Chapter V

Virtual 3D Cities

Virtual 3D Cities

- 5.1 – Introduction

- 5.2 – CityGML

- 5.3 – Google Earth

- 5.4 – Virtual Earth

- 5.5 – Conclusions

5.1 – Introduction

- 3D Visualization of cities
- Languages such as CityGML
- New projects covering the whole earth
  - Google Earth
  - Microsoft's Virtual Earth
- Global vision and local search
- Integration of data coming from different sources

Components

- Modeling of buildings and human artifacts

- Modeling of terrains

- Modeling of urban furniture

Berlin

Heidelberg

Potential applications

- Simulation of urban noise, air pollution
- Simulation of floods
- Simulation of natural and technological hazard consequences
- Comparison of real building heights and maximum authorized heights
- Visual impact of a new project
- Checking declaration for local taxes
- Etc.

Others applications

- Geomarketing: visual impact of advertising
- Real estate agencies: give an idea of the vicinity
- Tourism: landmarks to visit
- Mobile phone: location of hotspots (intervisibility)
- Solar panels: optimal location
- Helicopters: places to land
- History and archaeology: modeling cities in previous centuries/millennia
- Etc.

Scale and semantics

Polyhedron

Examples

Californian suburbs
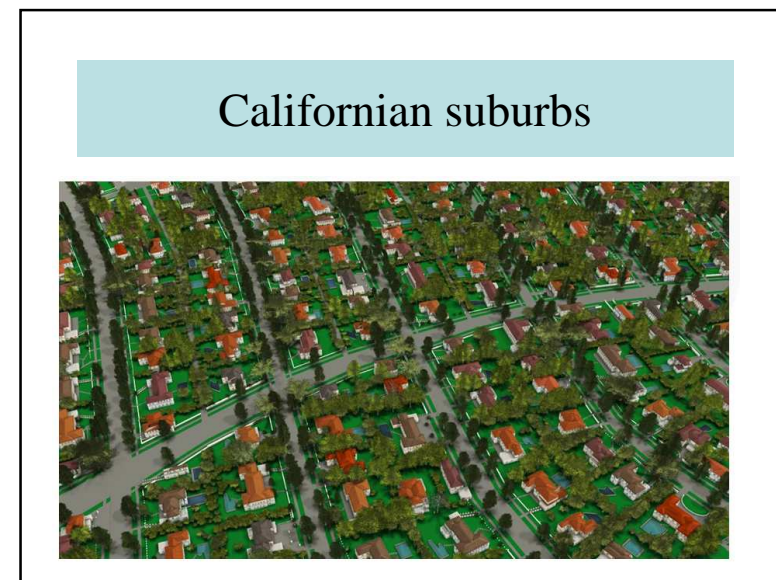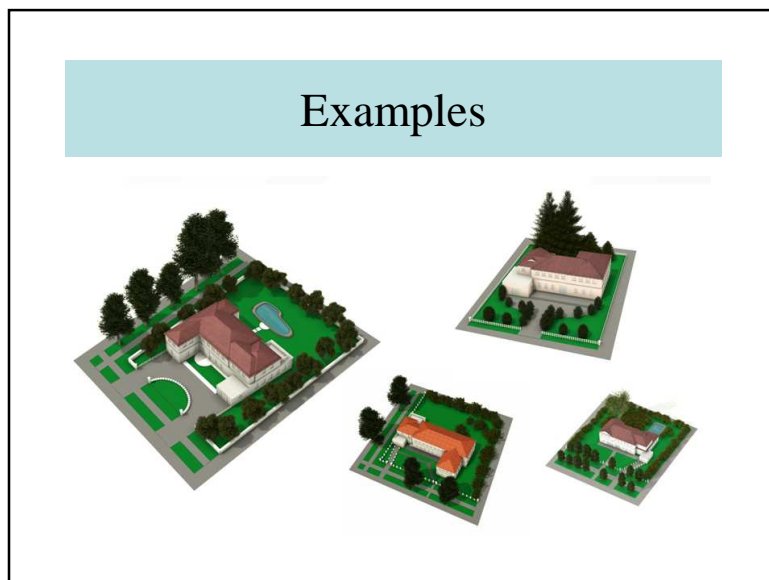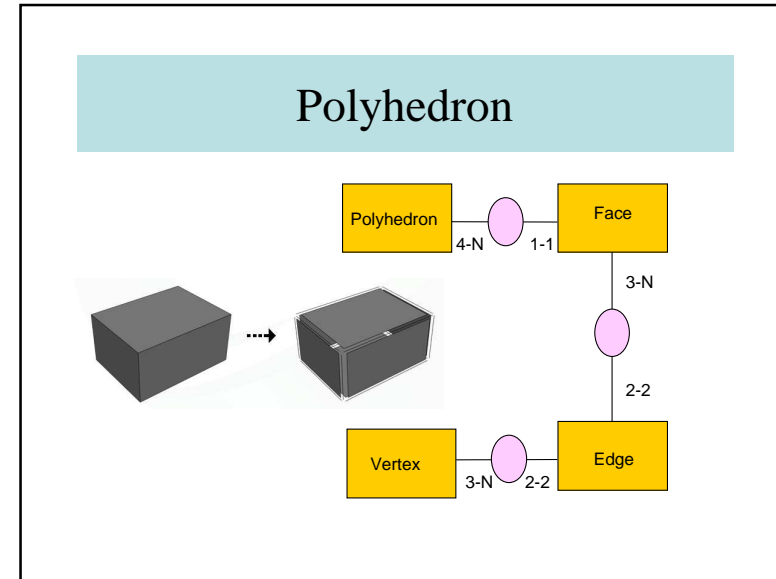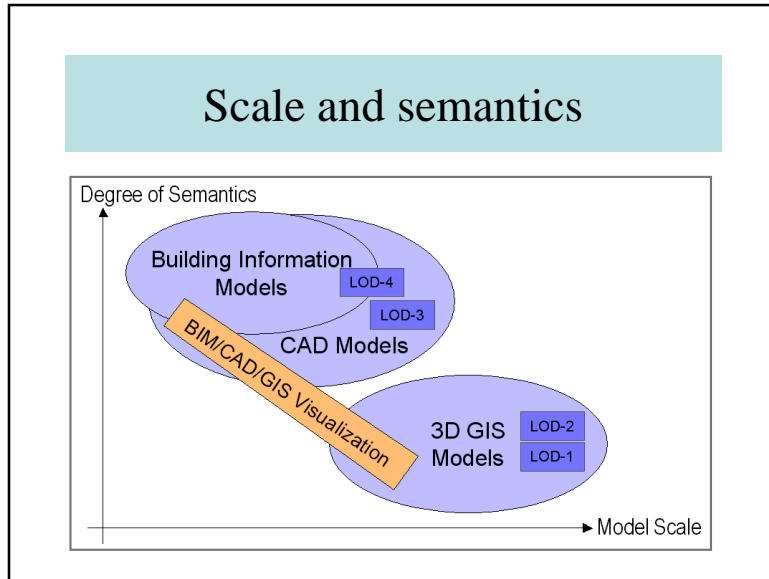
Reconstitution of Pompei

