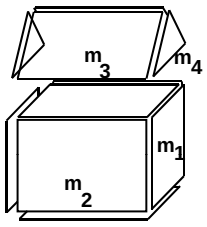
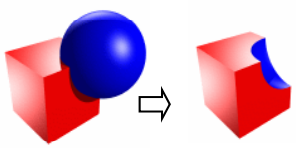
3D Modeling Techniques and Data Quality

Accuracy and Correctness

Parametric Instancing	Enumeration	BREP	CSG
			 (Image: Wikipedia)

Consistency

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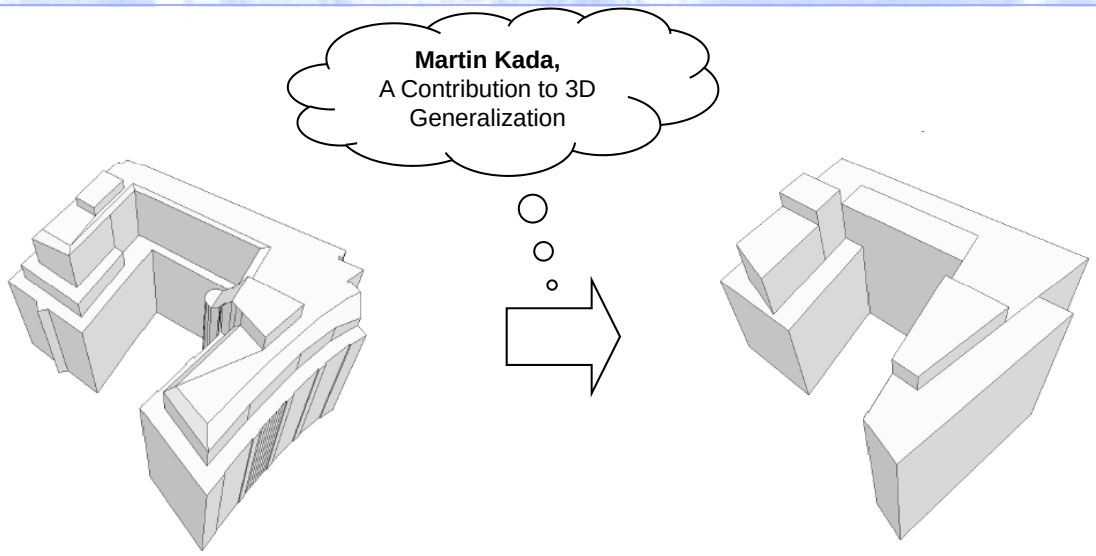
Levels-of-Detail (LOD)

