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Jan Halatsch
halatsch@arch.ethz.ch

URBANISM, SYSTEMS AND MODELS

ETH Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

NECESSITY FOR URBAN MODELS IN THE PLANNING CONTEXT

Models can be

- parameterized
- computed
- rendered

NECESSITY FOR URBAN MODELS IN THE PLANNING CONTEXT

Models can be used to produce

(a) simulations (energy, windflow, crowd behaviour),
(b) visualizations (data representation from (a)),
(c) iteration (manipulation and gained intuition)

MODELLING VS. DIRECT MEASUREMENT

Models are used IF

(a) impossible or impractical to have experimental conditions with measurable outcomes

(b) models use assumptions

(c) number and precision of assumptions affect accuracy and thus relevance of models

(d) Models are not necessarily digital

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MODELLING VS. DIRECT MEASUREMENT

Direct measurement

(a) where experimental conditions possible

(b) controlled experiment, scientific method, for observation

(c) accuracy higher than modelled estimates, depending on monitoring errors

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MODELLING LANGUAGES

Artificial language (or convention) to express

(a) information
(b) knowledge
(c) systems

Defined by consistent set(s) of rules.

MODELLING LANGUAGES

Rules are used for the intepretation in the model structure.

Examples:

(a) CGA shape grammar
(b) Unified Modelling Language (UML)
(c) CityGML (City Model for the Geographic Markup Langauge)

SIMULATION VS. MODEL

A simulation is the functional implementation of a model in descriptive dimensions.[2]

[2] Systems Engineering Fundamentals. Defense Acquisition University Press, 2001.

SIMULATION VS. MODEL

A simulation

(a) shows behaviour of particular object / phenomenon
(b) is useful for testing, analysis, training.

STRUCTURE OF A MODEL

Structure [3]

Fundamental notion covering

(a) recognition

(b) observation

(c) nature

(d) stability of patterns

(e) relationships of entities

[3] Pullan, Wendy (2000). Structure. Cambridge: Cambridge University Press. ISBN 0521782589.

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STRUCTURE OF A MODEL

Structure [3]
Represents definition of a system:

(a) configuration of items
(b) collection of inter-related items
(c) hierarchy (1 to n connections) or
(d) network (n to n connections)

[3] Pullan, Wendy (2000). Structure. Cambridge: Cambridge University Press. ISBN 0521782589.

STRUCTURE OF A MODEL

Types of structures
Classification in

(a) biological structure
(b) chemical structure
(c) built structure
(d) musical composition
(e) social structure
(f) data structure

SYSTEM

A system is a set of interacting or interdependent entities forming an integrated whole.

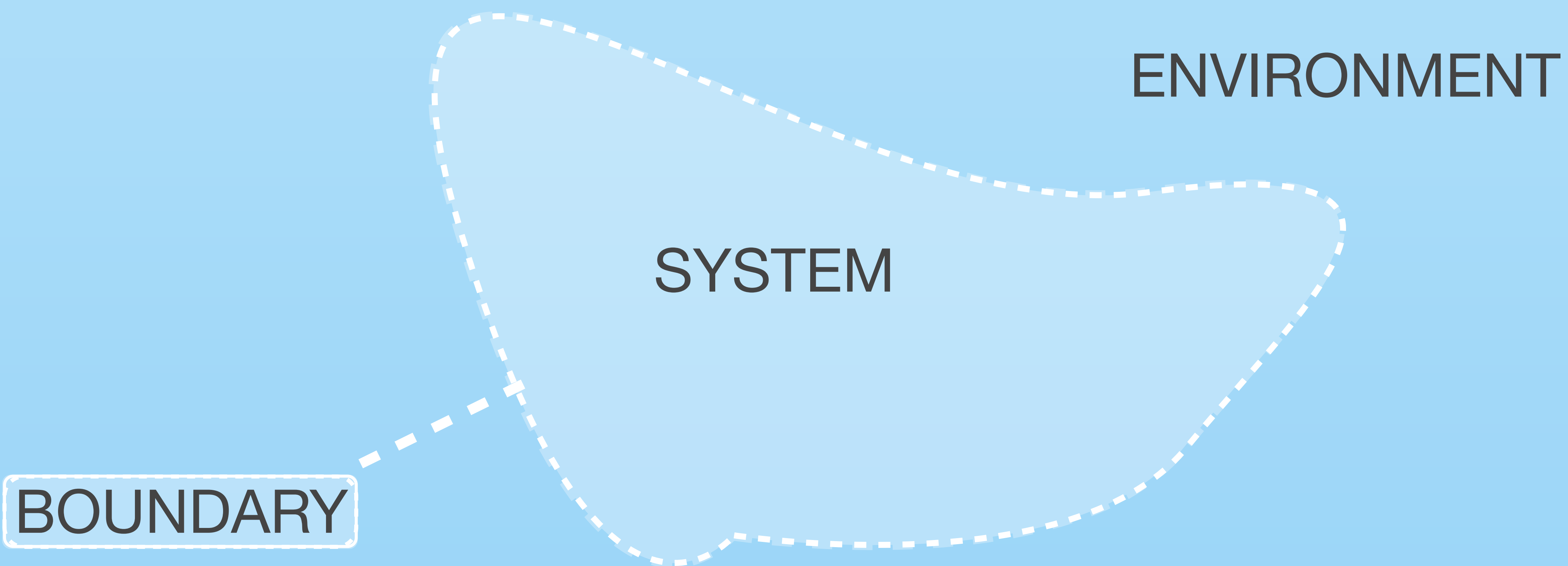
SYSTEM

Common characteristics of a system:

(a) structure

(b) behavior

(c) interconnectivity



SYSTEM CONCEPTS

Environment and boundaries

(a) System scope has to be defined e.g. what is inside/outside.

(b) Inside = part of system

(c) Outside = part of the environment.