## Maya Architecture
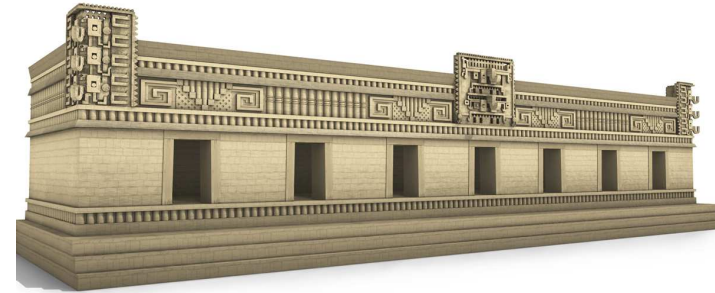
Roof models

5.2 – CityGML

- German initiative

- Extension of GML

- Objective: 3D virtual city modeling

CityGML objects

- Natural terrain
- Buildings, constructions,
- Bridges, tunnels, walls
- Excavations, streets, transports, railways,
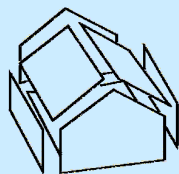- Water bodies, vegetation
- Traffic lights
- Urban furniture

Examples of CityGML objects

Terrain   Building   Transport network   Vegetation

Urban furniture   Water bodies   Land use   Groupings
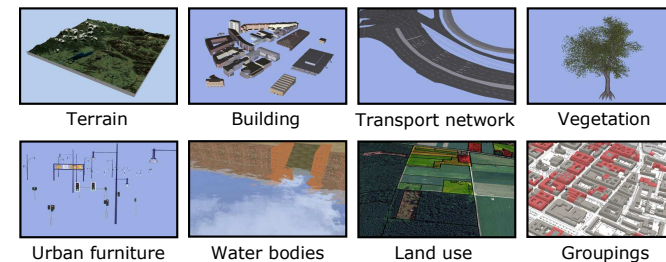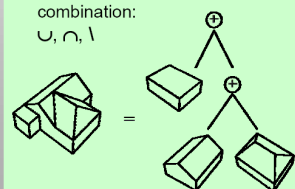
3D Models of buildings

