Stadtmodellierung à la SIG 3D:

von NRW zum Broadway,

von der 3D-Grafik zur Smart City

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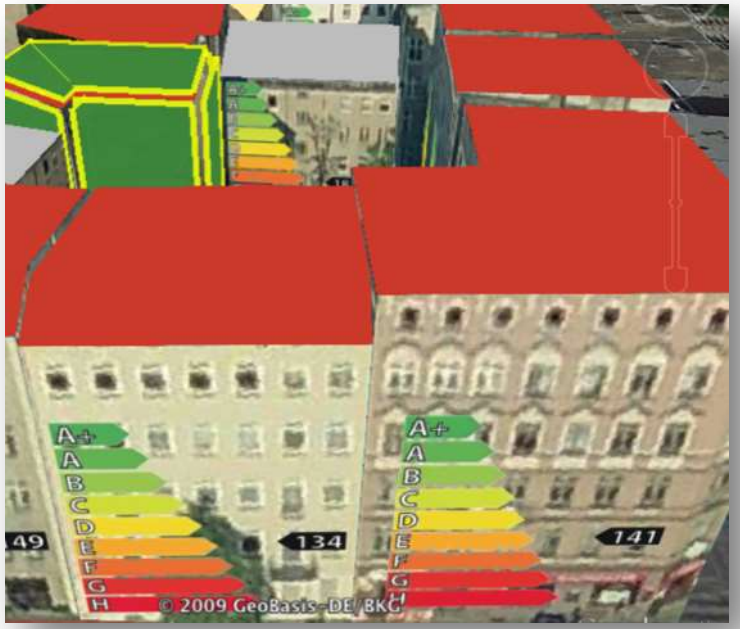
16. Oktober 2015

50. Sitzung der SIG 3D, Bad Godesberg



Die ersten Schritte der SIG 3D

Dr. Thomas H. Kolbe

Sprecher der SIG 3D

28. Juni 2002

Institut für Kartographie und Geoinformation, Uni Bonn
Lehrstuhl für Geoinformation

INITIATIVE Geodaten Infrastruktur NRW

Was bisher geschah. . .

Kickoff-Sitzung am 8. 5. 2002

- Kurzvorstellung der Teilnehmer, Erwartungen an SIG 3D
- Identifikation und erste Bündelung wichtiger Themen
- Im Nachgang: Verteilung von Fragebögen dazu

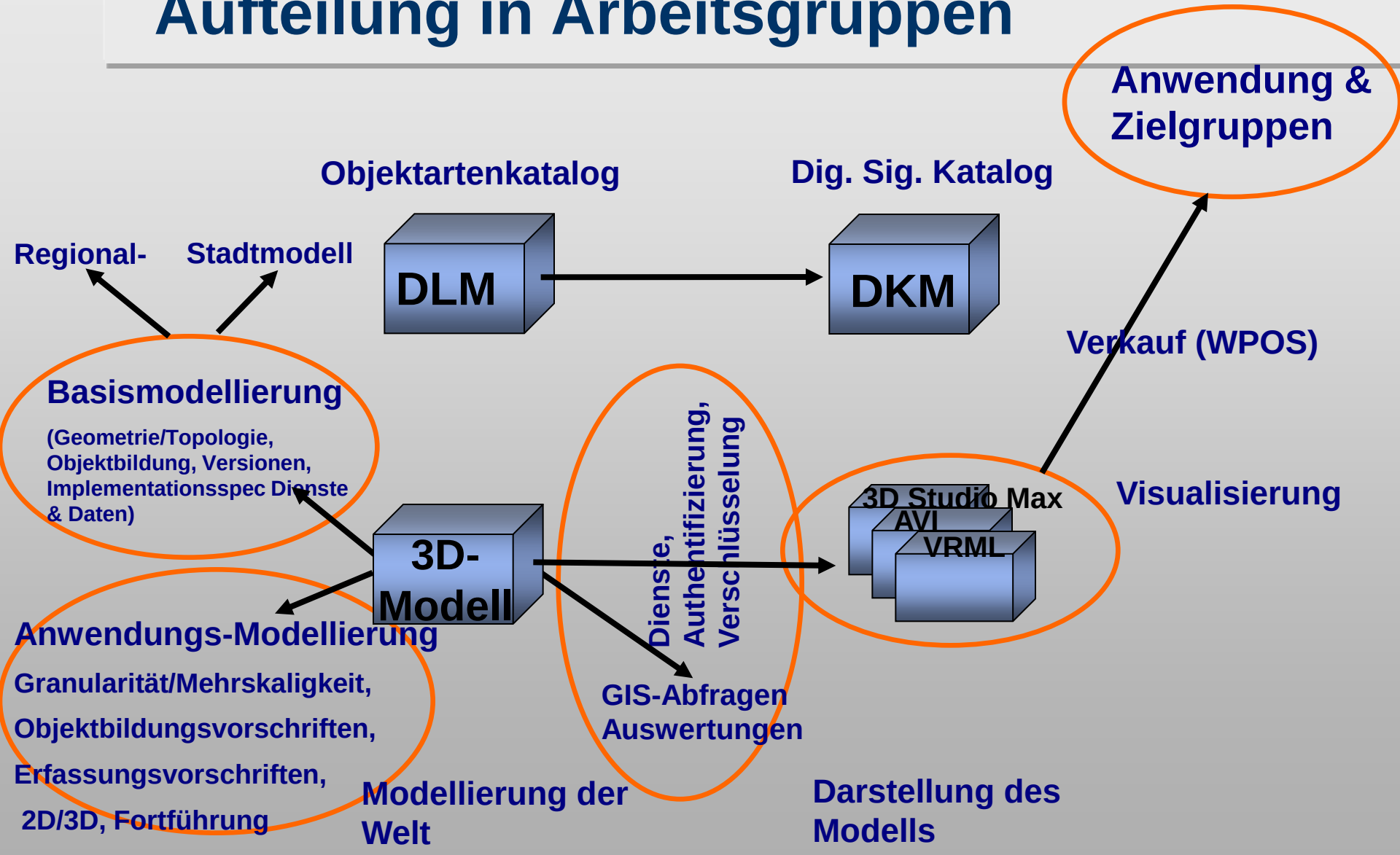
2. Sitzung am 25. 6. 2002

- Präsentation der Auswertung der Fragebögen
- Vertiefende Vorträge
- Bildung und Einteilung von 5 Arbeitsgruppen

Teilnehmer

- z.Zt. 66 Teilnehmer, davon
  - 26 aus der Wirtschaft,
  - 29 aus den Kommunen und den öffentlichen Verwaltungen, u.a.
    - Vertreter des BKG und des LVermA NRW,
    - Sprecher des „Arbeitskreises 3D“ des Städtetags NW
  - 11 aus der Wissenschaft
- Aus welchen Bereichen der Wirtschaft?
  - Geo-Dienstleister (Datenerfassung, -aufbereitung, Beratung)
  - Systemhersteller (GIS, CAD, Datenerfassung, Visualisierung)
  - Nutzer (Großindustrie, Telekommunikation)
- Einige Teilnehmer von außerhalb NRW

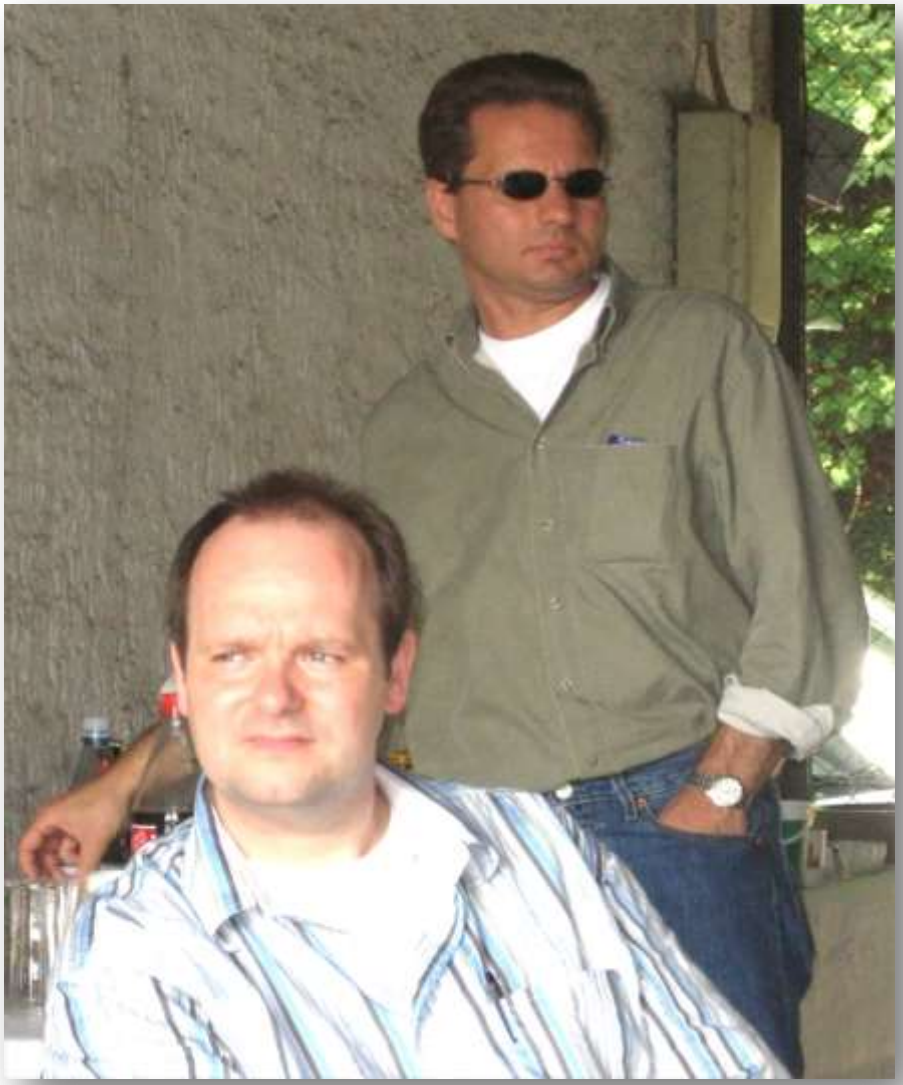
Aufteilung in Arbeitsgruppen



Koordinatoren der Arbeitsgruppen

Basismodellierung	Dr. Gerhard Gröger IKG, Uni Bonn
Anwendungsmodellierung	Prof. Dr. Przybilla GH Essen
Dienste	Christoph Uhlenküken Conterra Münster
Anwendungen / Zielgruppen	Bettina Petzold Stadt Wuppertal
Visualisierung	PD Dr. Christoph Averdung CPA Geo-Information

... vertrauen Sie den seriösen SIG 3D Sprechern!



- [Fotos von 2003]

Wichtige erste Meilensteine der SIG 3D

- Kickoff der SIG 3D am 8. 5. 2002
  - Gründung von fünf AGs in der Folgesitzung im Juni 2002
- SIG 3D / GDI NRW 3D Pilot – Stufe I
  - Schwerpunkt: interoperable 3D-Geovisualisierung
  - Implementierungen und Tests der Web 3D Service-Spezifikation
- SIG 3D / GDI NRW 3D Pilot – Stufe II
- EuroSDR CityGML-Projekt
  - hat die Übersetzung der CityGML-Spezifikation ins Englische (durch Angela Czerwinski) finanziert
- Der Weg ins OGC
  - CityGML erstmals im September 2004 in Chicago vorgestellt
  - Umfassende Präsentation und Diskussion von CityGML und W3DS im Januar 2005 in New York City