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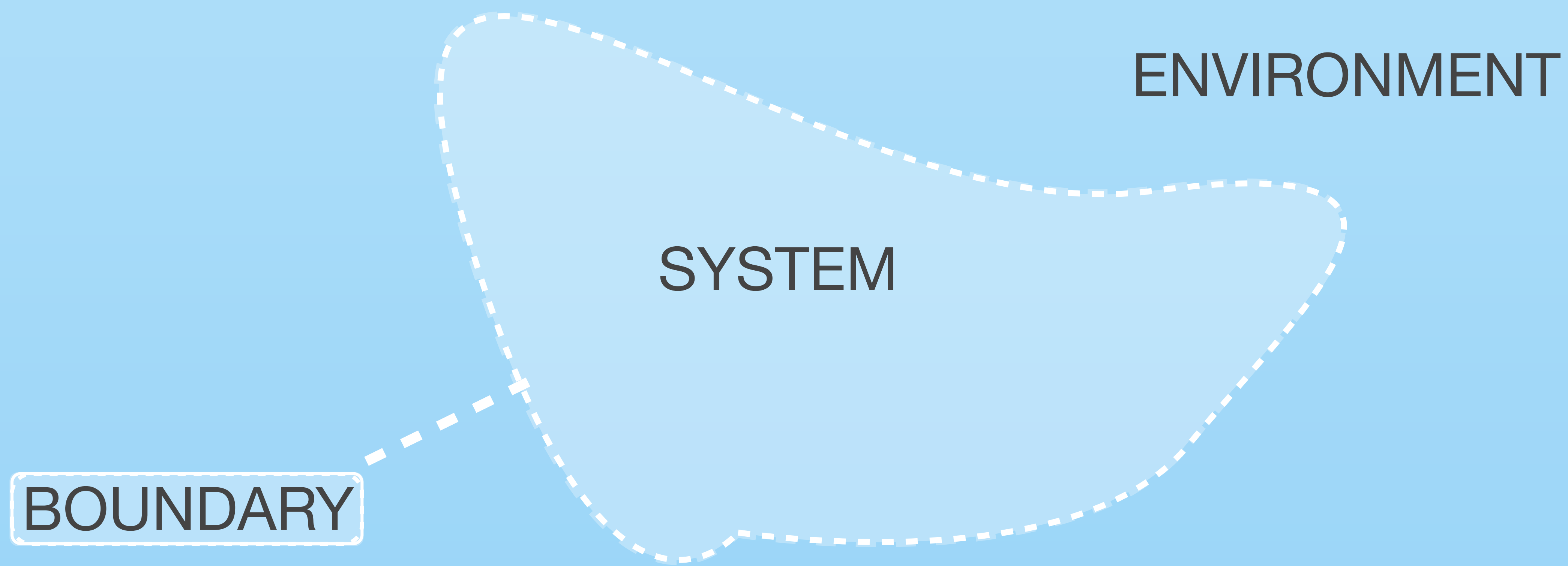
SYSTEM CONCEPTS



Environment and boundaries

Result

Simplified representation = Model

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SYSTEM CONCEPTS

Natural and man-made systems

Natural systems:

(a) may not have apparent objectives

(b) output can be interpreted by related systems

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SYSTEM CONCEPTS

Natural and man-made systems

Man-made systems:

(a) purpose: delivery of outputs

(b) coherent entity, otherwise two or more distinct systems

SYSTEM CONCEPTS

Open system vs. closed system

Open system
interacts with its environment (with some entities)

Closed system
is isolated from its environment

SYSTEMS APPROACH & QUANTITATIVE REVOLUTION

Late 1950s: rigorous theory building vs. loose speculation

(a) Quantitative Revolution

(b) Systems Approach

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SYSTEMS APPROACH OF URBAN MODELS

Quantitative Revolution (1950s-90s)

- connection geographical space with mathematics, statistics
- analytical approaches for urban economics
- Operations Research medium for the analysis of a host of ‘human’ problems (link to Systems Approach[4])

[4] Batty (1976). Urban Modelling.

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SYSTEMS APPROACH OF URBAN MODELS

Systems Approach (until today)

Blurring boundaries between disciplines
sharing of basic methodologies
transdisciplinary system engineering as a science[5,6]

[5] Von Bertanlaffy (1971). General Sytems Theory.
[6] Wiener (1948). Cybernetics.

ORIGINS OF URBAN MODELLING

Hippodamian System as a development model[7] (Hippodamus of Miletos, 498 BC -408 BC)

- city of 10.000 (free) men,
- up to 50.000 people (including women, children, slaves)

[7] Artistotle, politics II: VIII

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ORIGINS OF URBAN MODELLING

Hippodamian System as a development model[7] (Hippodamus of Miletos, 498 BC -408 BC)

- system of social classes: soldiers, artisans and ‘husbandmen’
- system of land use allocation: sacred, public, private

[7] Artistotle, politics II: VIII

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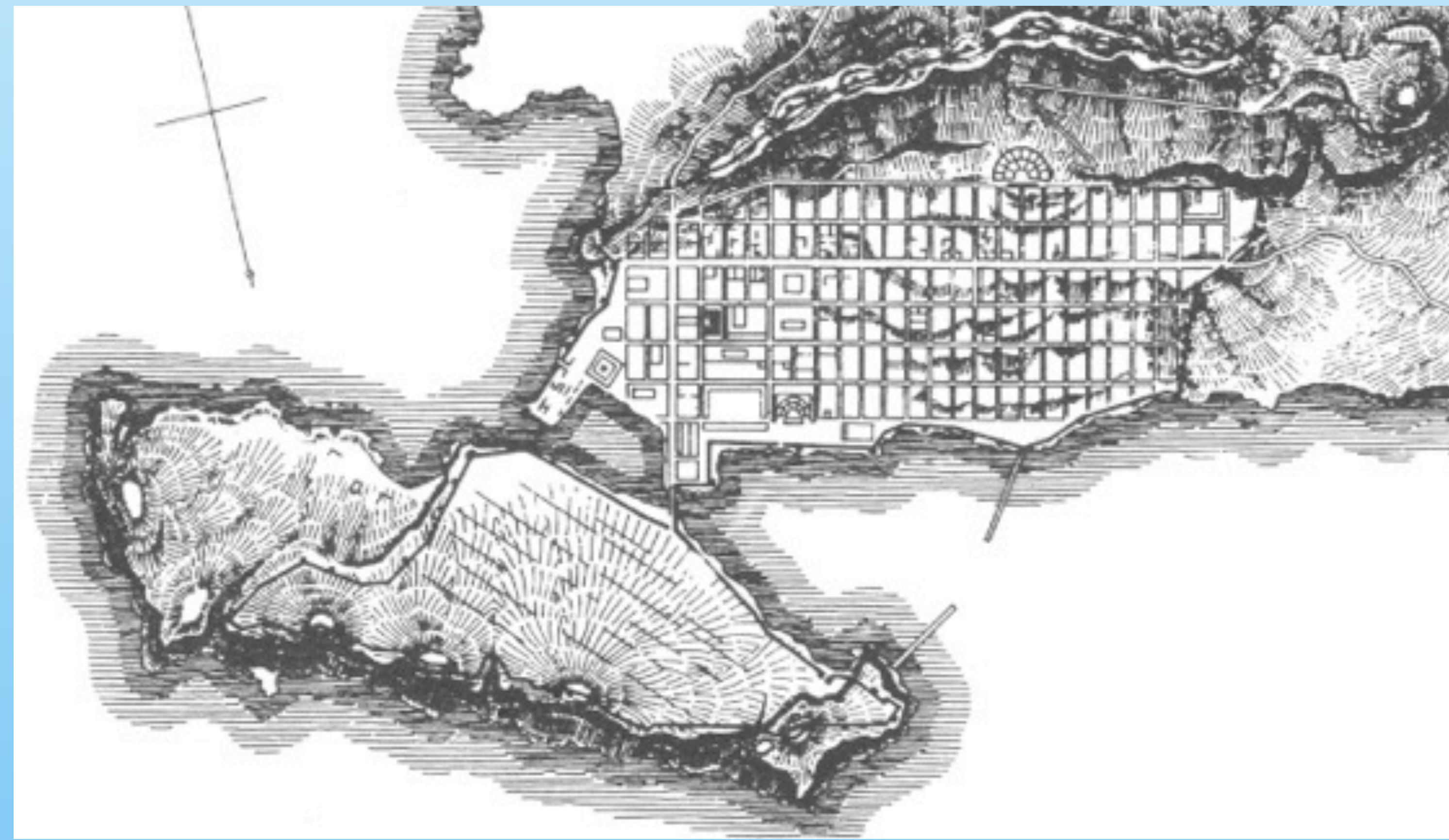
ORIGINS OF URBAN MODELLING