GIS: *accumulative*
Boundary Representation

- Aggregation of all surfaces enclosing the object's volume
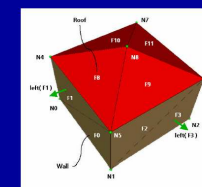
CAD: *generative*
Constructive Solid Geometry

- Volumetric primitives
- Set theoretical operators for combination:
  $\cup, \cap, \setminus$

Simple model

3D Data Model 1

- Define Geometry by point coordinates
- Example:
  x0 y0 z0, x1 y1 z1, x5 y5 z5, #F0
  x0 y0 z0, x5 y5 z5, x4 y4 z4, #F1
  x1 y1 z1, x6 y6 z6, x5 y5 z5, #F2
- Redundancy: Each Point coordinate is stored 6 times !!!
- Used in CityGML, Spatial DB

More complex model

3D Data Model 2

Edges and Halfedge dominate storage cost (E = T + V !)
3D-FDS, Molenaar (1990)
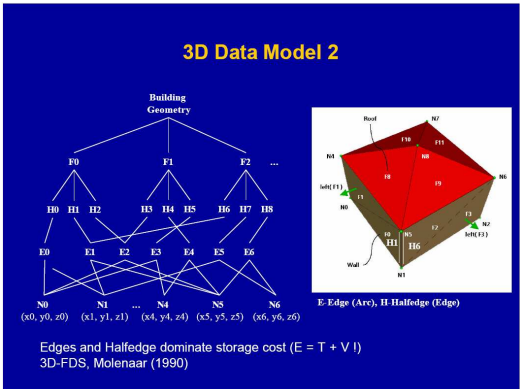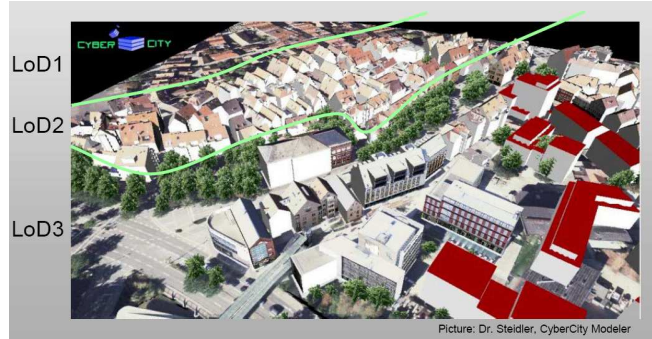
Levels of details

- LoD0 – Regional Model
  - 2.5D Terrain Model
- LoD1 – City/Model of the site
  - Block model w/o roofs
- LoD2 – City/Model of the site
  - Texture of roofs and façades
- LoD3 – City/Model of the site
  - Detailled architectural Model
- LoD4 – Inside Model
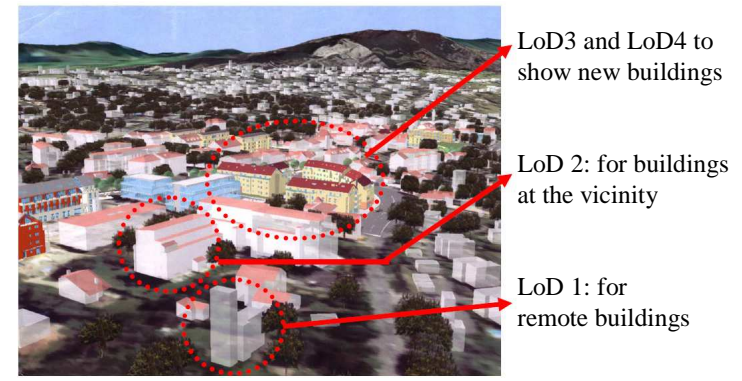 - Navigation within the building