Schlossakademie Uni Bonn 2006

Thema:
Lärmkartierung NRW

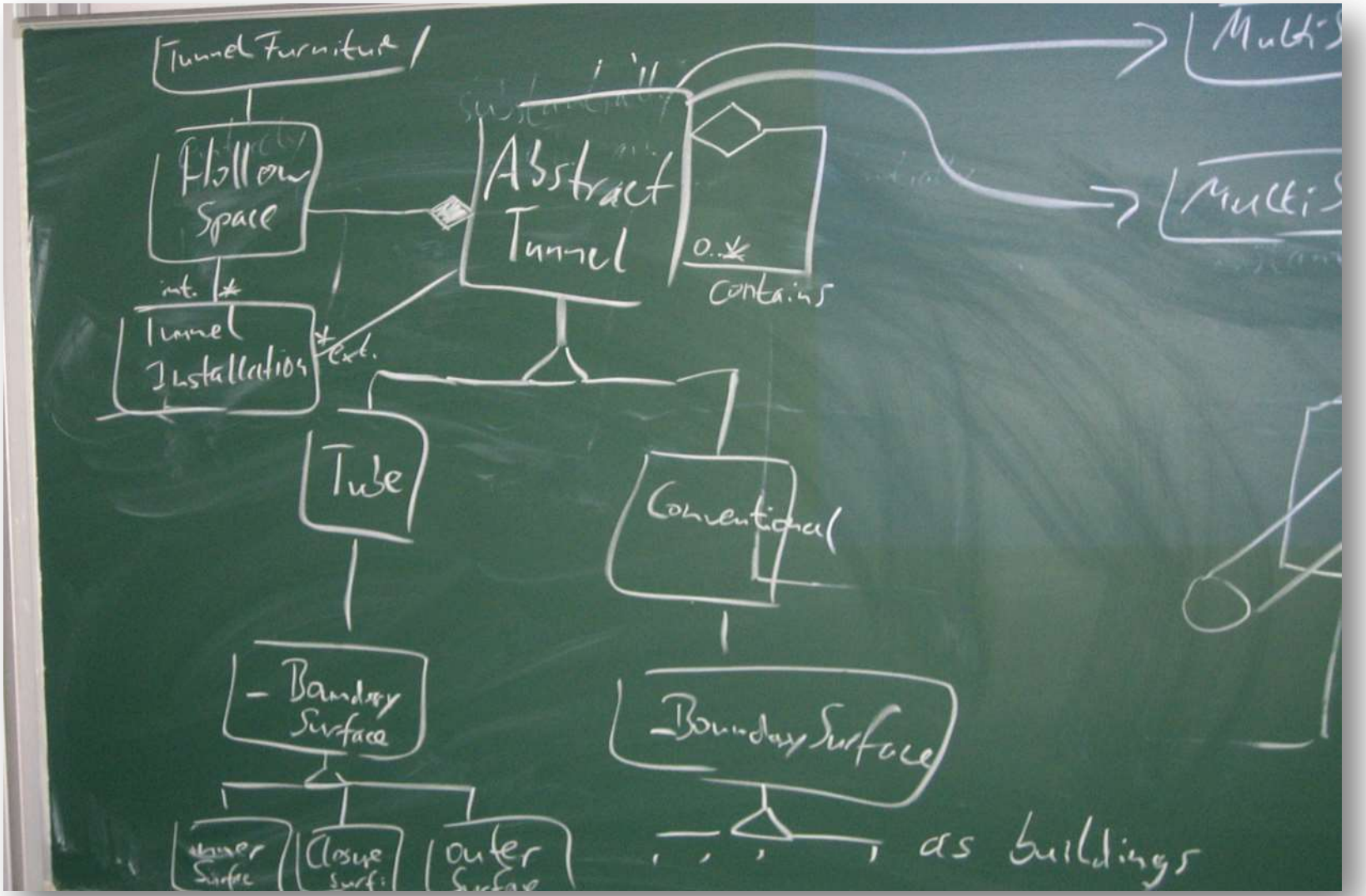
Wichtige Meilensteine von CityGML im OGC

- 2006 – Verabschiedung von CityGML 0.3.0 als OGC Discussion Paper
- 2007 – Verabschiedung von CityGML 0.4.0 als OGC Best Practice Paper
- 2008 – Verabschiedung von CityGML 1.0.0 als Internationaler Standard des OGC

AG Modellierung 2008 an der TU Berlin

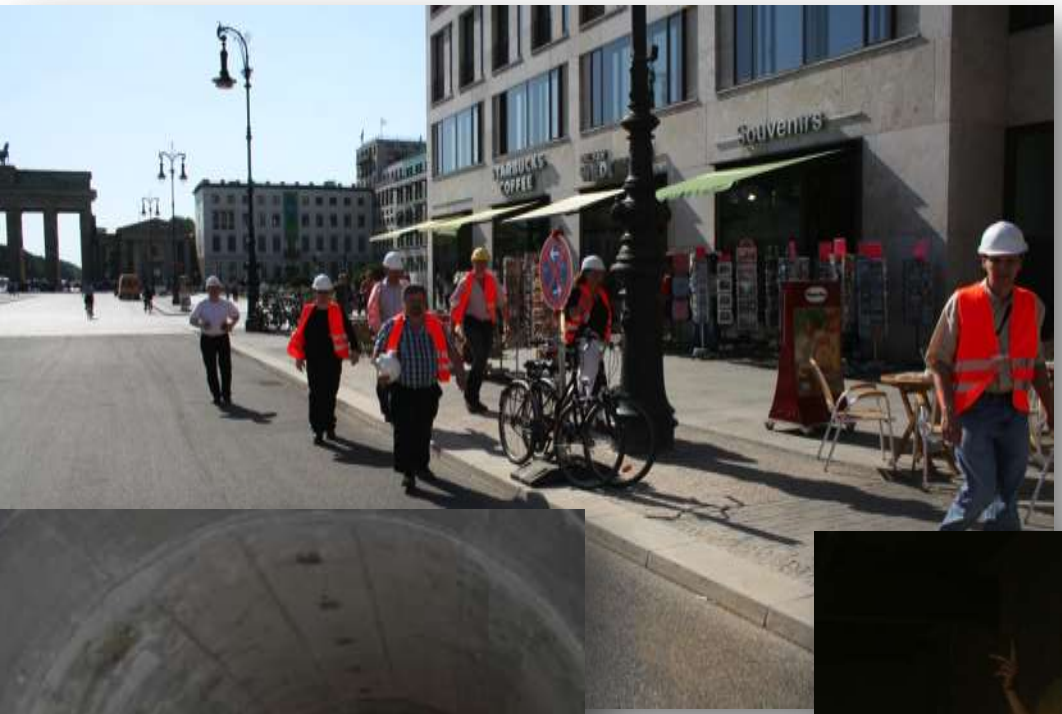
AG Modellierung 2008 an der TU Berlin

Wichtigstes Modellierungstool – die Tafel



AG Modellierung 2008 an der TU Berlin

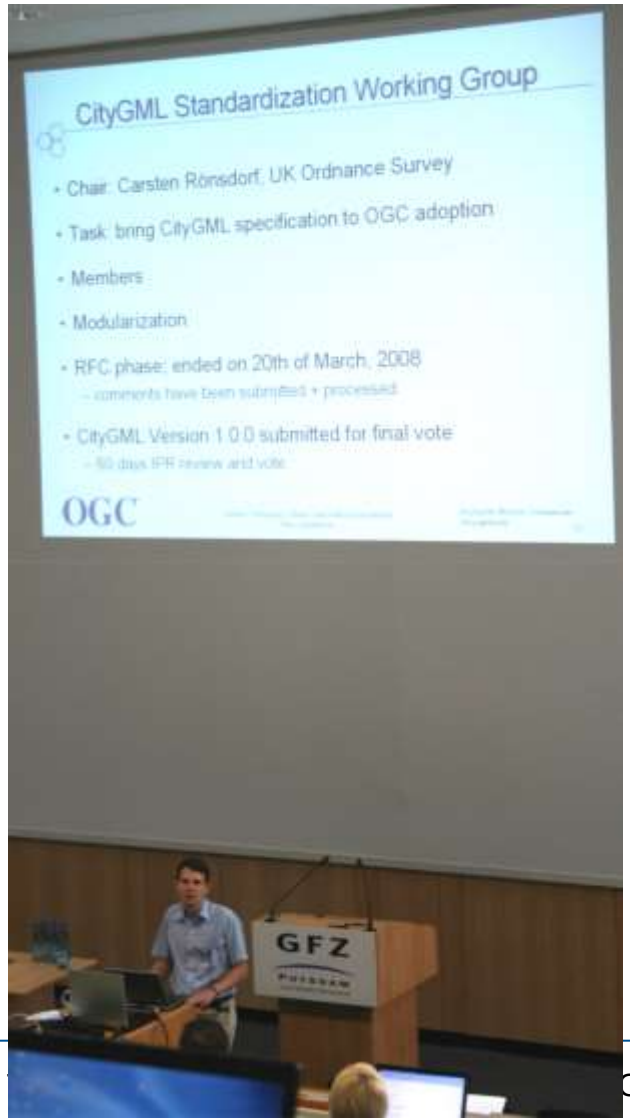
AG Modellierung 2008 an der TU Berlin



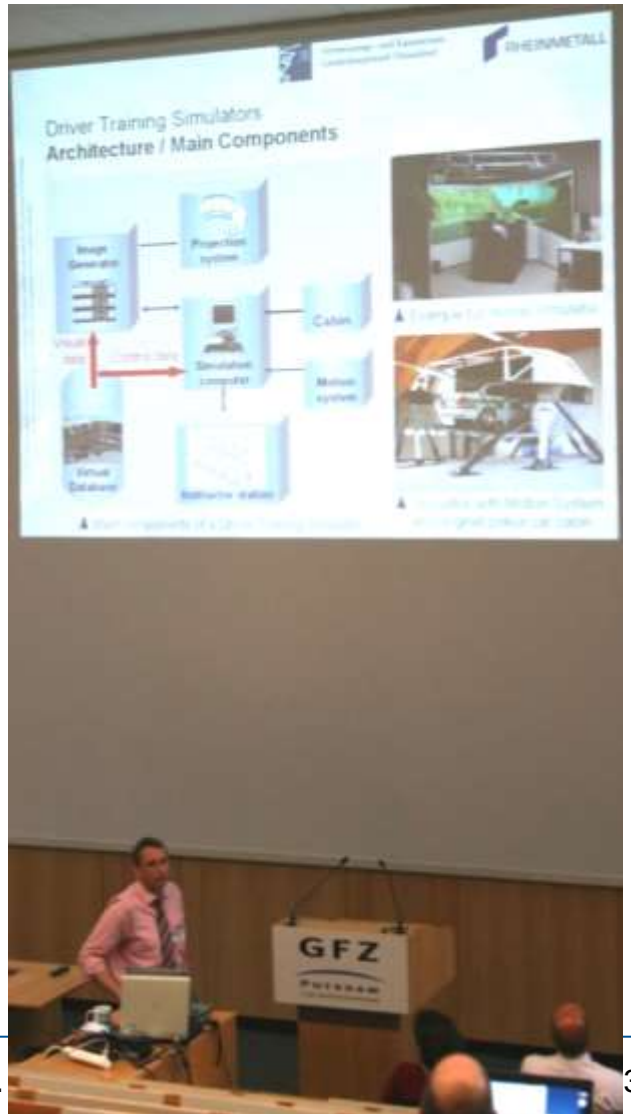
Arbeitsschutz wird in der SIG 3D groß geschrieben

AG Modellierung 2008 an der TU Berlin

OGC/SIG 3D Interoperability Day 2008 in Potsdam



OGC/SIG 3D Interoperability Day 2008 in Potsdam



OGC/SIG 3D Interoperability Day 2008 in Potsdam

OGC/SIG 3D Interoperability Day 2008 in Potsdam

OGC TC Meeting in St. Louis, MO, 2008

Abstimmung über CityGML 1.0

Betreff: [Tc] OGC E-Vote Notification
Von: gbuehler@opengeospatial.org
Datum: Fri, 13 Jun 2008 12:33:57 -0400
An: tc@lists.opengeospatial.org

Dear OGC Member,

THIS IS A COURTESY COPY OF AN ELECTRONIC VOTE.

An official ballot has been sent directly to the Voting Members of Record.

This is a notification of an OGC Electronic Vote within the Technical Committee.

MOTION:

To Approve 08-007r1, CityGML as an Official OpenGIS Standard version 1.0

MOVED BY:

CityGML SWG

SECONDED BY:

NA

VOTE START DATE:

2008-06-13

Wichtige Meilensteine von CityGML im OGC

- 2006 – Verabschiedung von CityGML 0.3.0 als OGC Discussion Paper
- 2007 – Verabschiedung von CityGML 0.4.0 als OGC Best Practice Paper
- 2008 – Verabschiedung von CityGML 1.0.0 als Internationaler Standard des OGC
- 2012 – Verabschiedung von CityGML 2.0.0 als Internationaler Standard des OGC
  - war eigentlich als Version 1.1 gedacht
- seit 2012 laufen die Arbeiten an CityGML 3.0.0
  - Ziel: Fertigstellung (und Verabschiedung?) in 2016