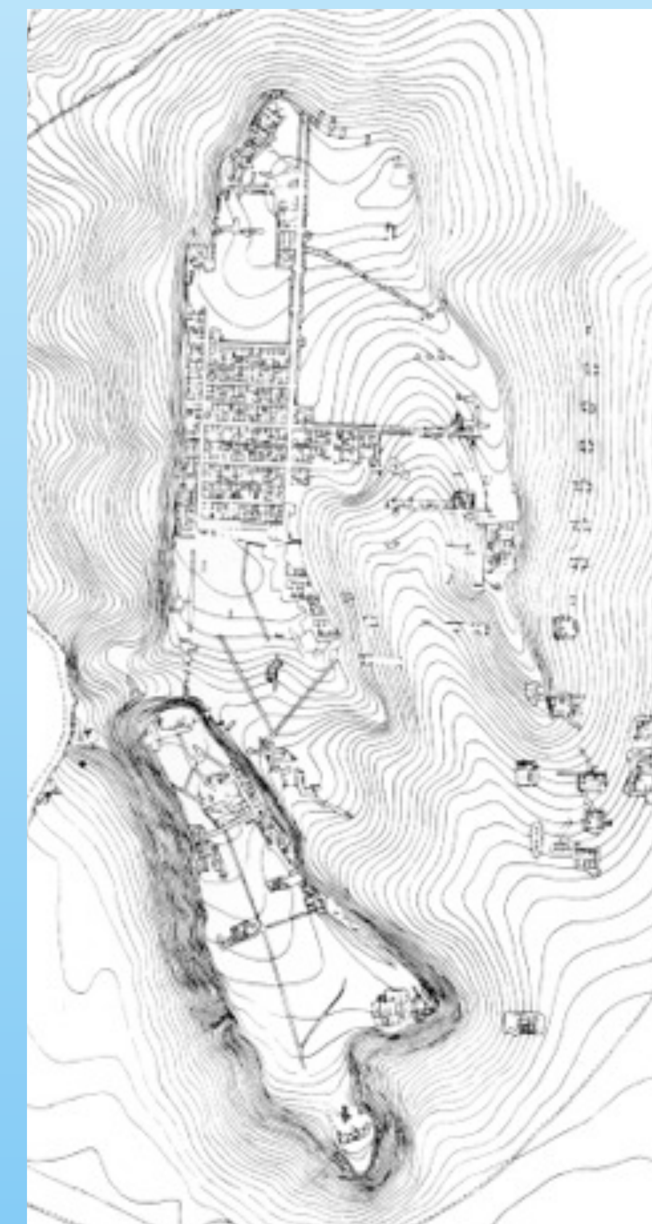
Hippodamian System as a development model[7] (Hippodamus of Miletos, 498 BC -408 BC)