Levels of details

LOD0   LOD1   LOD2

LOD3   LOD4
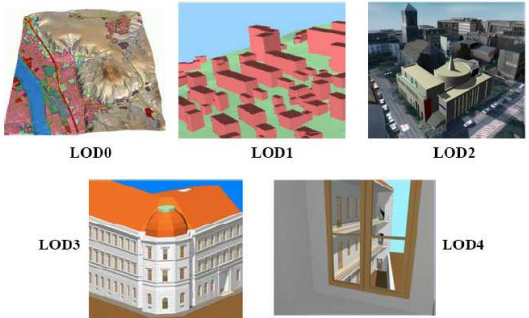
CityGML LoD 1 Modell

CityGML LoD 2 Modell

CityGML LoD 3 Modell

IFC Modell   CityGML LoD 4 Modell

Levels of details – example 1

LoD1
LoD2
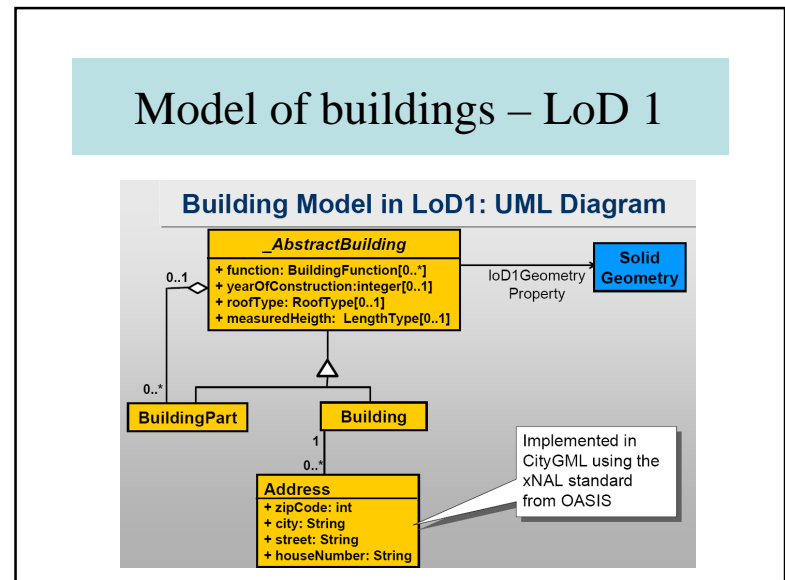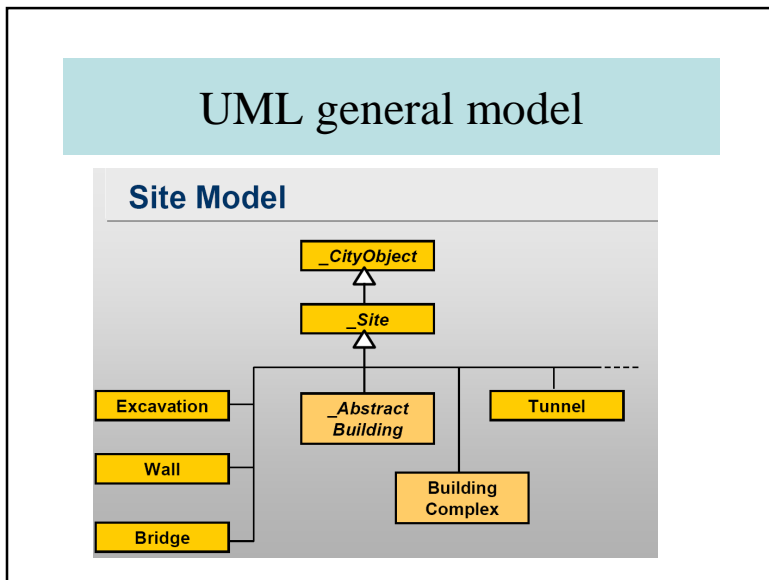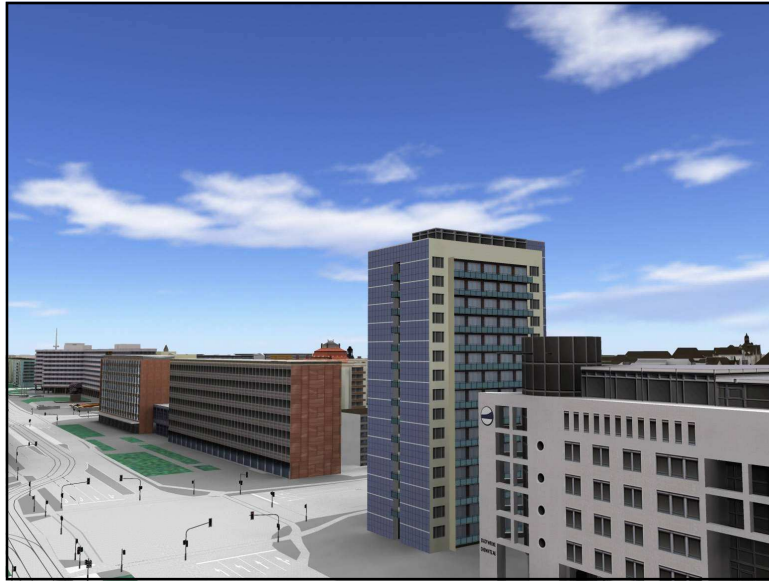LoD3