OGC TC Meeting in Sydney, Dezember 2010

OGC TC Meeting in Boulder, CA, 2011

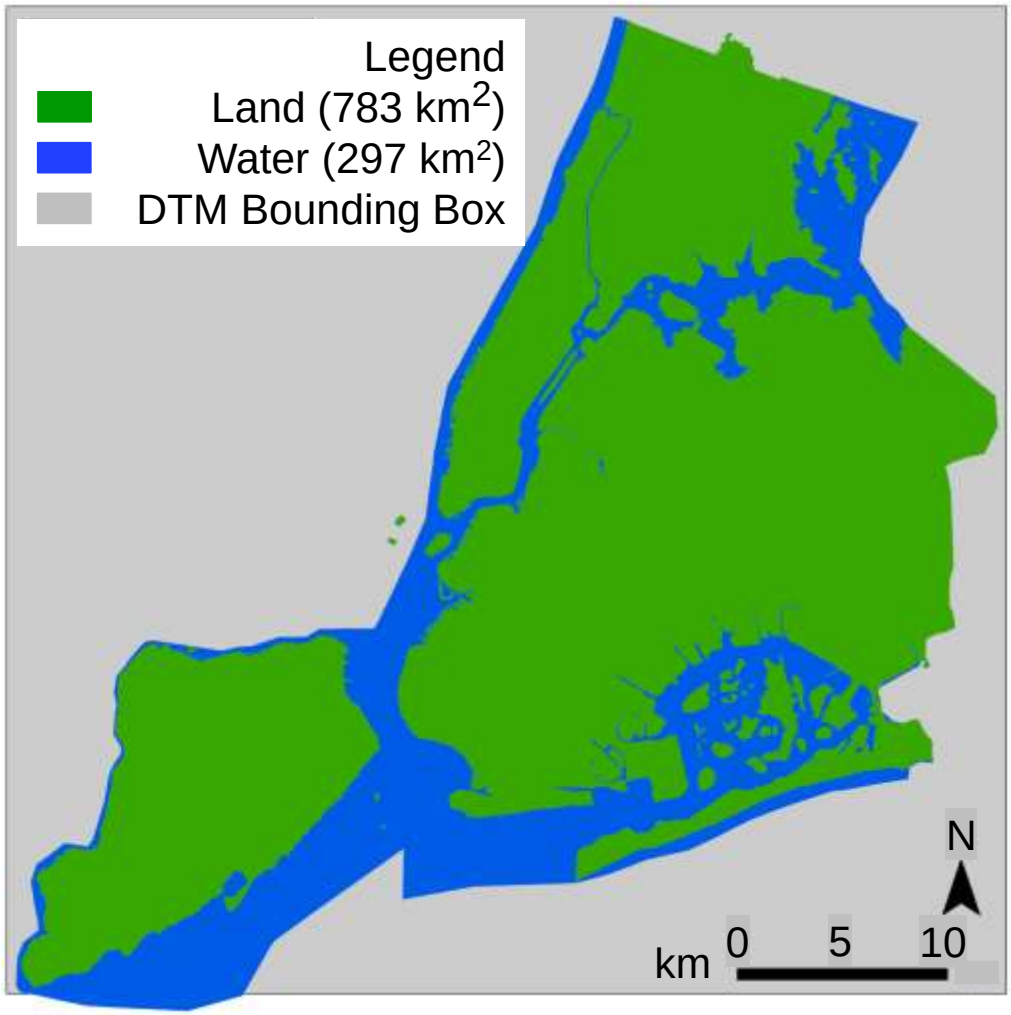
OGC TC Meeting in Boulder, CA, 2011

Weitere wichtige Meilensteine der SIG 3D

- Anschluss der SIG 3D an die Geodateninfrastruktur Deutschland GDI-DE
- Aktive Mitgestaltung von INSPIRE
  - INSPIRE-Gebäudemodellierung (Gerhard Gröger), CityGML INSPIRE ADE (G. Gröger, T. Kutzner, T. H. Kolbe)
  - INSPIRE-Anlagenmodellierung (Heinrich Geerling)
- Mitwirkung bei der Erweiterung von ALKIS um 3D-Gebäude
  - zunächst 3D-Geometrietypen in GeoInfoDok 6
  - 3D-Gebäudeklassen in GeoInfoDok 7 (u.a. Ulrich Gruber)
  - CityGML-Profil der AdV (u.a. Ulrich Gruber)
- CityGML-Modellierungshandbuch
- Mitwirkung bei der Entwicklung der CityGML Energy ADE

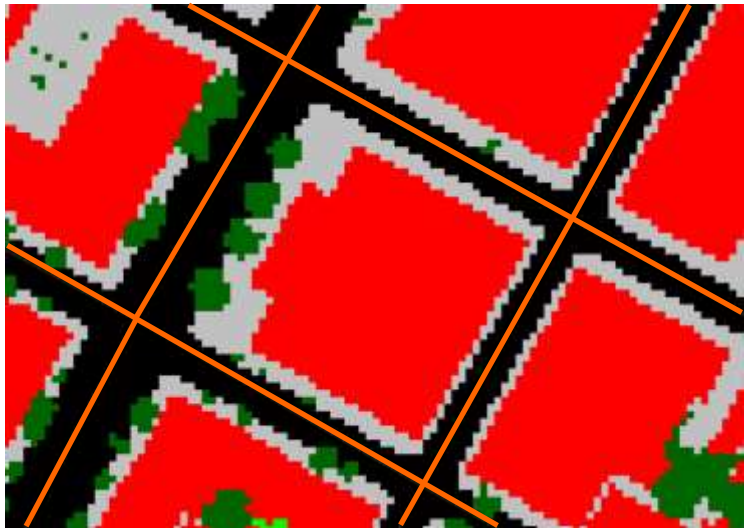
Und wo ist jetzt der Broadway?

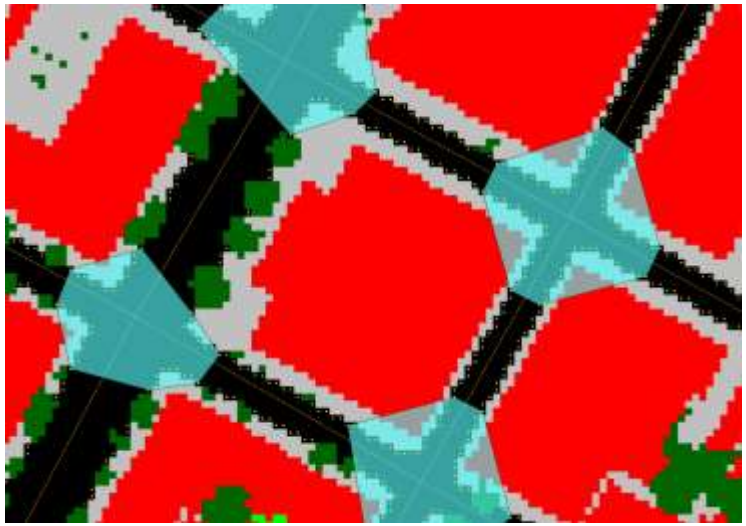
Employed Data Sets from NYC Open Data



Feature type	Input datasets	Dept.
Addresses	NYC Address Points	DoITT
Buildings	Building Footprints	DoITT
	MapPLUTO	DTM
DTM	1 ft. Digital Elevation Model (DEM)	DEP & DoITT
Lots	MapPLUTO	DTM
Parks	Mèmèkas Meadow	DoITT
	Parks Properties	DPR
Streets	LION Geodatabase	DCP
Trees	Street Tree Census	DPR
Waterbodies	Hydrography	DoITT
Waterbody Structures	Hydrography-structures	DoITT
Zoning	Zip Code Boundaries	DoITT
	Census Tracts 2010	DCP
	Borough Boundaries	DCP

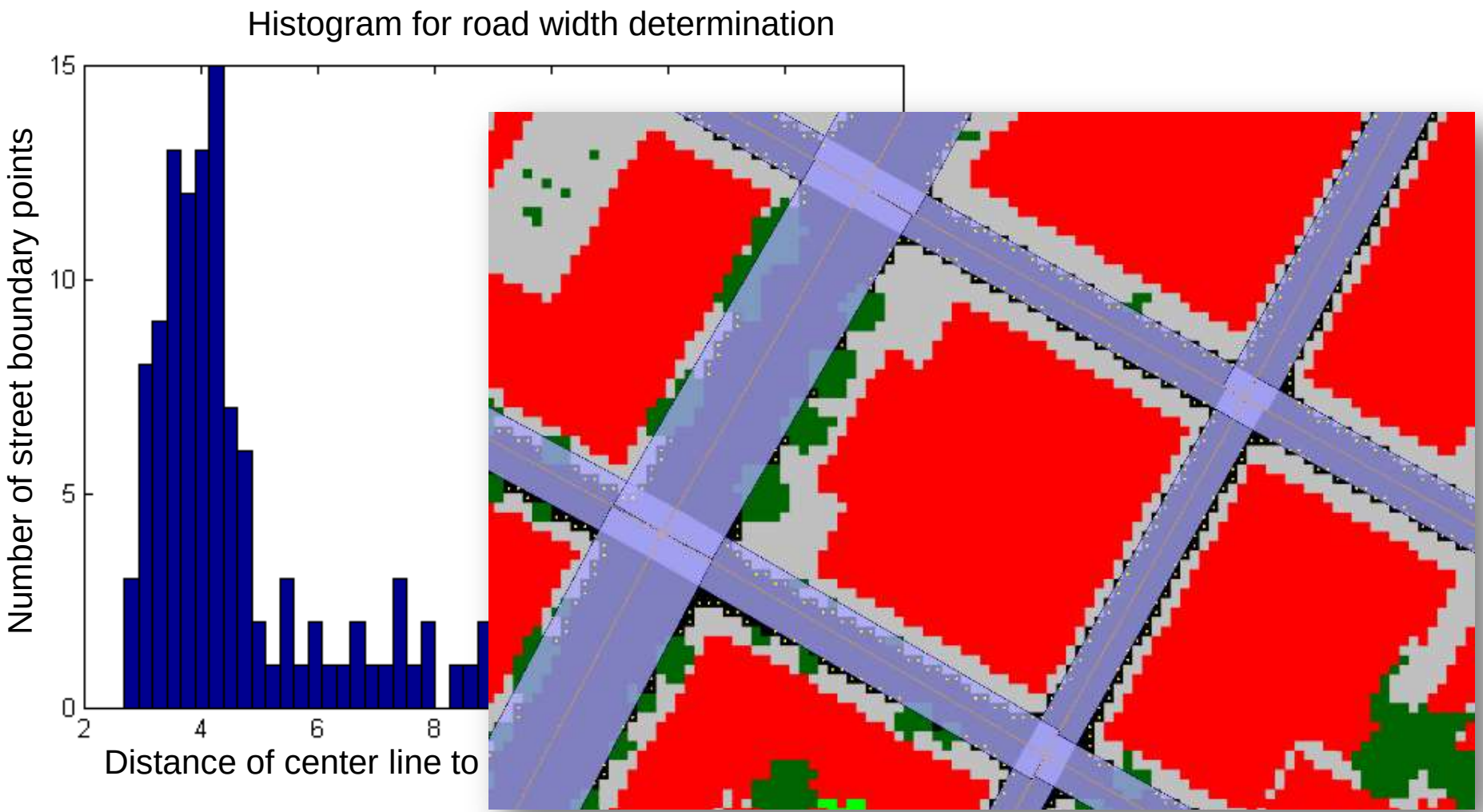
Estimation of Road Widths (1)





- road centerlines (orange) overlaid onto the land cover classification map
- identification of crossings
  - areas have to be excluded from road with estimation
- for each individual segment
  - determination of the distances from the center line to the first cell not classified as ‘road‘
  - accumulation of distances in a histogram
  - selection of the mostly occuring width; buffering of the line

Estimation of Road Widths (2)



Generated 3D Street Geometries (2)

- Complex motorway junction with many different height levels
  - 3D embedded graph usable for routing applications has been created

Generated CityGML Objects for NYC (1)

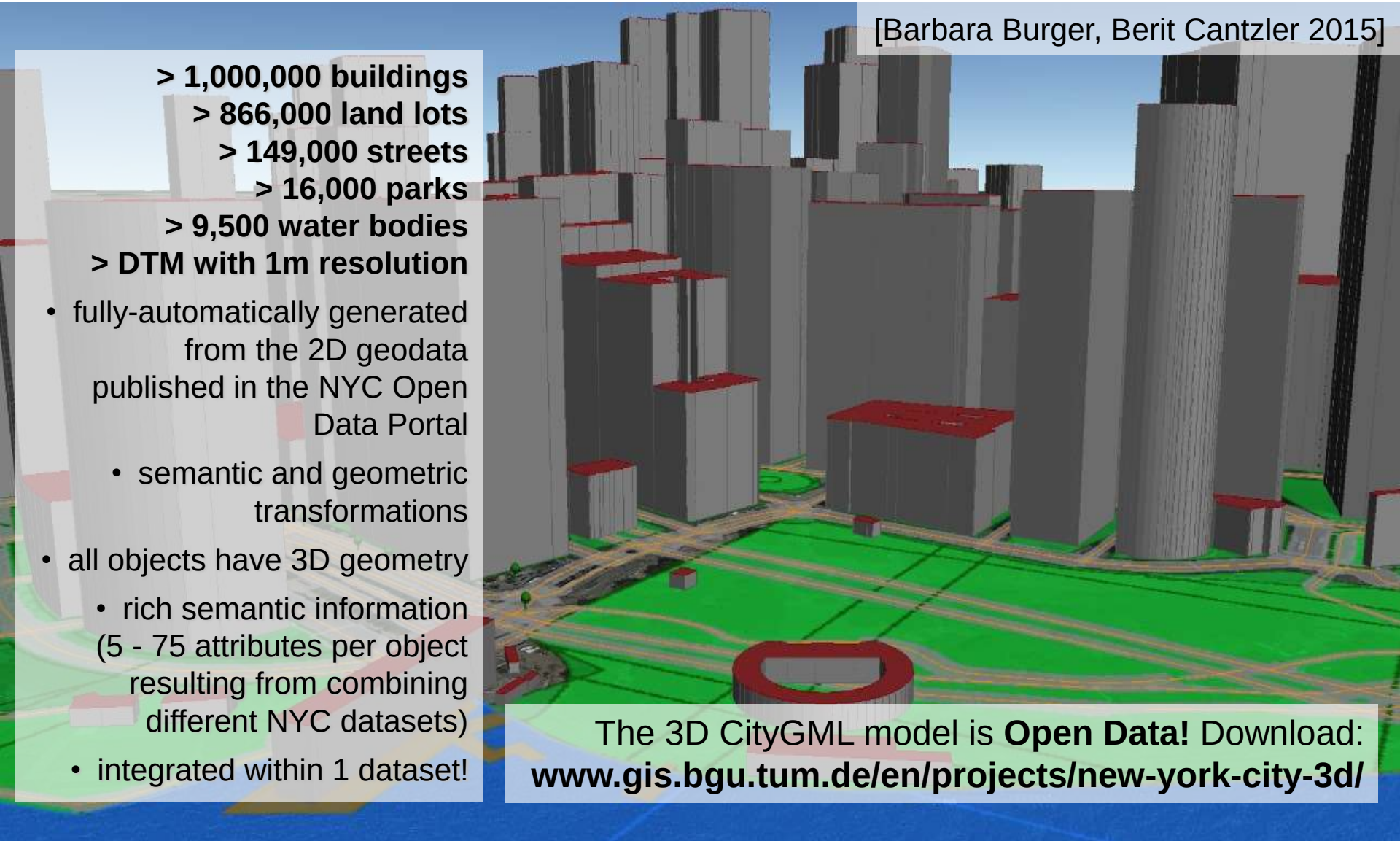
Dataset	Format	Geometry types	Number of objects	Num of attributes	Data size [GB]
Buildings/ Addresses	Shape	2D polygon/point	2,023,531		0.931
	CityGML	3D Solid	2,020,523	20 – 55	11.085
DTM	Raster	Grid	1		121
	CityGML	Tiled TIN	35,153 tiles	–	1,450
Land Cover	Raster	Grid	1		0.2
	CityGML	–	–	–	–
Lots	Shape	2D Polygon	857,853		0.867
	CityGML	3D Polygon	866,853	75	8.021
Parks	Shape	2D Polygon	14,674		0.025
	CityGML	3D Polygon	16,159	10	0.054
Streets	ESRI File gdb	2D Line	212,890		0.128
	CityGML	3D Line+Polygon	149,292	31	0.482
Street Inter-sections	ESRI File gdb	2D Point	125,118		0.128
	CityGML	3D Point	104,754	1	0.055