Knidos

[7] Artistotle, politics II: VIII

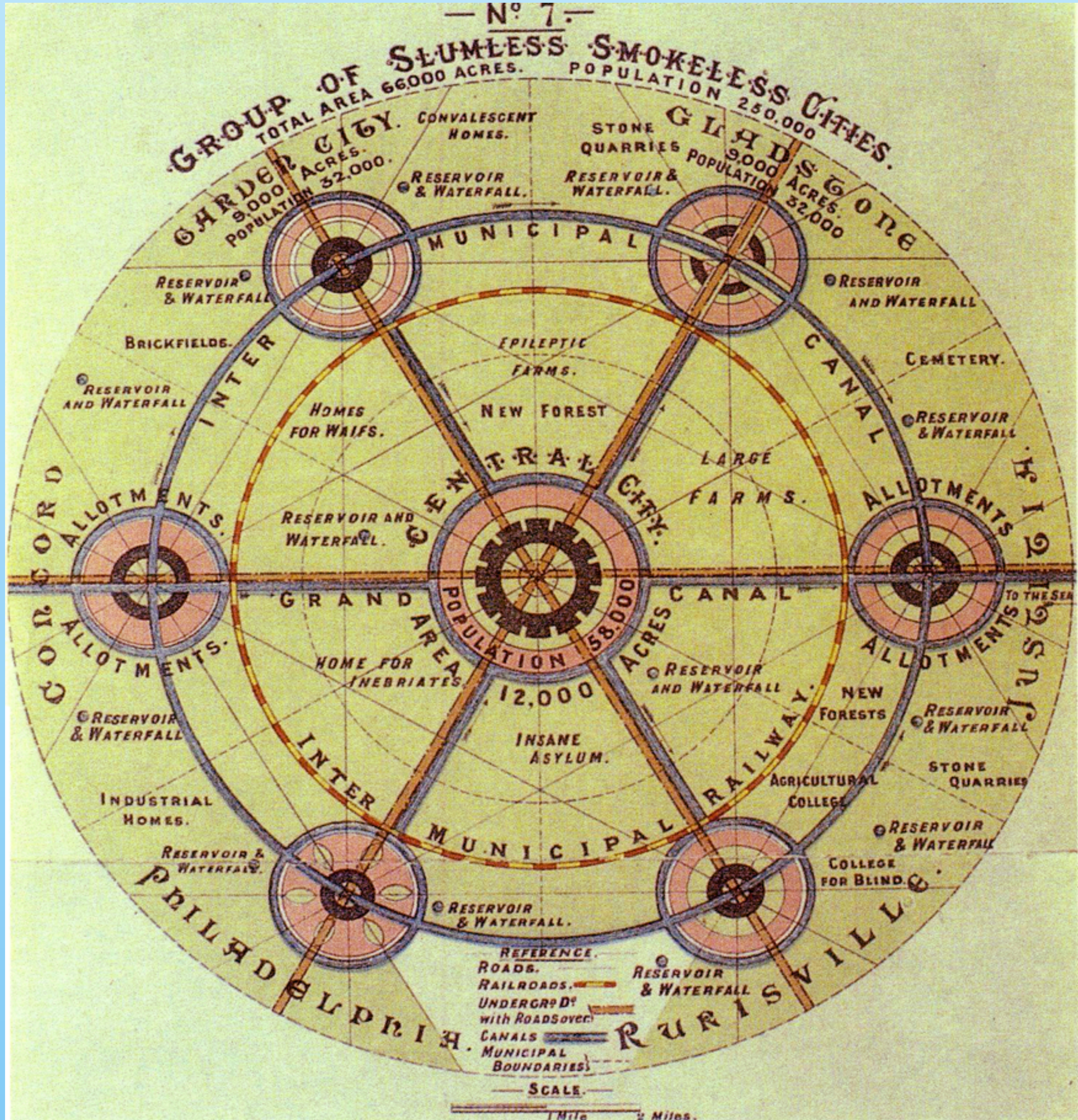
Miletos



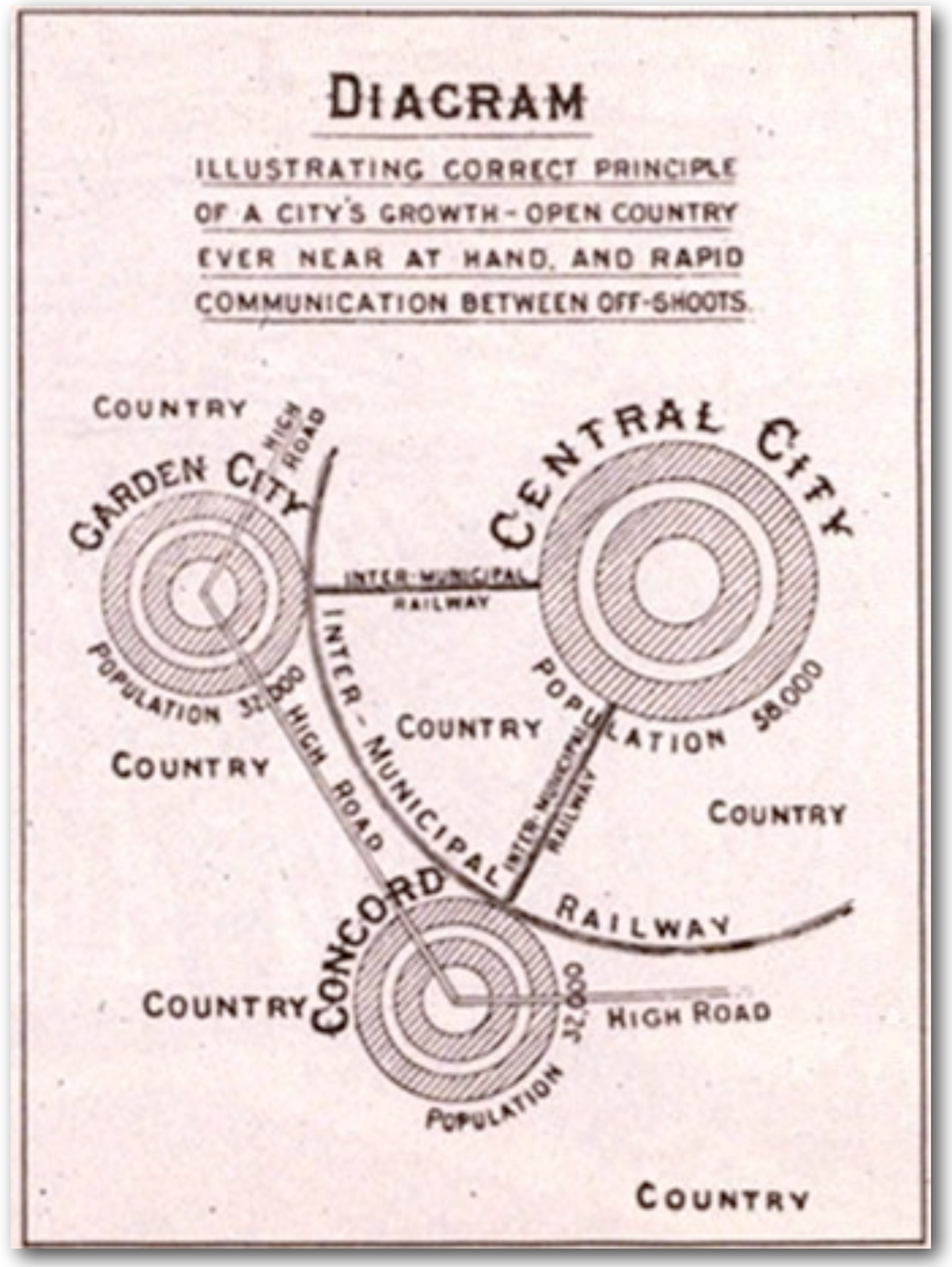
Olynthos

Priene

GARDEN CITY MODEL



Howard (1898). Garden Cities of tomorrow.