Picture: Dr. Steidler, CyberCity Modeler

Levels of details – example 2

LoD3 and LoD4 to show new buildings

LoD 2: for buildings at the vicinity

LoD 1: for remote buildings

Near Bonn

Near Trento

UML general model

Site Model

_CityObject

_Site

Excavation

Wall

Bridge

_Abstract Building

Building Complex

Tunnel

Model of buildings – LoD 1

Building Model in LoD1: UML Diagram

_AbstractBuilding
+ function: BuildingFunction[0..*]
+ yearOfConstruction:integer[0..1]
+ roofType: RoofType[0..1]
+ measuredHeigth: LengthType[0..1]

loD1Geometry Property

Solid Geometry

0..1

0..*

BuildingPart

Building

1

0..*

Address
+ zipCode: int
+ city: String
+ street: String
+ houseNumber: String

Implemented in CityGML using the xNAL standard from OASIS

Model of buildings – LoD 2

Building Model in LoD2

_AbstractBuilding
+ function: BuildingFunction[0..*]
+ yearOfConstruction:integer[0..1]
+ roofType: RoofType[0..1]
+ measuredHeigth: LengthType[0..1]

loD1SolidProperty
loD2SolidProperty — Solid Geometry
loD2SurfaceProperty — Surface Geometry
loD2LineProperty — Line Geometry
loD2Terrain IntersectionCurve

_CityObject

_BoundarySurface — loD2SurfaceProperty

Roof | Wall | Ground | ClosureSurface

Model of buildings – LoD 3 and 4

Building Model in LoD3 & LoD4

Building Characteristic — exterior — _Abstract Building — loD3GeometryProp.
interior — loD4Geometry Property — Solid Geometry
Building Furniture — interior — Room — interior
loD4GeometryProperty
Opening — GroupOf Rooms
loD3Geo-metryProp. — Surface Geometry
Window | Door — _BoundarySurface — loD4Geo-metryProperty
Ceiling | Room Wall | Floor | Roof | Wall | Ground | Closure Surface

Terrain model

City Model — LoD0 / LoD4 — Complex Relief

Relief
+ name: String[0..1]

Validity Extent

TIN | Grid | Breaklines | MassPoints

Triangle

Surface Geometry | Line Geometry | Point Geometry

Transportation model in LoD2

Auxillary Traffic Areas

Traffic Area

Traffic Area

Traffic Area

Road

Application of textures

Multi-resolution for terrain texture

Habillage

Example

Hierarchical texture atlas composition

Texture and resolution

a) Full texture resolution.   b) Insufficient texture resolution.