Generated CityGML Objects for NYC (2)

Dataset	Format	Geometry types	Number of objects	Num of attributes	Data size [GB]
Trees	Shape	2D Point	623,920		0.206
	CityGML	3D tree shape solid	277,108	16	113
Water Bodies	Shape	2D Polygon	1,976		0.01
	CityGML	3D Polygon	9,542	5	0.025
Water Body Structures	Shape	2D Polygon	2,464		0.003
	CityGML	3D Polygon	2,464	3	0.006
Zoning	Shape	2D Polygon	2,436		0.005
	CityGML	CityObjectGroups	2,436	23	≤ 1
Total	Original	2D + 2.5D	**3,864,864**		**123.4**
	CityGML	3D + 2.5D	**3,484,284**		**1,583.7**

- The largest share (1.45 TB) is required by the DTM, due to the XML representation of > 5 billion triangles
- File compression reduces CityGML files to 5% of their original size. The compressed NYC dataset has 79 GB.

New: CityGML Model of New York City in LOD 0&1



[Barbara Burger, Berit Cantzler 2015]

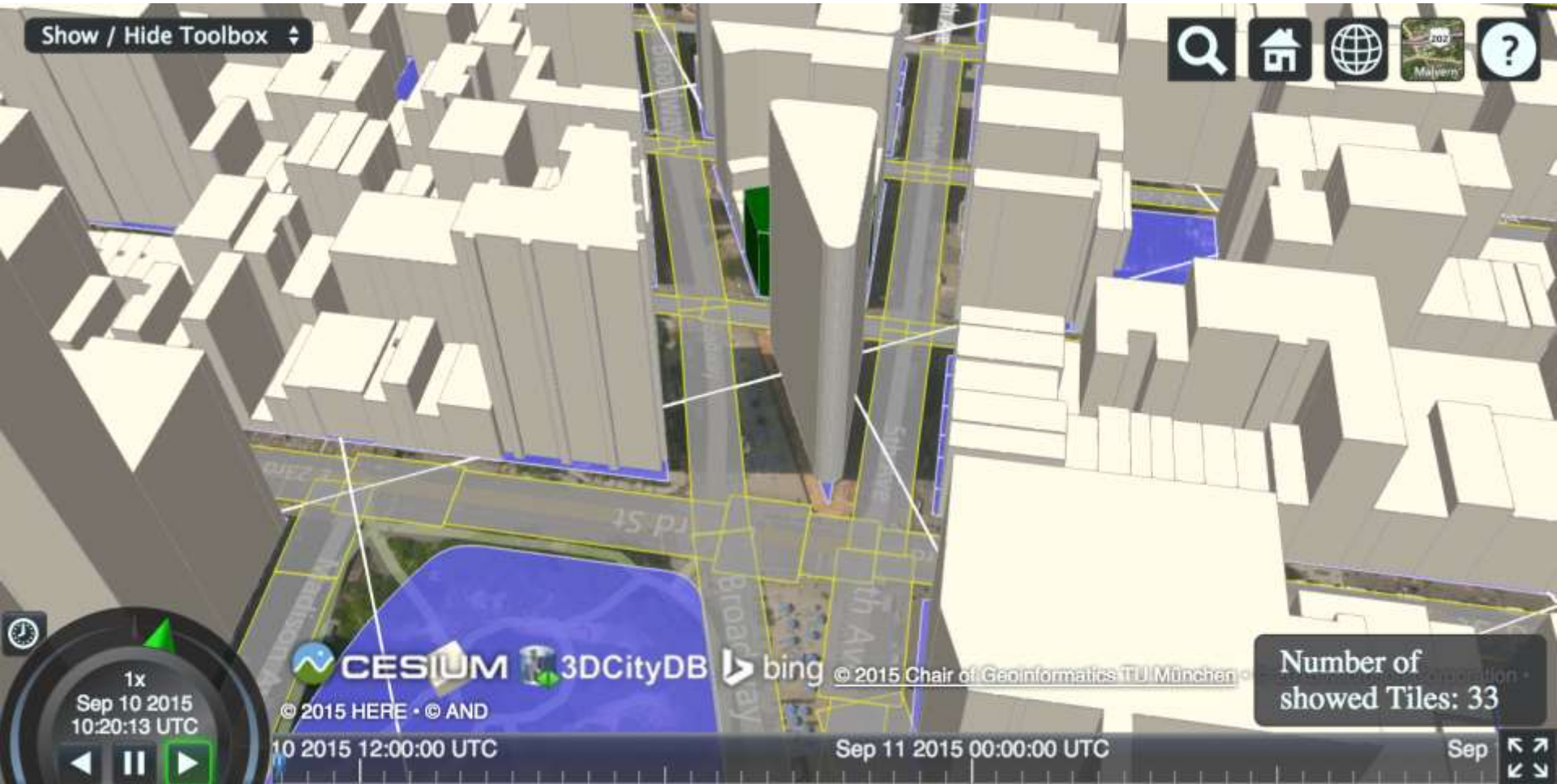
> 1,000,000 buildings
> 866,000 land lots
> 149,000 streets
> 16,000 parks
> 9,500 water bodies
> DTM with 1m resolution

- fully-automatically generated from the 2D geodata published in the NYC Open Data Portal
- semantic and geometric transformations
- all objects have 3D geometry
- rich semantic information (5 - 75 attributes per object resulting from combining different NYC datasets)
- integrated within 1 dataset!

The 3D CityGML model is **Open Data!** Download:
www.gis.bgu.tum.de/en/projects/new-york-city-3d/

Web-based 3D Visualization & Data Inspection

- Using the Open Source 3DCityDB + the new Webclient
  - www.3dcitydb.net & https://github.com/3dcitydb/3dcitydb-web-map



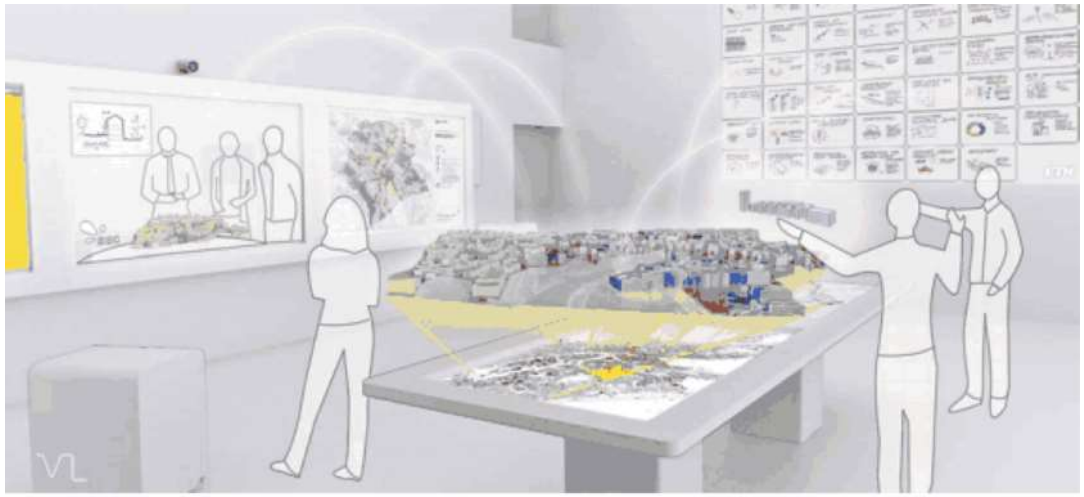
Und Smart Cities?

Smart Sustainable Districts (SSD)

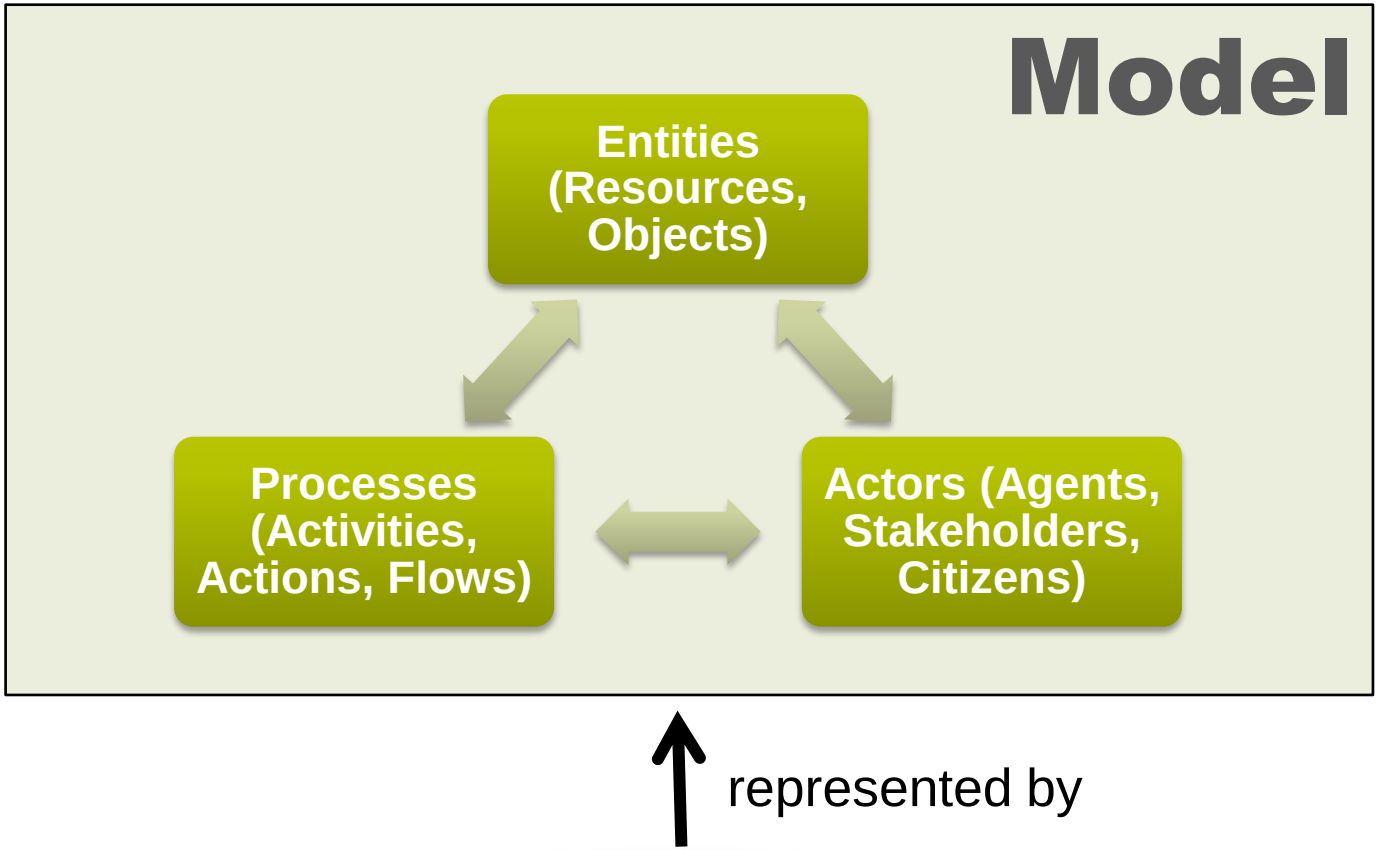
- Climate-KIC Flagship Project
- Project partners: Imperial College London, ETHZ, Chalmers Univ., TU Berlin, TU München, Reading, Univ. of Birmingham, Institute for Sustainability, TNO, Deltares, ESRI, Smarter Better Cities, Aria, zahlreiche Großstädte
  - Further partners can become members during project runtime
- Project duration: 01.06.2014 – 31.05.2017 (3 Jahre)
- EIT Funding (total): 5 Mio € (2014 und 2015)

Modeling City Systems (MCS)

- Climate-KIC Innovation Project
- Project partners: ETH Zürich (iA, CVL), Imperial College, TU Berlin, TU München, SmarterBetterCities, TNO, ESRI
- Project duration: 1. 1. 2014 – 31. 12. 2015 (2 years)
- EIT Funding (total): 2.4 Mio €