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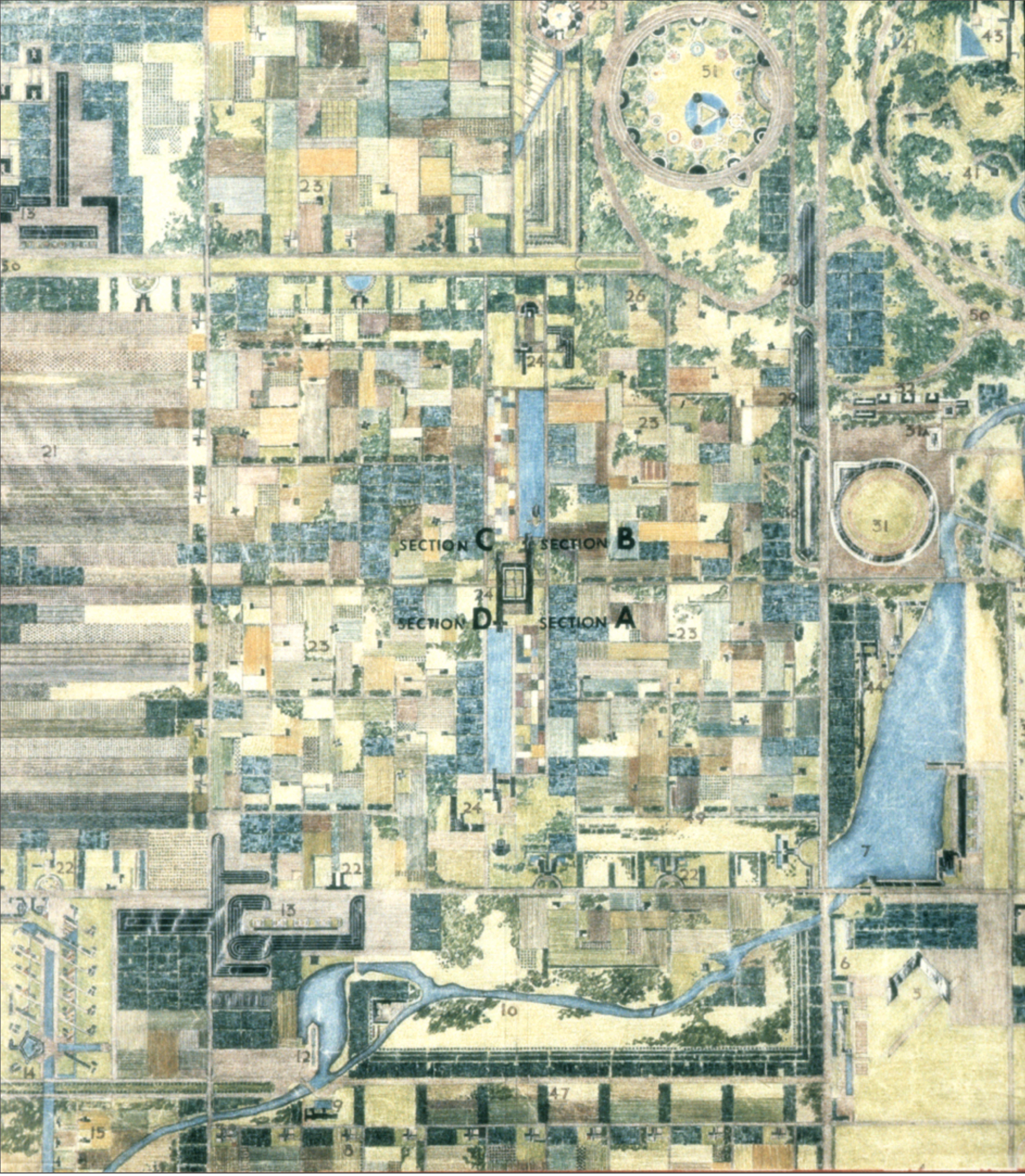
DEVELOPMENT MODELS

Broadacre City Model

(a) antithesis of a city
(b) newly born suburbia
(c) one acre for each family (~4000 sq. m.)
(d) car traffic network



Wright (1932). The Disappearing City.

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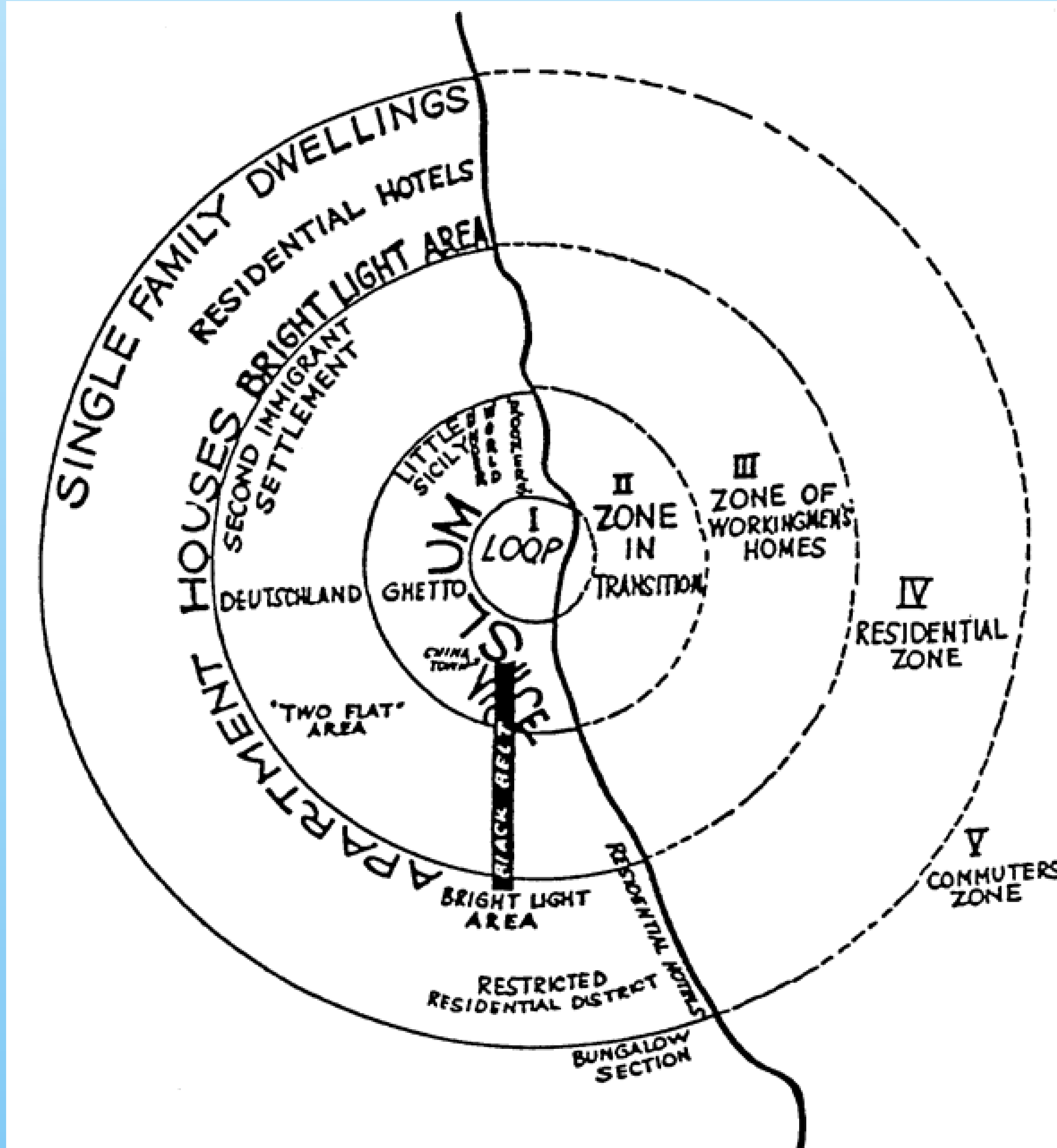
DEVELOPMENT MODELS