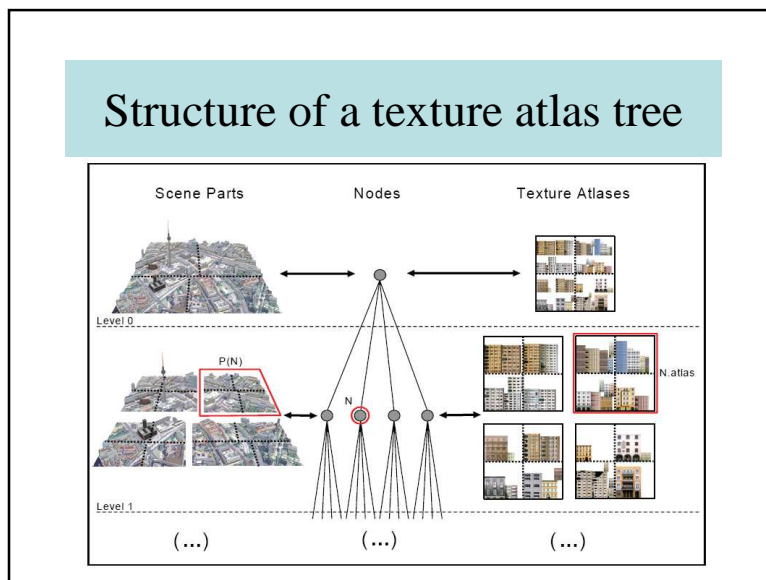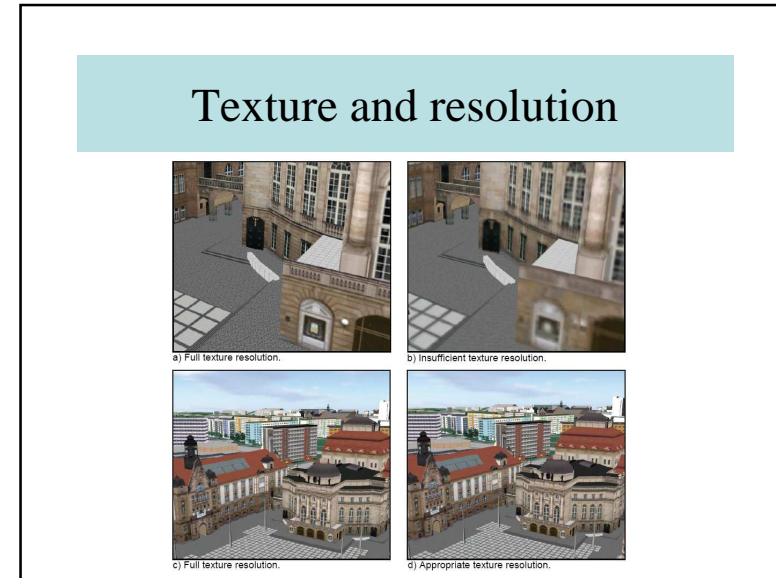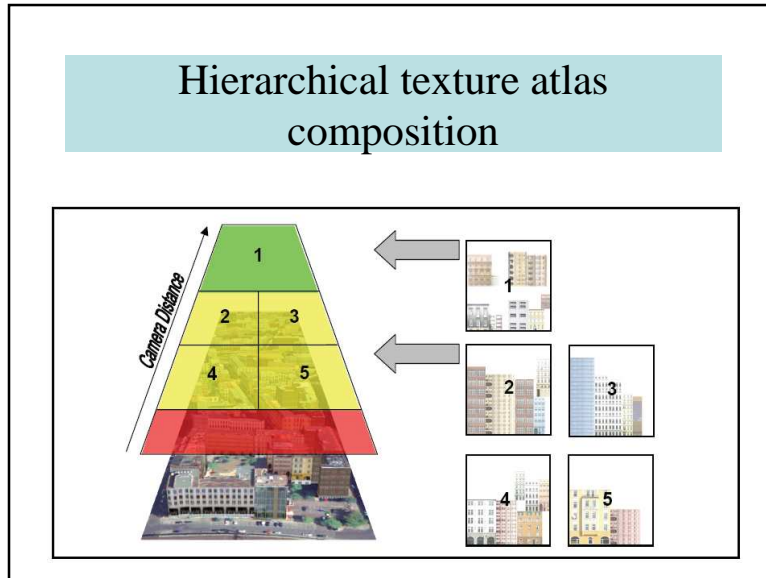c) Full texture resolution.   d) Appropriate texture resolution.

Structure of a texture atlas tree

5.3 – Google Earth

- *« Organize the world's information and make it universally accessible and useful »*
- Keyhole ➔ Google
- Global infrastructure to organize information
- Google book search: places mentioned in books