City System Modeling



Today: Separate Modeling by Sectors

Energy

- Commu-nity
- Models
- Indicators
- Evalua-tion
- Planning

Mobility

- Commu-nity
- Models
- Indicators
- Evalua-tion
- Planning

Ecology

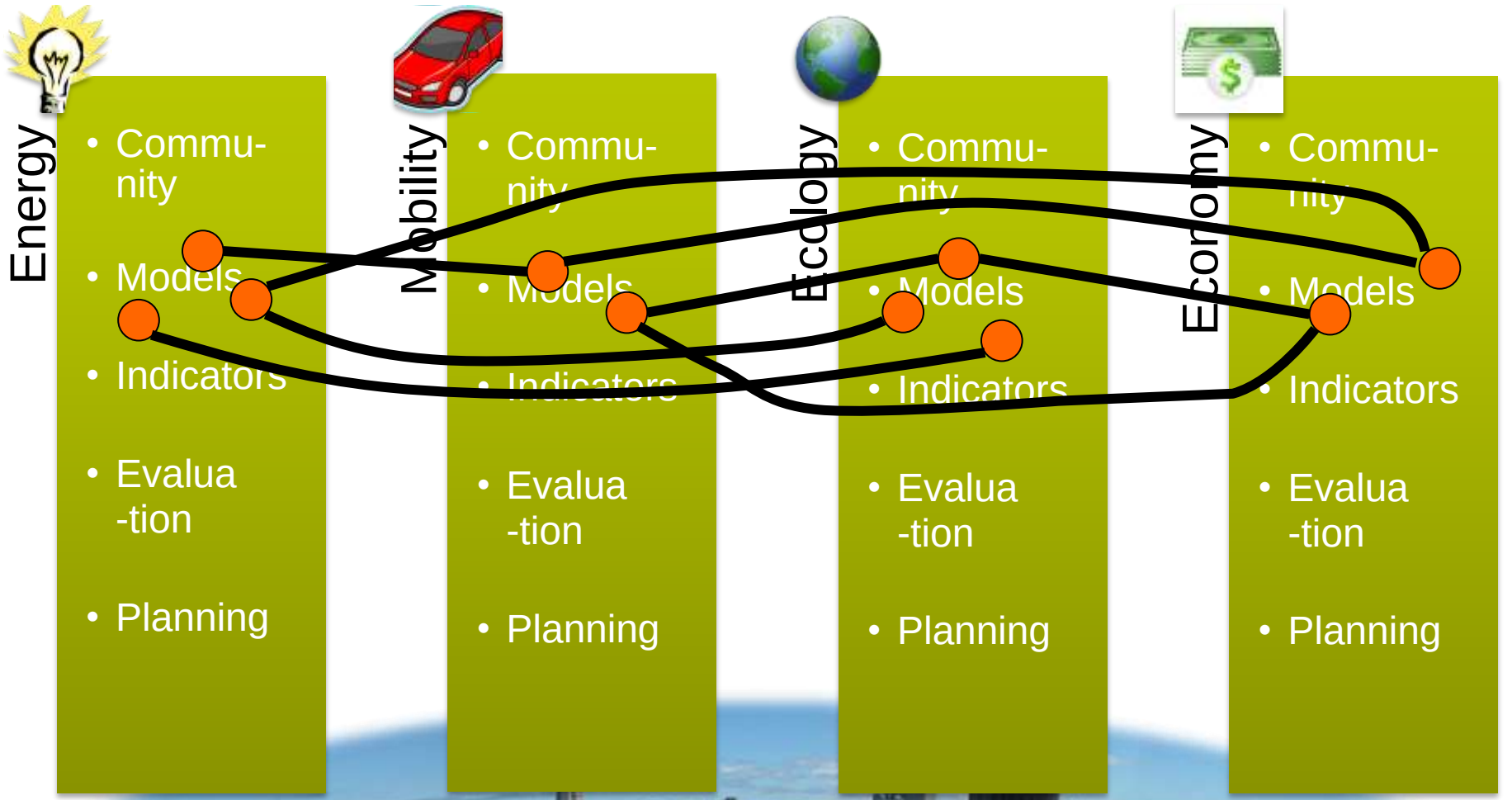
- Commu-nity
- Models
- Indicators
- Evalua-tion
- Planning

Economy

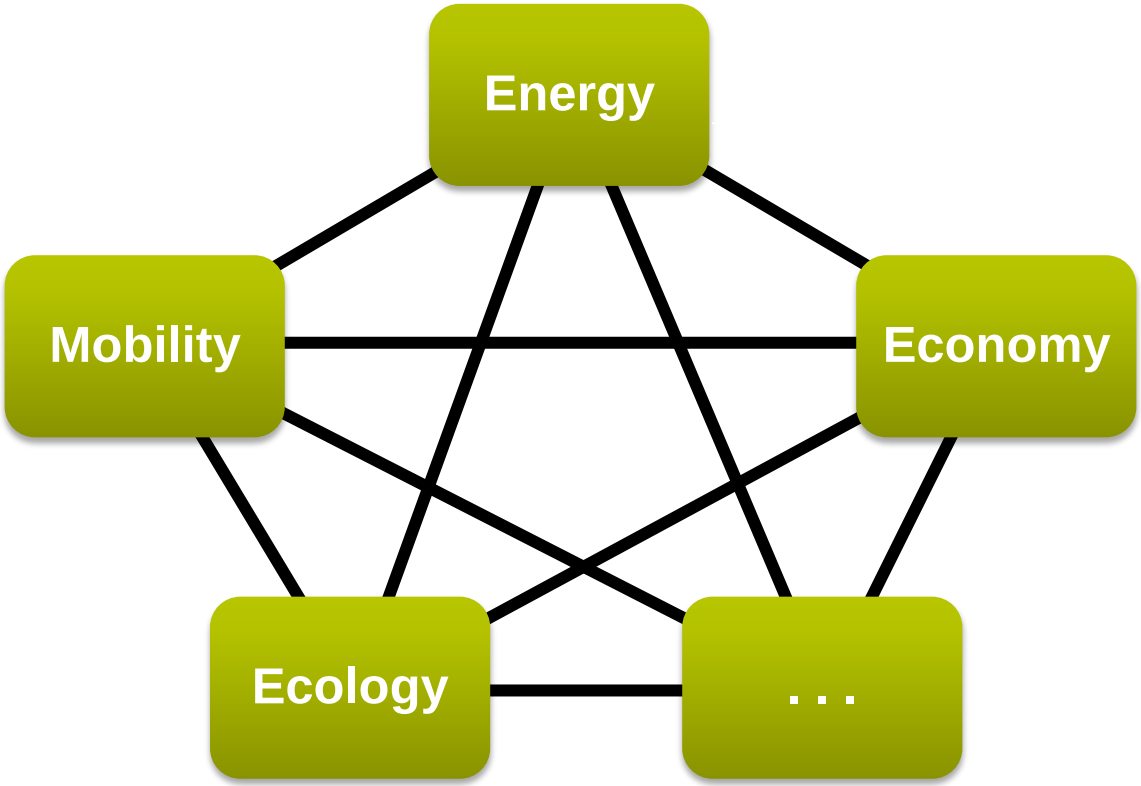
- Commu-nity
- Models
- Indicators
- Evalua-tion
- Planning

City System

Linking Sectors creates a Lattice of Models

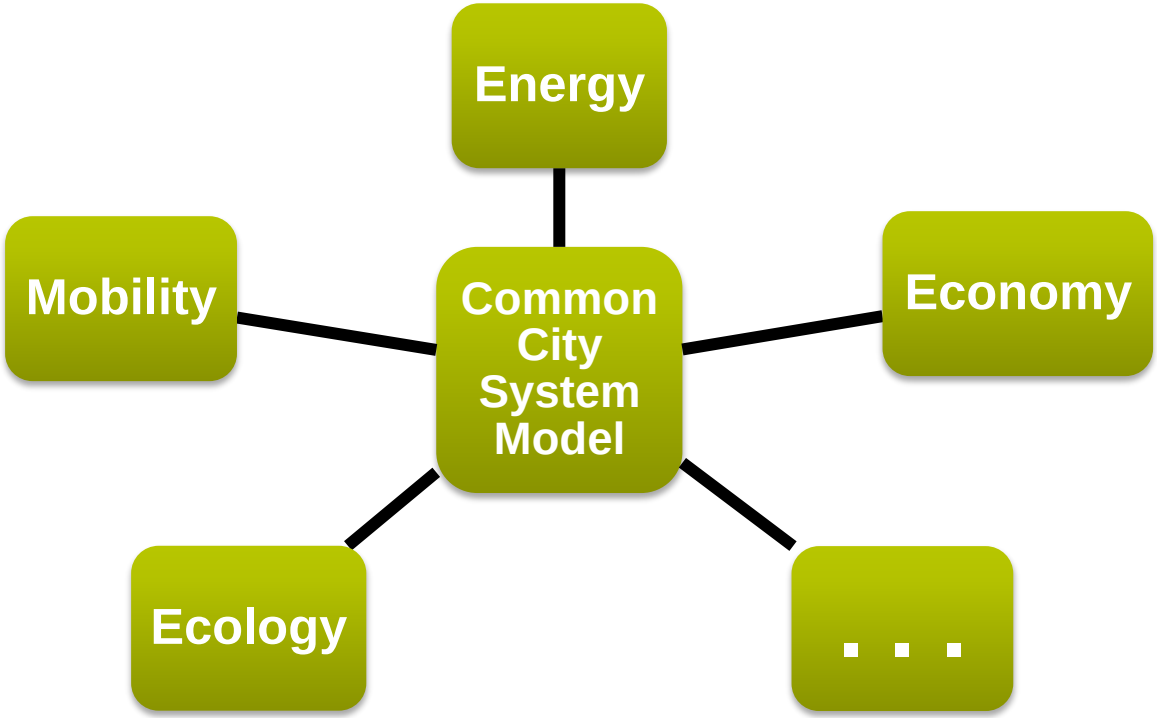


Lattice of Sector Models



- *n* Sectors → **potentially n^2 connections!**
- difficult to express, to maintain, and to keep consistent

What if we could link to One Common Model?

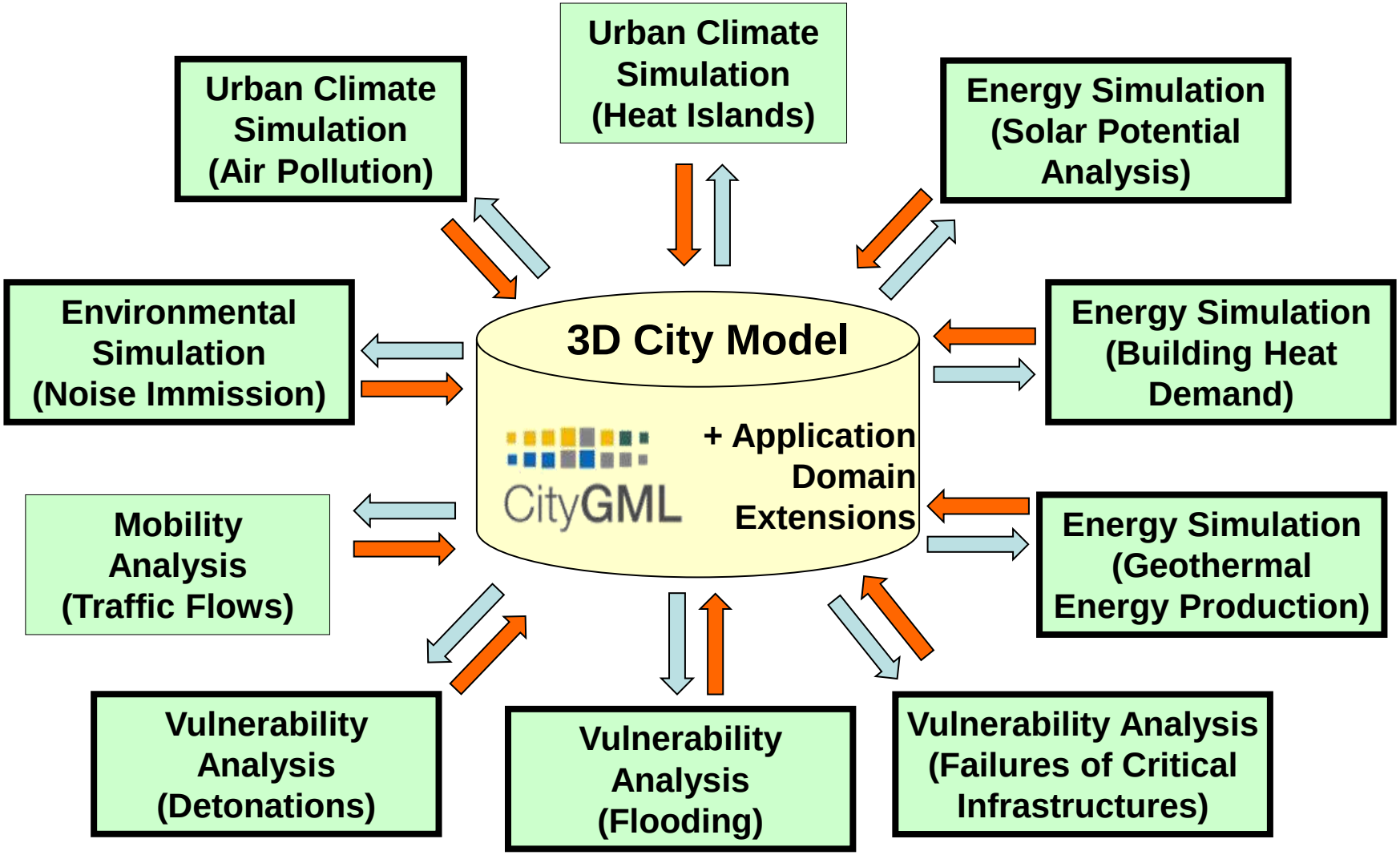


- *n* Sectors → ***n* connections!**
- Sector models can be linked via the Common Model
- Sector models need to be aligned with the Common City System Model → **high degree of coherence required**

Is there such an integrative model? Candidates?