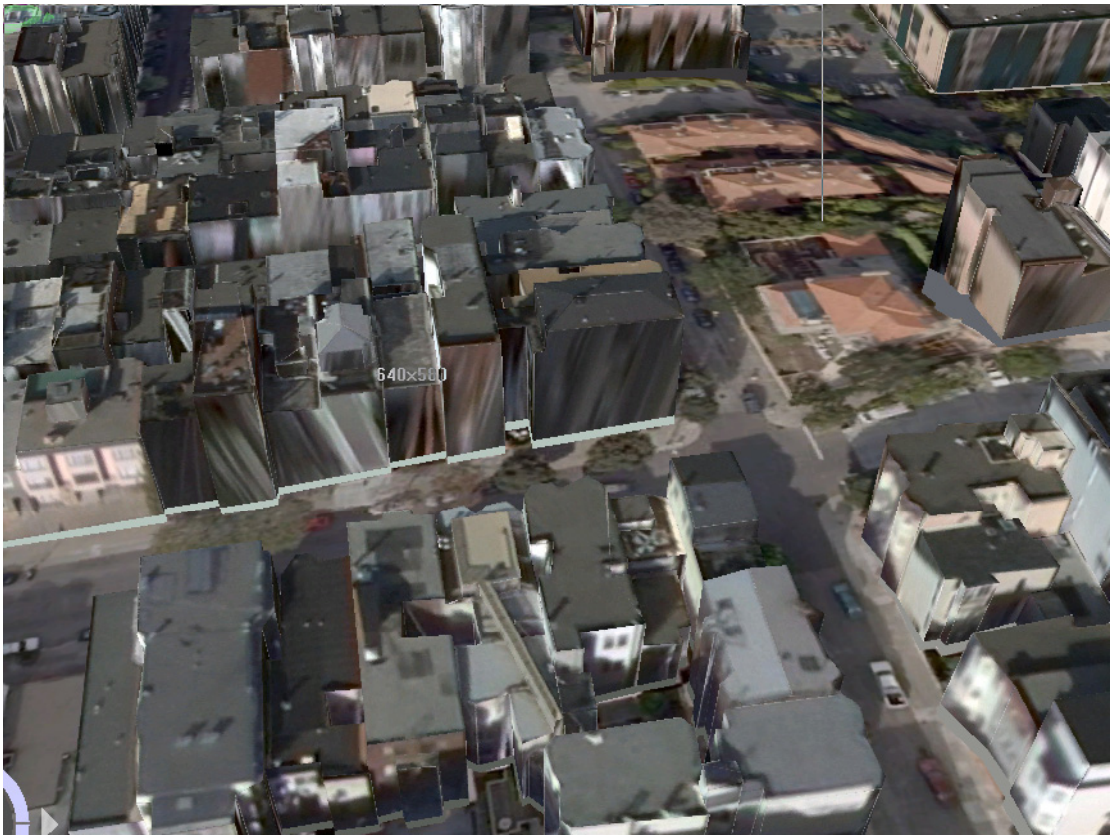
- LOD concepts are very important for real-time visualization, visualization on mobile devices or if the data has to be transferred through narrow-band networks
- **CityGML**:
  - **LOD 0**: 2.5D DTM and 3D landmarks
  - **LOD 1**: block models without roof structures
  - **LOD 2**: houses with roof structures and textures, vegetation
  - **LOD 3**: detailed house structures, vegetation, road furniture
  - **LOD 4**: indoor model, detailed architecture model
- Automatic generalization tools are needed

Quality of Generalization



- Generalization strongly influences *Accuracy* and *Correctness*
- Different generalization approaches lead to different results
- Measures are needed in order to describe the quality of the generalization

Quality of Textures



Quality of Textures

- Influence factors:
  - spatial resolution
  - radiometric resolution
  - light conditions
  - accuracy of inner and exterior orientation
  - contrast
  - disturbing objects (like cars or pedestrian)
  - …
- Currently no quality model is available that describes these characteristics

Automatic Update and Quality Control

- Automatic quality control and automatic update is needed to estimate and improve automatically the *Accuracy*, *Completeness*, *Correctness* and *Up-to-dateness*
- Realization with image interpretation algorithms
- Problem with 3D geospatial data: terrestrial laser scanner data or terrestrial images are not available with high repetition rate and for large areas
- Vision: Distributed imagery collection with mobile sensor networks:
  - capture data with low quality but high redundancy
  - many redundant representation of the same object can be transformed to one high quality model
  - data sources: imagery and video streams from PDAs or mobile phones, car-mounted sensors or even smart dust sensor networks

Discussion

- The recent developments will continue
  - mobile Laser scanning
  - increasing performance of CPUs and GPUs
- There is an increasing distance between users which are less aware of the quality of geospatial data (the end users) and those who are best informed about the quality (the data producers)
- GIS applications use any kind of data, independent from their quality
- Many data producers have internal data quality control but the quality characteristics are not given to the user
- The problems are similar to 2D geospatial data, but
  - acquisition of 3D data is more expensive
  - modeling of 3D data is more complex
    - different modeling techniques
    - LOD concepts – Generalization
    - Quality of textures