Google Maps/Earth

- http://maps.google.com/help/maps/streetview/index.html

- http://www.youtube.com/watch?v=MGfozDZDSI8

- http://www.youtube.com/watch?v=fHkXYaRP0ls

- http://video.google.com/videoplay?docid=-3097896187368461444&q=%22google+earth%22&total=11996&start=0&num=10&so=0&type=search&plindex=3
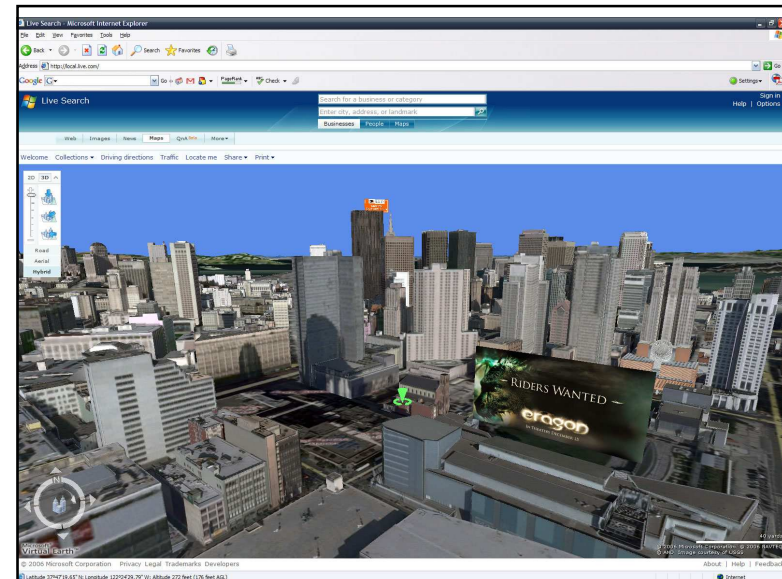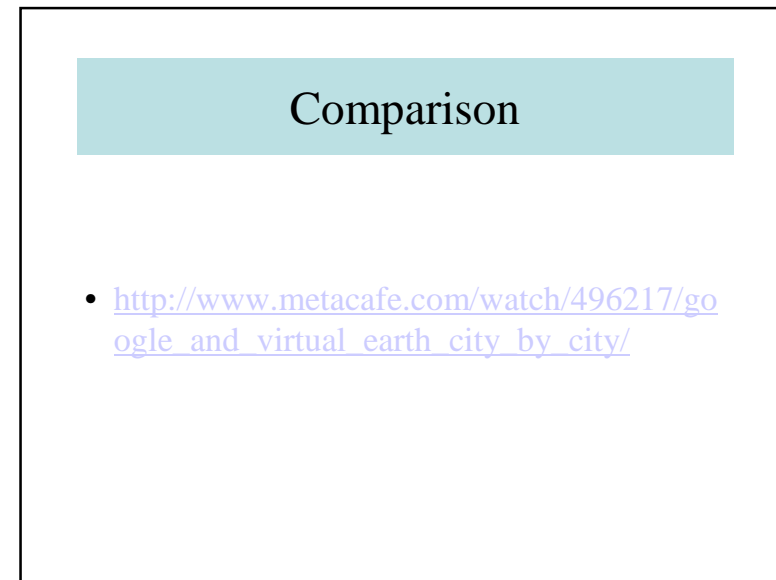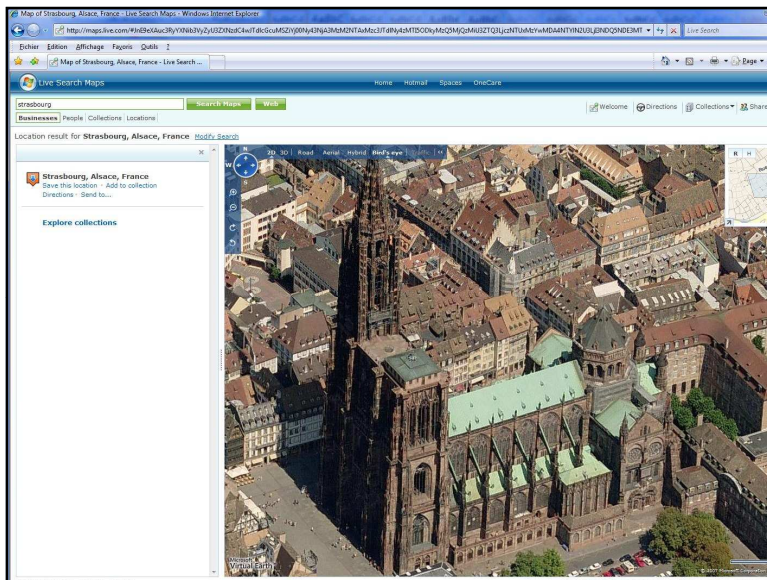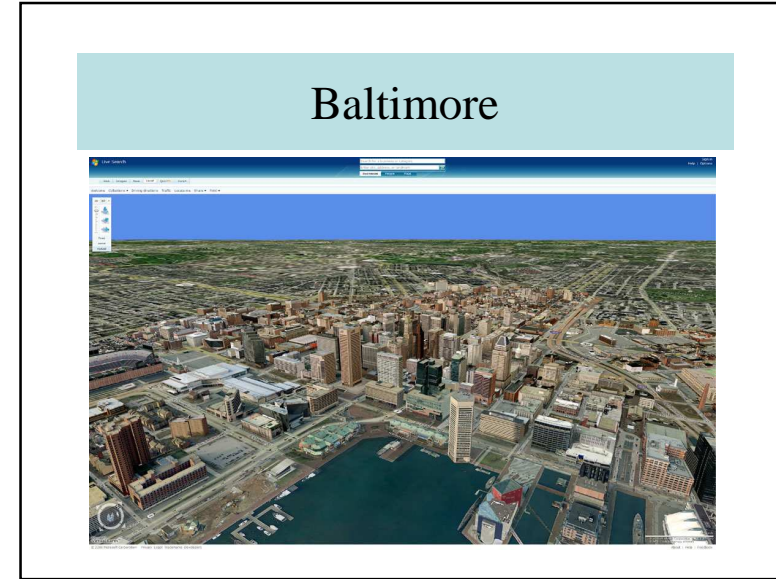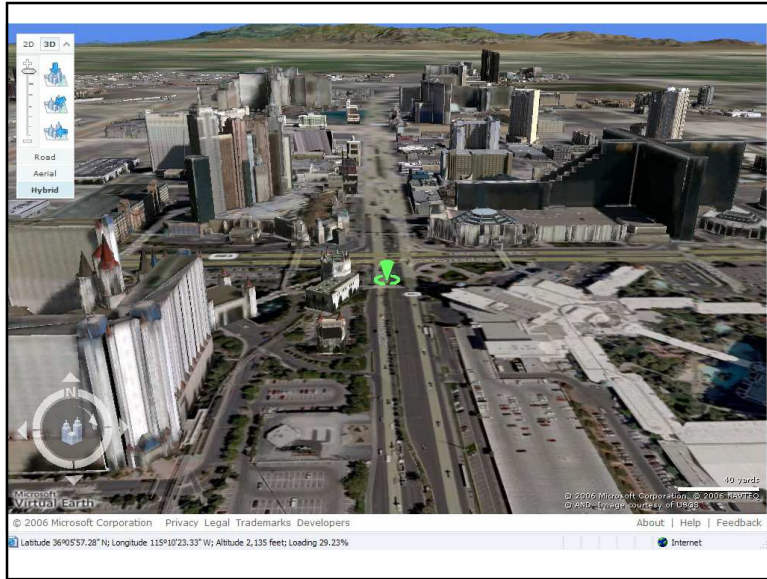