Semantische 3D-Stadtmodelle (und CityGML)

Multi Simulation Integration



Bold-framed boxes: projects that were carried out by or with participation of my teams so far

Linking Urban Simulations across Domains

- Output of one simulation can be the input for another one
  - **cascading simulations** need lossless information handling
- **Semantic 3D city models** are well suitable data integration platforms
  - **source for simulation input data**
  - **container for simulation output data**
- Simulations often require and produce **time-dependent data**
- Smart City projects integrate **sensors & observations**
  - **observations are also time-dependent**
- **Time-variant data is not supported in CityGML 2.0**

Anwendungsbeispiel

Strategische Energieplanung (Energieatlas Berlin)

Ziele des Energieatlas Berlin

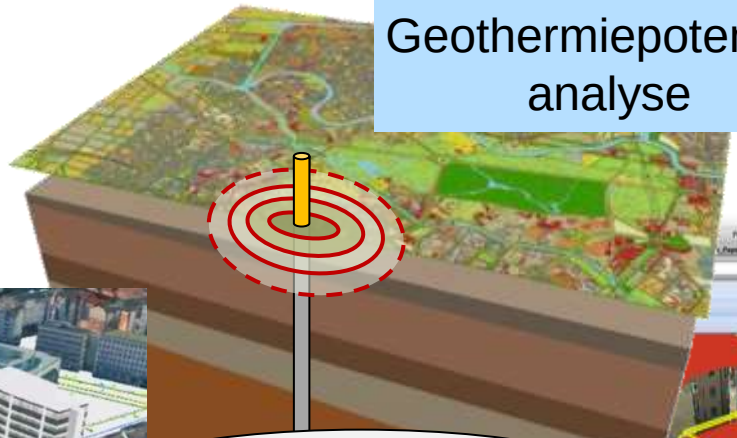
- Entwicklung eines ganzheitlichen Planungswerkzeuges zur
  - **Repräsentation des Ist-Zustandes** der umwelt- und energierelevanten Objekte und Parameter
  - Darstellung der **energetischer Zusammenhänge**
  - Untersuchung und Darstellung von **Handlungsoptionen**
  - **Entscheidungsunterstützung** bei der Planung verschiedener Maßnahmen **durch Visualisierung**
- Gemeinsames **Datenrückgrat für Analysen und Simulationen**
  - Abschätzung von Strom- und Wärmeenergiebedarfen
  - Energetische Gebäudeeigenschaften und Sanierungspotentiale
  - Gestaltung eines optimalen Energienetzausbaus unter Berücksichtigung des Strombedarfes und Lastspitzen
  - Berücksichtigung der Geothermie- und Solarenergiepotentiale

Energieatlas

Geothermiepotential-analyse

Einsparpotential-analyse

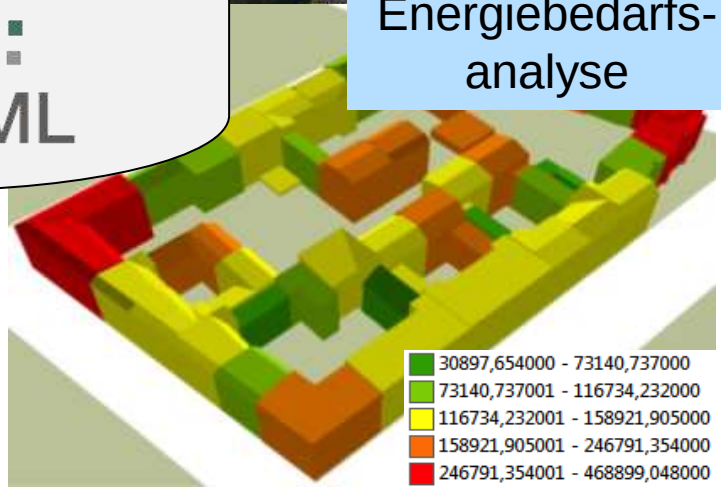
Infrastruktur-analyse

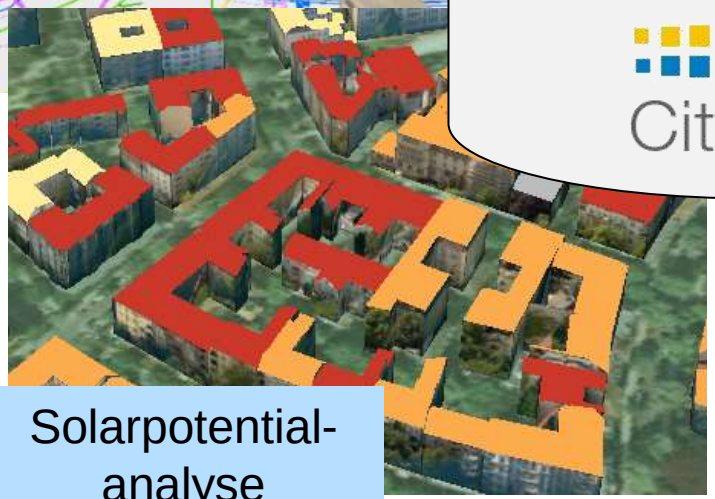


Energieatlas

CityGML

Energiebedarfs-analyse





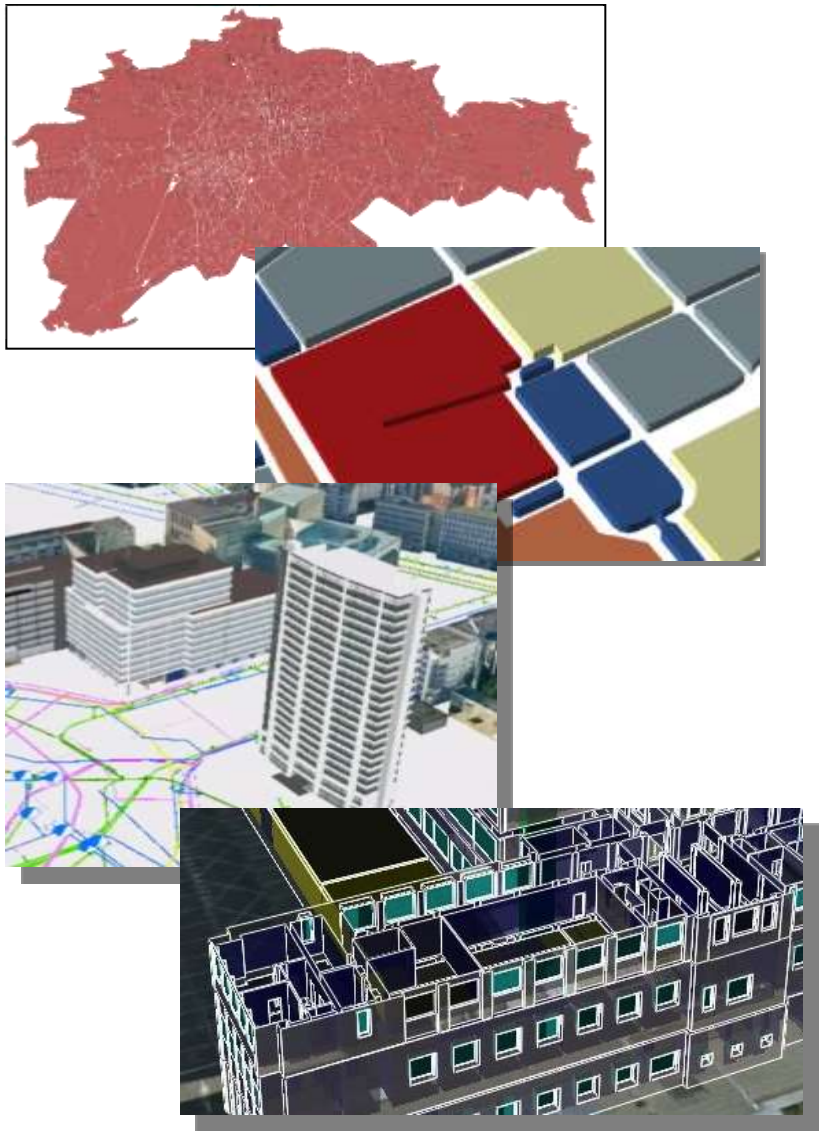
Solarpotential-analyse

Skalenbereiche des Energieatlas

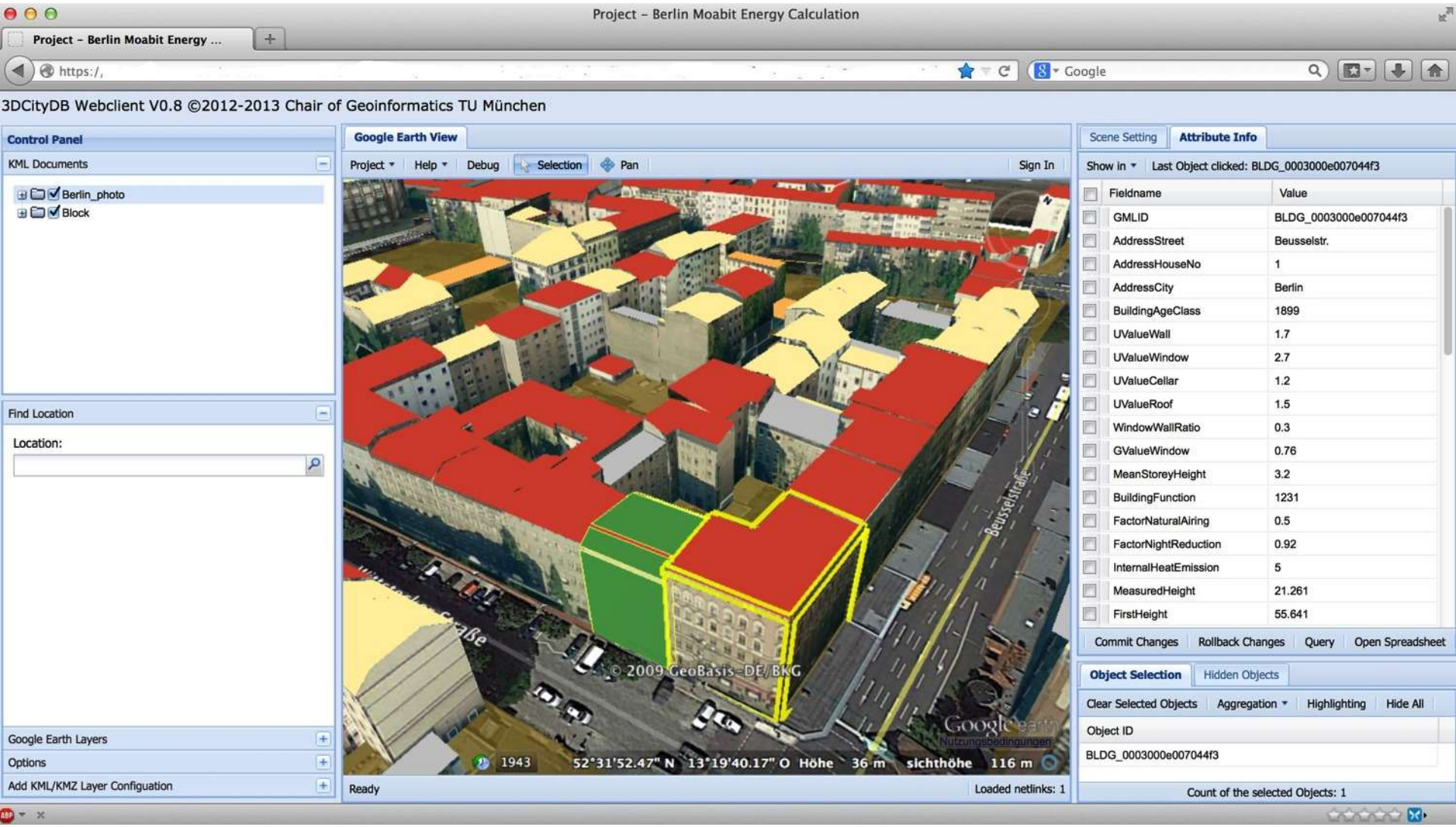
- Stadt
- Stadtteil
- Quartier / Block
- Gebäude / Straße
- Wohnung
- Raum

Generalisierung / Aggregation

Auflösung / Detaillierungsgrad



Bildschirmkopie des Energieatlas-Webclients



Anwendungsbeispiel

Dachbegrünung zur Reduktion von Feinstaub

Green Roofs Munich (1)

- Particulate matter is a big environmental problem in cities

Feinstaub PM_{10}:

Tabelle 2/3: Immissionswerte an den LÜB-Stationen 2010 – 2013 für PM_{10}

LÜB- Stationen PM_{10}	Jahresmittel [µg/m³]				Anzahl der Überschreitungen beim Tagesmittelwert			
	2010	2011	2012	2013	2010	2011	2012	2013
Stachus	32	31	26	26	**47** (5)*	35 (9)*	14 [11]**	19 [17]**
Landshuter Allee	38	36	29	31	**65** (8)*	**48** (17)*	27 [17]**	39 [30]**
Prinzregentenstraße	28	25	-	-	31 (4)*	(4)*	-	-
Johanneskirchen	22	21	16	18	23 (4)*	9 (		
Lothstraße	24	22	18	20	27 (3)	11 (2)		
Andechs (zum Vergleich)	17	15	14	12	11	4		