Concentric zone model



Burgess et al. (1925).

(a) use area at city center
(b) grow through migration
(c) use an population from center to
  outside zone
(d) zone in transition between center and
outside zone
(e) zones with decreasing density

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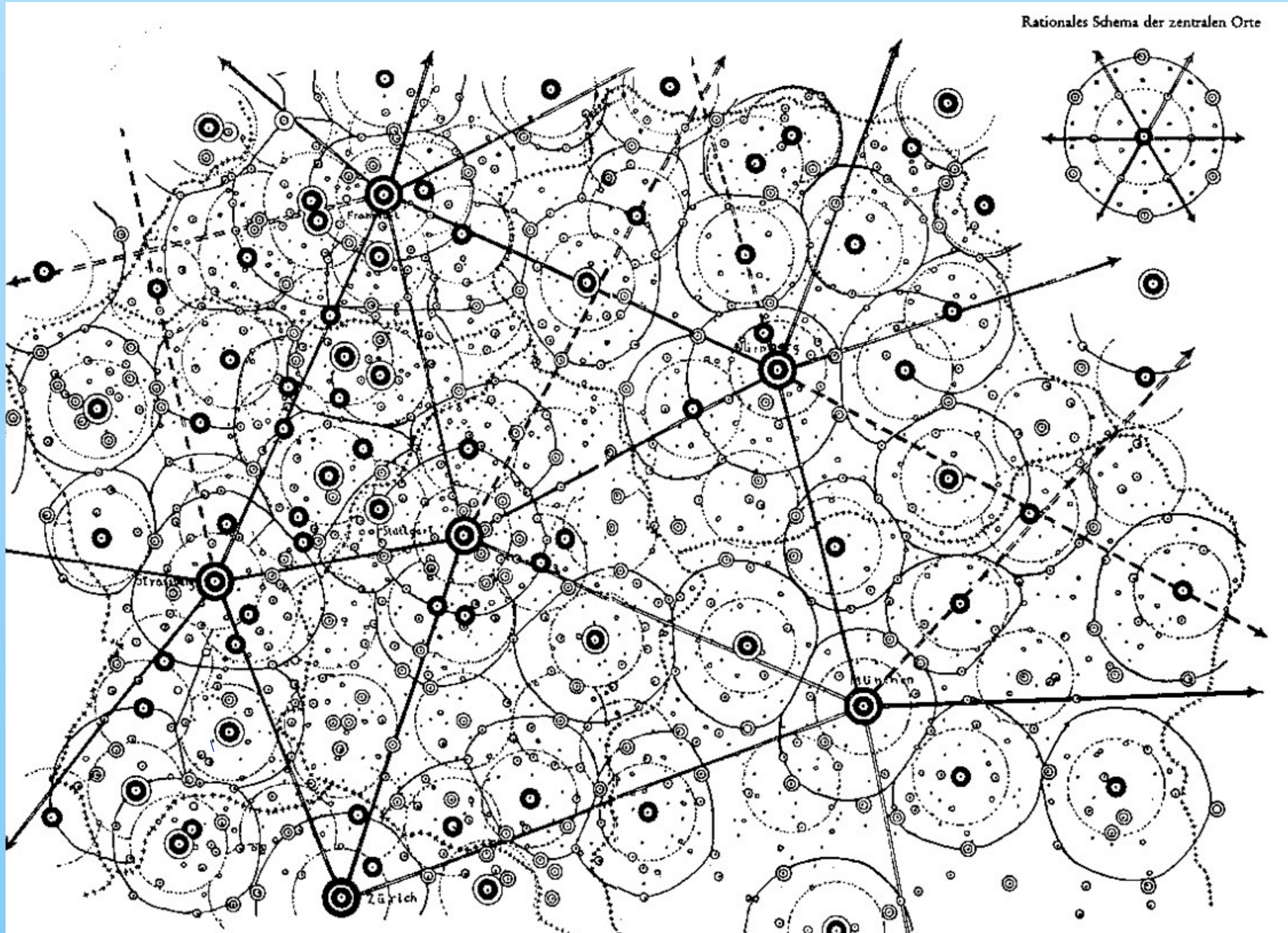
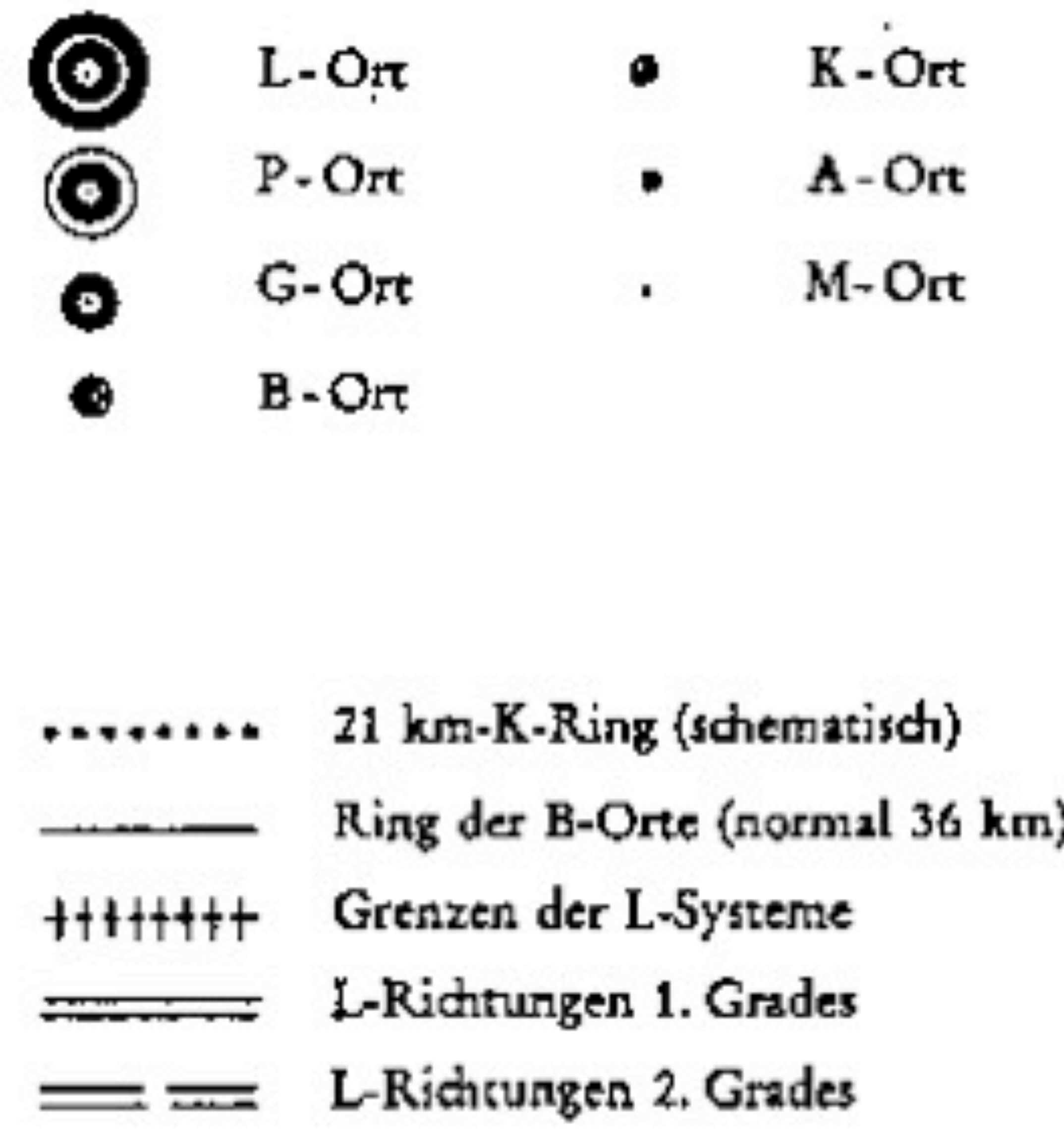
DEVELOPMENT MODELS