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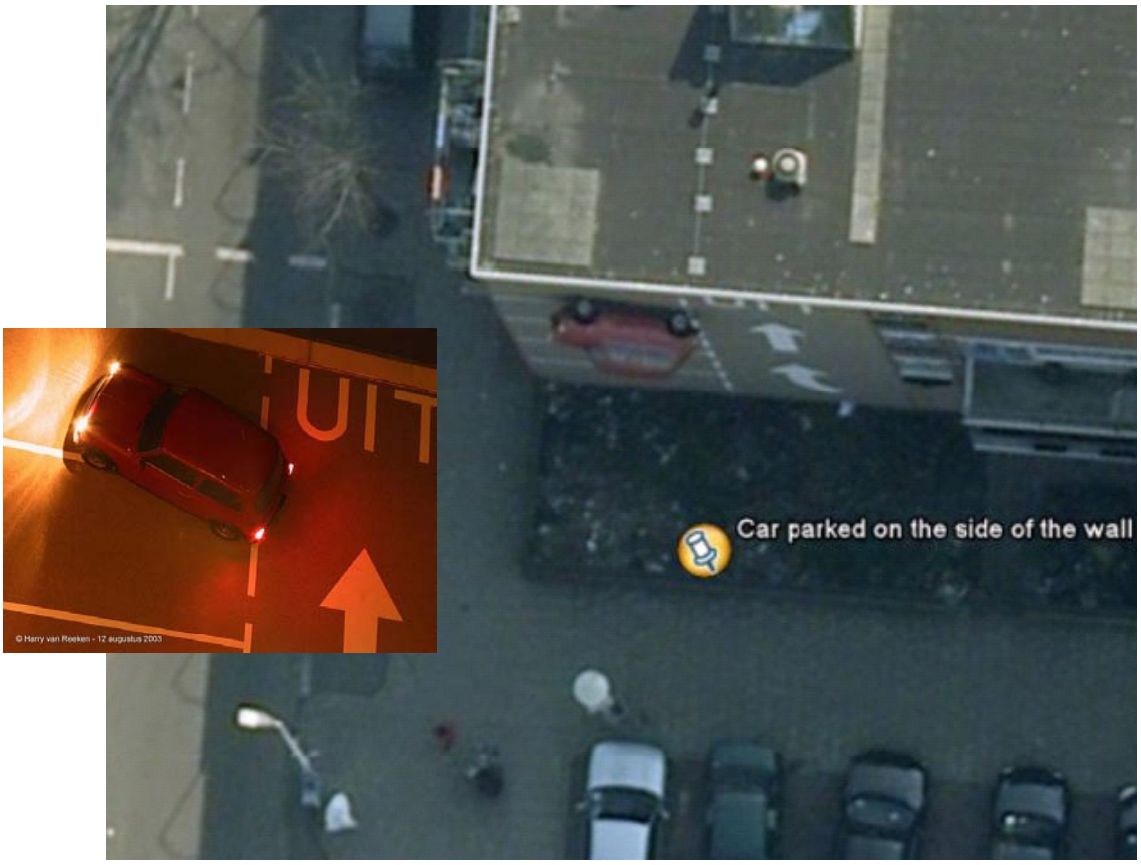
Discussion

- Especially 3D city models are already available for many cities, but they are:
  - acquired and managed by different organizations
  - with different quality characteristics
  - in different systems
  - in different data models
  - in different exchange formats
- If the data is only used for visualization, quality is not very important. But for future applications like:
  - Location Based Systems
  - Virtual Globes with Indoor and Outdoor data
  - Pedestrian Navigation
  - …

Future Work

- Quality Models have to be defined, to
  - describe the quality of generalization
  - describe quality of textures
- Semantic Interoperability
- Methods are needed to derive quality information from aggregated data
- Quantification of data quality in spatial analyses
- Quality visualization
- Distributed imagery collection with mobile sensor networks

Car parked on the side of the wall



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