Values exceed EU directive on ambient air quality

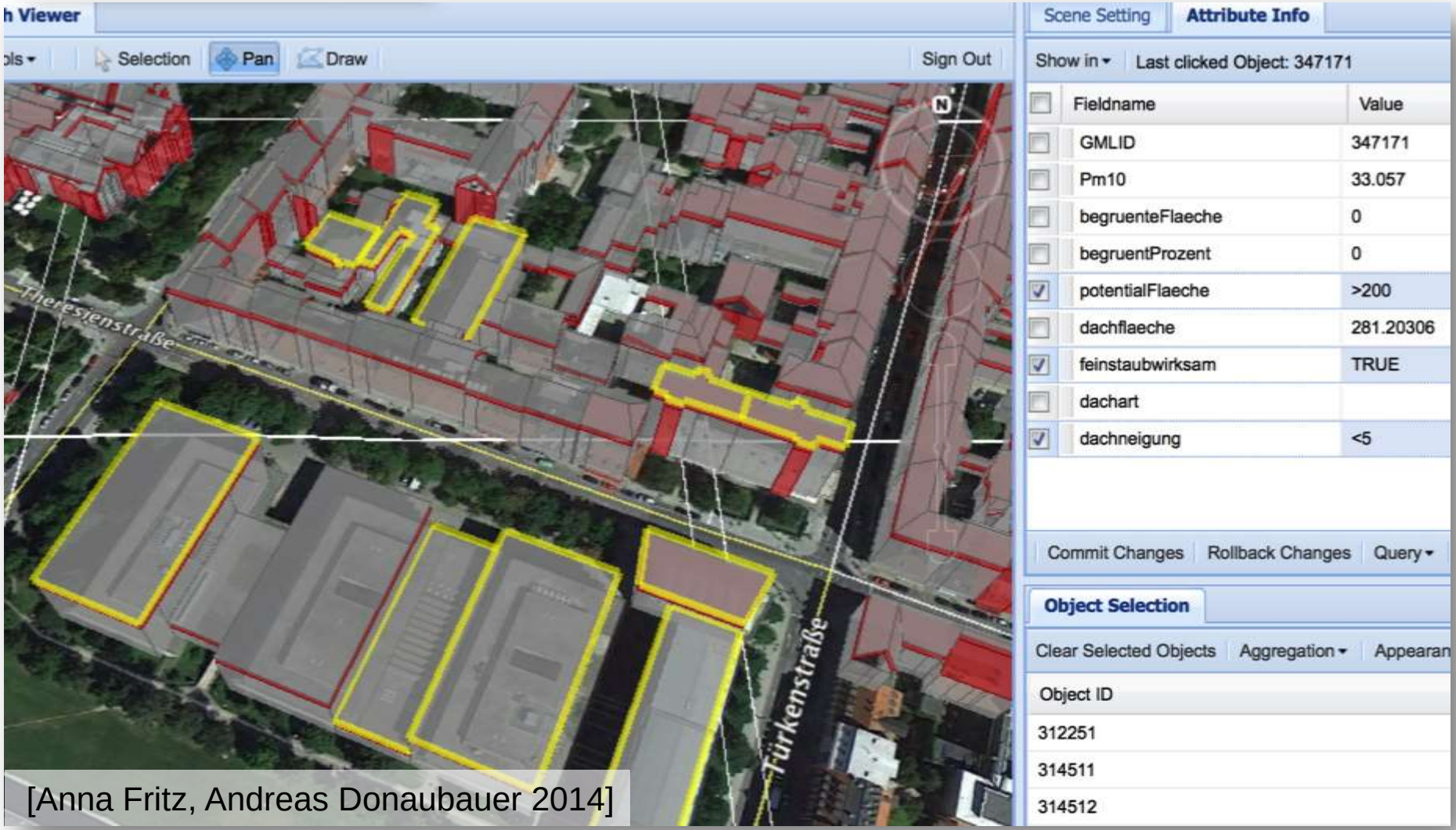
- Plants can help reducing PM concentration
- Space for greening is scarce, esp. at major traffic routes

→ Roofs of buildings could be used for greening

Green Roofs Munich (2)

- Identification of suitable roof surfaces using Munich‘s CityGML model and the Urban Analytics Toolkit
- Assumptions:
  - Flat roofs are best suited
  - Roofs which are already greened partially are best suited
  - Roofs which are within a distance of 50 meters from a major road are most effective for PM reduction
- Processing workflow of Green Roof tool (simplified):
  - Calculate surface area and slope of roofs and filter roofs by slope
  - Overlay roof surfaces with color infrared aerial images
  - Calculate „Normalized Difference Vegetation Index (NDVI)“
  - Select roofs within a distance of 50 meters from major roads
  - Assign attributes to the CityGML RoofSurface objects: greened surface area, ratio of greened area / non-greened area, effectivity for PM reduction
- Result: **semantically enriched RoofSurface objects**

Screenshot of the Green Roofs Application



[Anna Fritz, Andreas Donaubauer 2014]

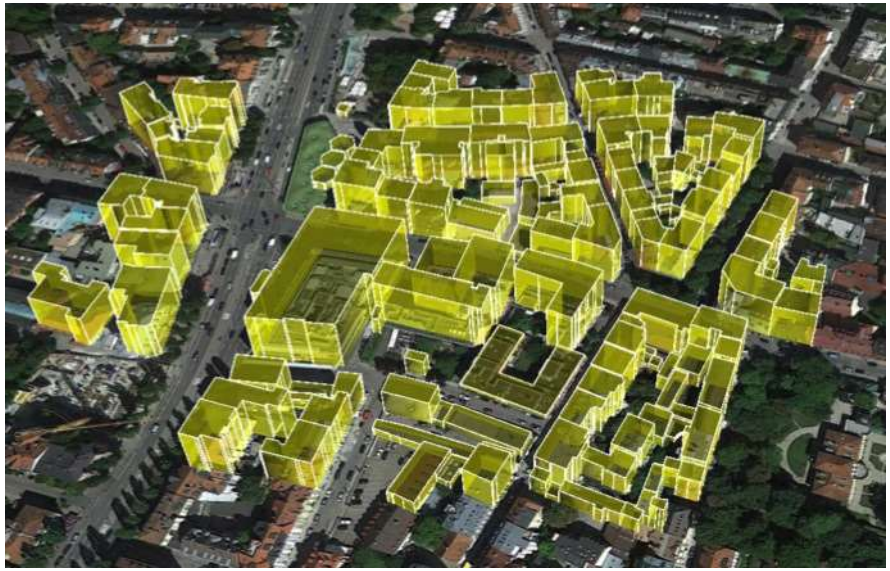
Anwendungsbeispiel

Vulnerabilitätsanalyse (Detonationssimulation)

‘Kontrollierte‘ Explosion eines Blindgängers aus dem 2. Weltkrieg

Detonation in München Schwabing, 2012

Source:
Münchner
Abendzeitung
Bildzeitung

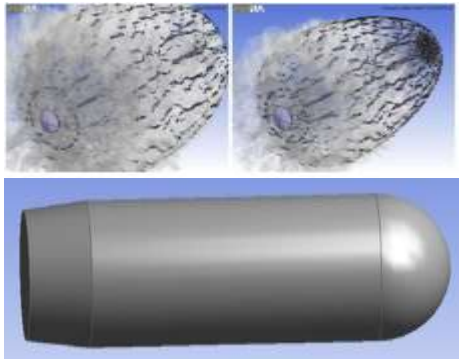


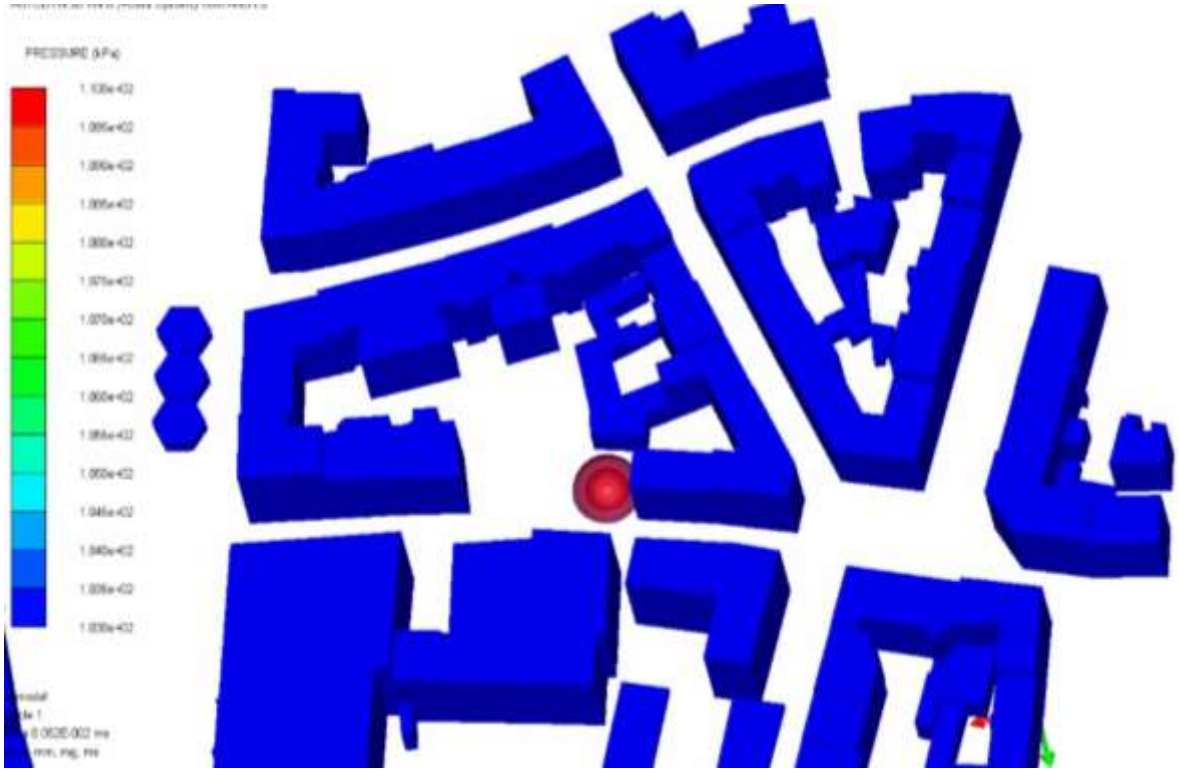
Amerikanische 500 lbs Fliegerbombe (120kg TNT)
Evakuierung von 2500 Einwohnern