Central Place Theory





Christaller (1933).

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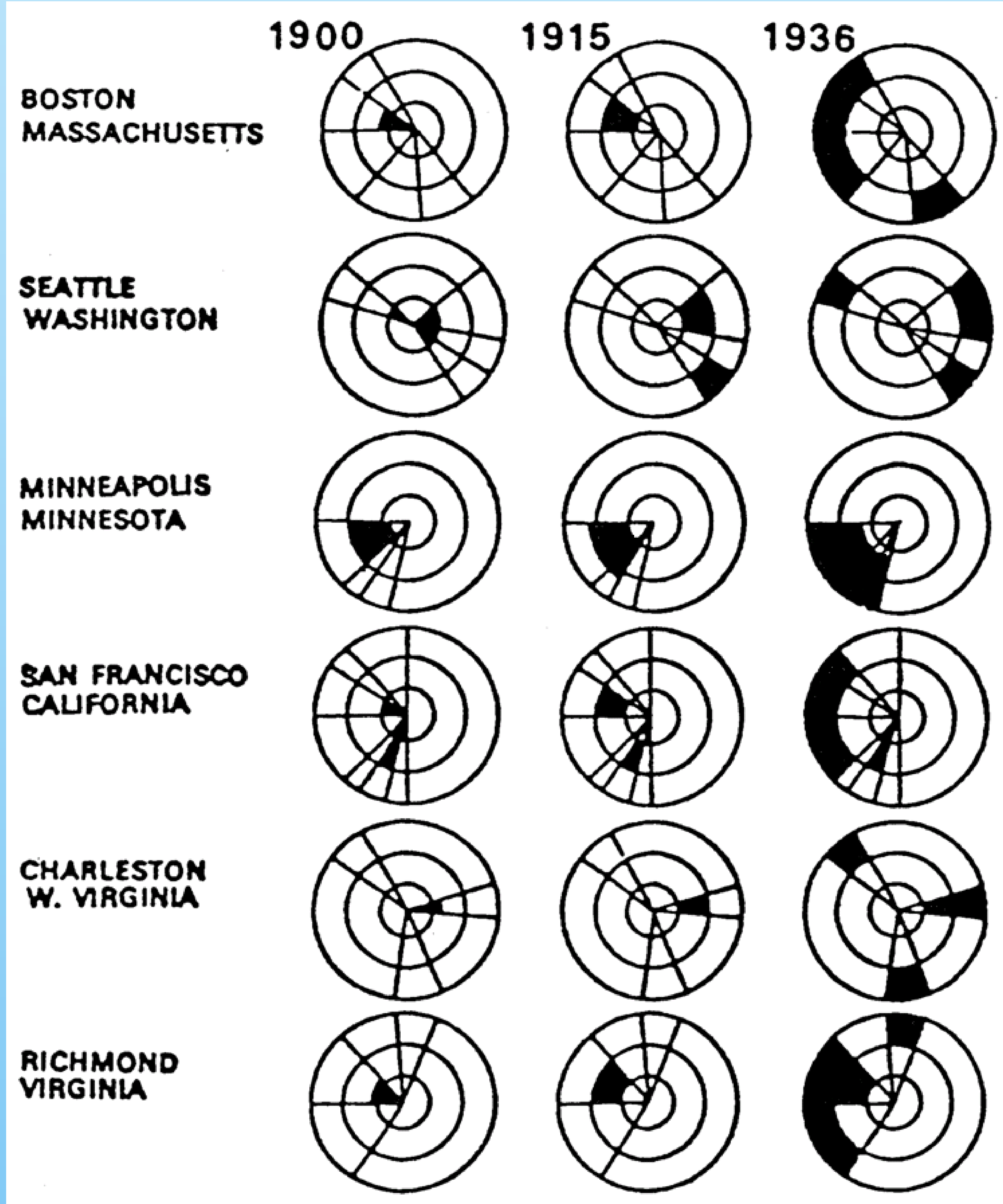
DEVELOPMENT MODELS
Central Place Theory