5.3 – Microsoft's Virtual Earth

- *« Mind-expanding »*
- Vexcel ➔ Microsoft

- Global infrastructur for geo-referenced applications

- Orthorectified aerial photos (pixel = 15cm)
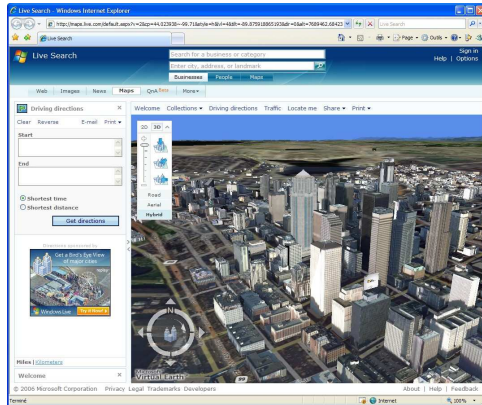- Bird's eye
- Buildings with textures
- Augmented reality

Microsoft

- Virtual Earth:
  - http://maps.live.com/
  - http://www.metacafe.com/fplayer/496241/flying_in_virtual_earth.swf
  - http://www.metacafe.com/watch/511066/boston_virtual_real_estate_viewing/
- Demo
  - http://imagine-windowslive.com/minisites/livemaps/default.aspx

Baltimore

Comparison

- http://www.metacafe.com/watch/496217/google_and_virtual_earth_city_by_city/
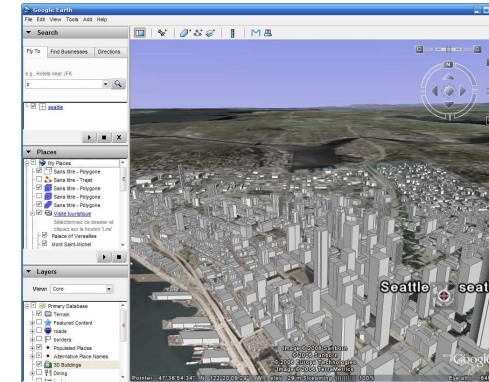
Seattle (Virtual Earth)

Seattle (Google Earth)

5.4 – Conclusions

- Importance of 3D visualization

- Existing 3D applications

- CityGML

- Use of photogrammetry

- Quest for realism