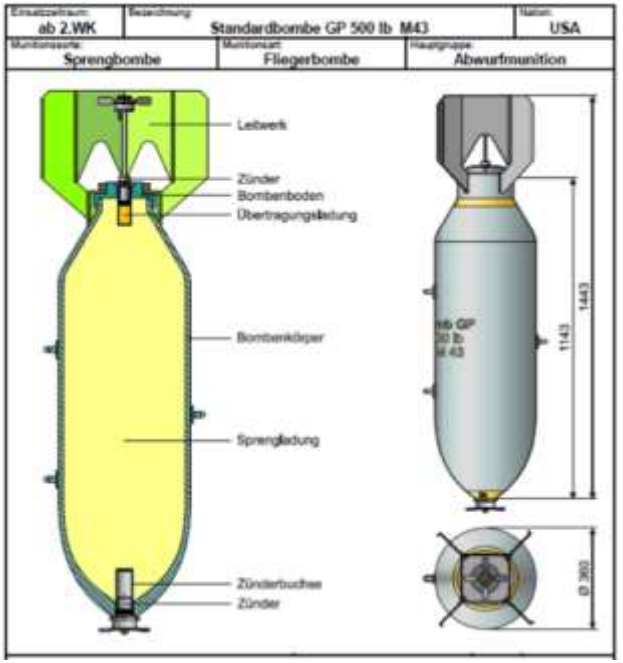
Source: Google Maps

‘Controlled‘ Blast of discovered unexploded Bomb from World War II

Detonation in Munich, District Schwabing, 2012







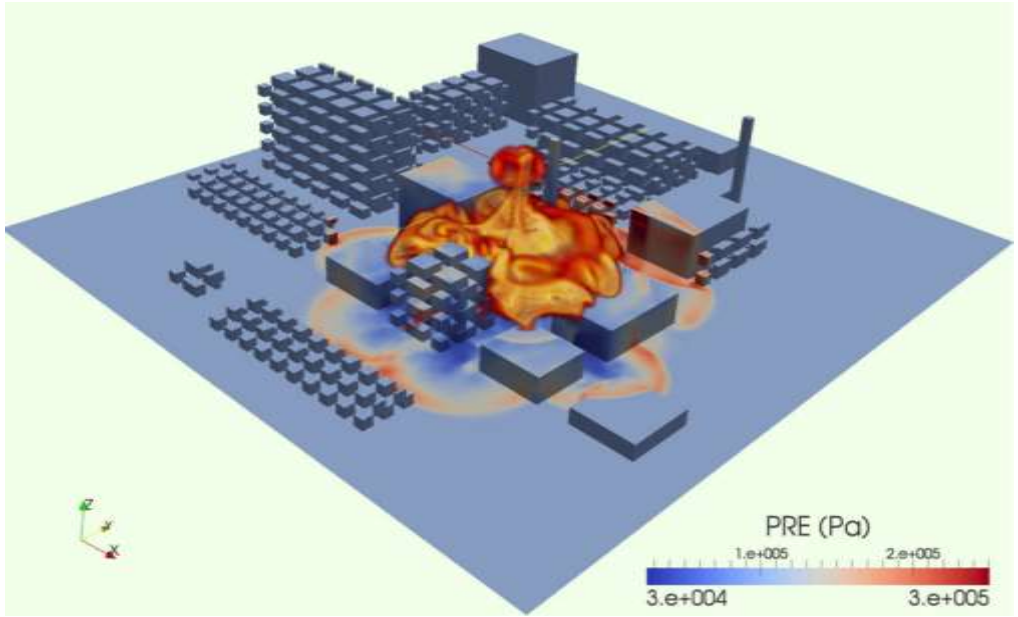
2013 Dresdner Sprengschule GmbH

Apollo Blastsimulator

APOLLO BLASTSIMULATOR

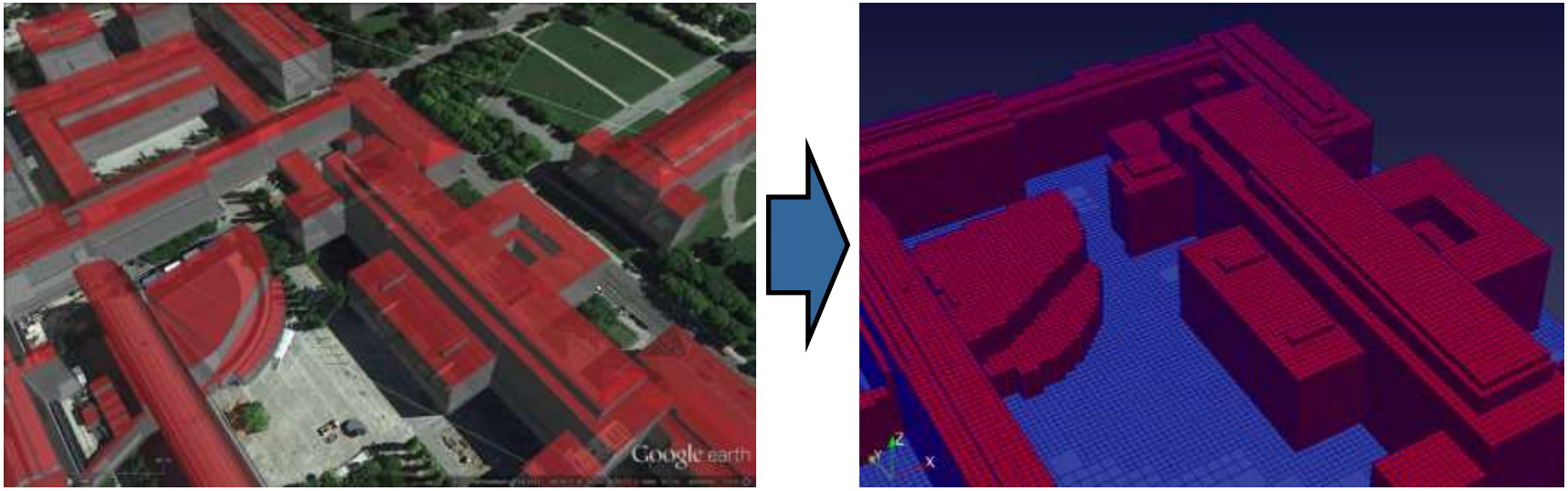
Fraunhofer EMI

- Entwickelt am Fraunhofer für Kurzzeitdynamik, Ernst-Mach-Institut (EMI) in Freiburg
- CFD Simulation für
  - Detonationen
  - Druckwellen
  - Gasdynamik
- physikalische Größen
  - Druck, Impuls
- Einsatzgebiet
  - Risikobewertung



Derivation of a Voxel Model from CityGML

- Selection of the simulation area
- Generation of a complete regular voxel grid for the simulation area
- Intersection of the voxel grid with the vector representation of the CityGML objects → occupancy grid

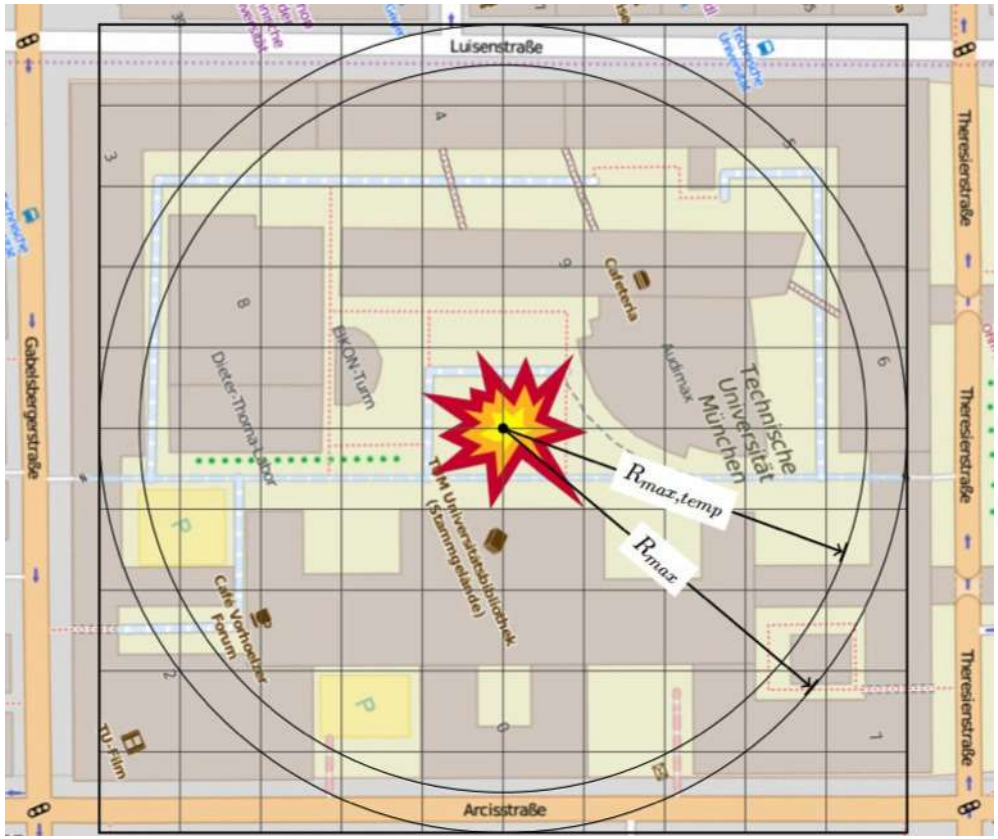


[Bruno Willenborg 2015]

Simulation of a Detonation at TUM Campus

- Radius R_{max} of endangered area determined based on the amount of TNT equivalent using an empiric formula

- Z_{min} = lowest point of the terrain
- $Z_{max} = R_{max}$ above the detonation site
- **No consideration of the urban topography** in the determination of R_{max} today

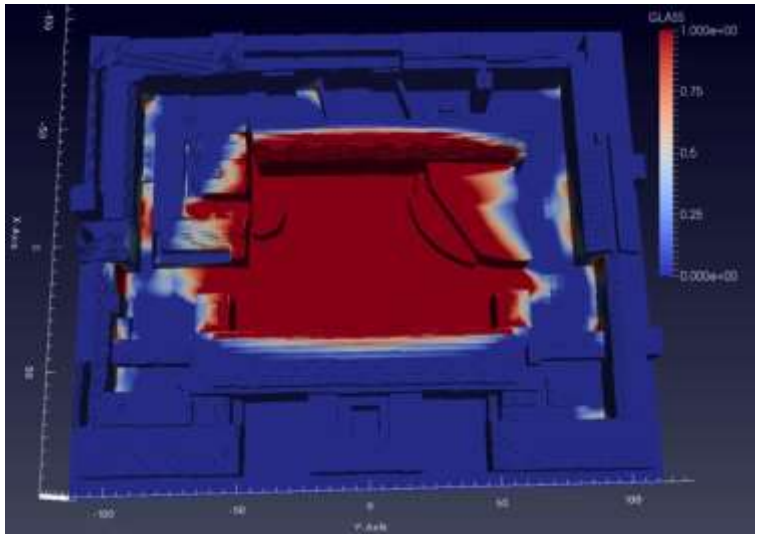


Mapping the Simulation Result back to CityGML

- A vector of parameters is being computed by the simulator for each voxel
  - peak overpressure, probabilities for glass & façade breakage, eardrum damage etc.
- These parameters are aggregated and mapped back to the objects of the CityGML model (RoofSurfaces, WallSurfaces)

$l_{voxel} = 0.40\ m$

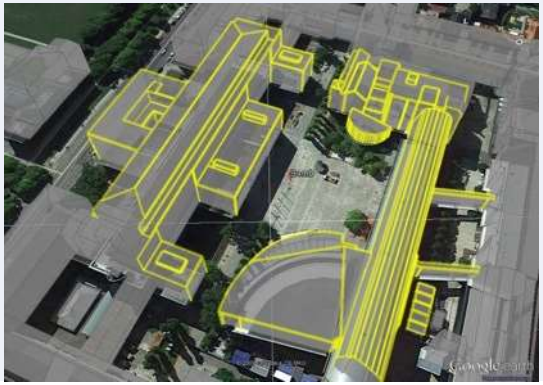
Probability for breakage of glass



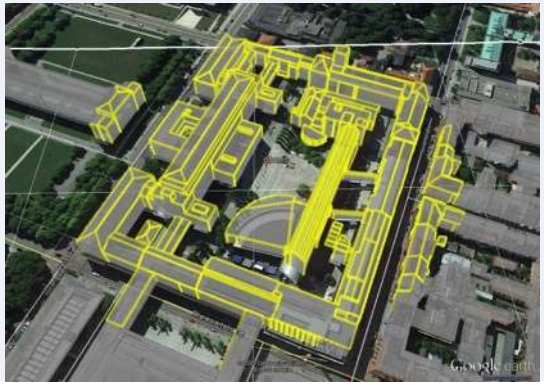
70% max probability for breakage of glass

Comparison: Simple Estimation ⇔ CFD-Simulation

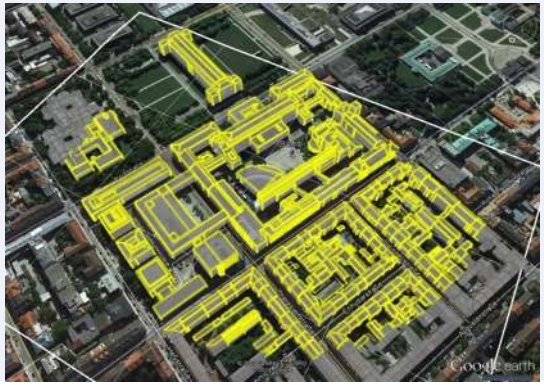
Conservative method, peak overpressure



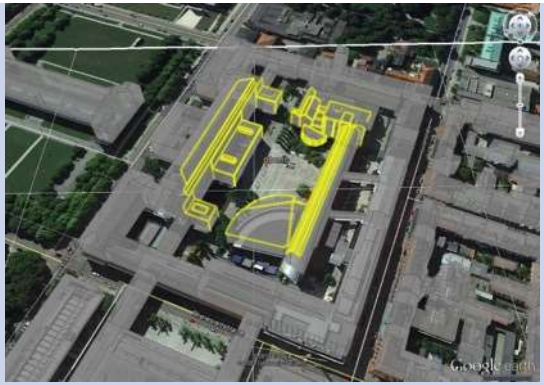
$>20\,000\ Pa$

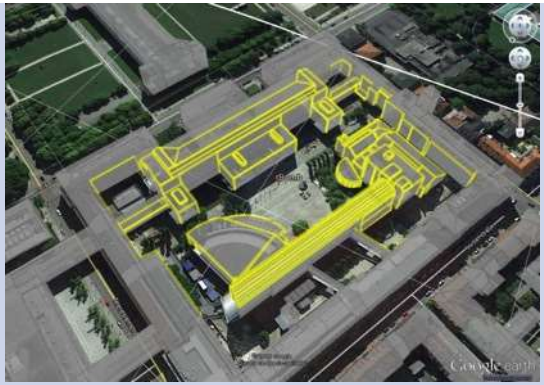


$>10\,000\ Pa$



$>5\,000\ Pa$





CFD simulation, peak overpressure

Schlussgedanken

- SIG 3D war wichtiger Wegbereiter und Akteur für die Entwicklung standardisierter Modelle und Dienste für 3D-Stadt- und Regionalmodelle
  - in Deutschland, Europa und weltweit
  - CityGML, Web 3D Service / Web View Service, INSPIRE Buildings
- SIG 3D bleibt wichtiges Gremium
  - Weiterentwicklung von CityGML unter starker Mitgestaltung und Mitentwicklung der AG Modellierung
  - SIG 3D betrachtet heute wichtige Aspekte, die anderswo (noch) nicht untersucht werden, u.a.
    - Qualität von 3D-Stadtmodellen
    - Modellierungshandbuch
- Also: **Viel Erfolg für die nächsten 50 Sitzungen!**