Optimal locations of production and supply

Given assumptions:

(a) infinite homogene area
(b) no topographic barriers
(c) proportional cost for transport to distance
(d) population with similar income, needs and density
(e) producers and consumers maximize win-win

DEVELOPMENT MODELS



Hoyt. (1939).

Concentric zone model

(a) Starting point: all uses at city centre

(b) high incomes move outside along public transport / streets

(c) low incomes occupy free appartements

(d) high income zones determine city development

(e) different uses around city center

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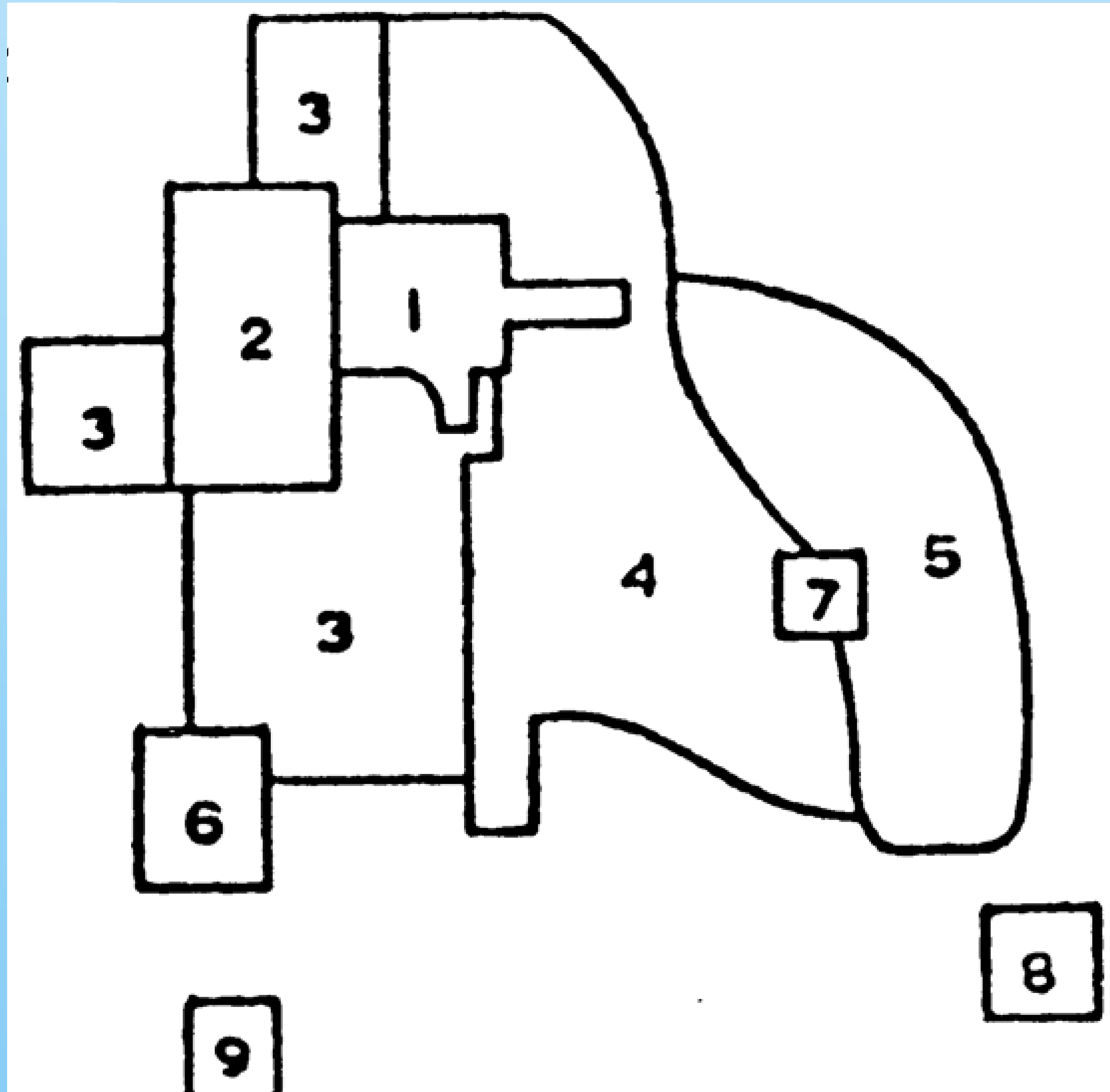
DEVELOPMENT MODELS



Harris and Ulmann. (1945).

Poly centric zone model

(1) CBD
(2) Retail
(3) Residential, low incomes
(4) Residential
(5) Residential, high incomes
(6) industry
(7) sub center
(8) residential suburb
(9) industrial suburb

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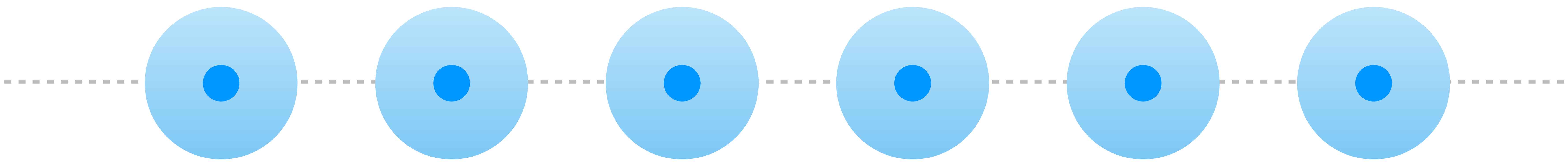
DEVELOPMENT MODELS
Polarized Development

Pre-industrial development



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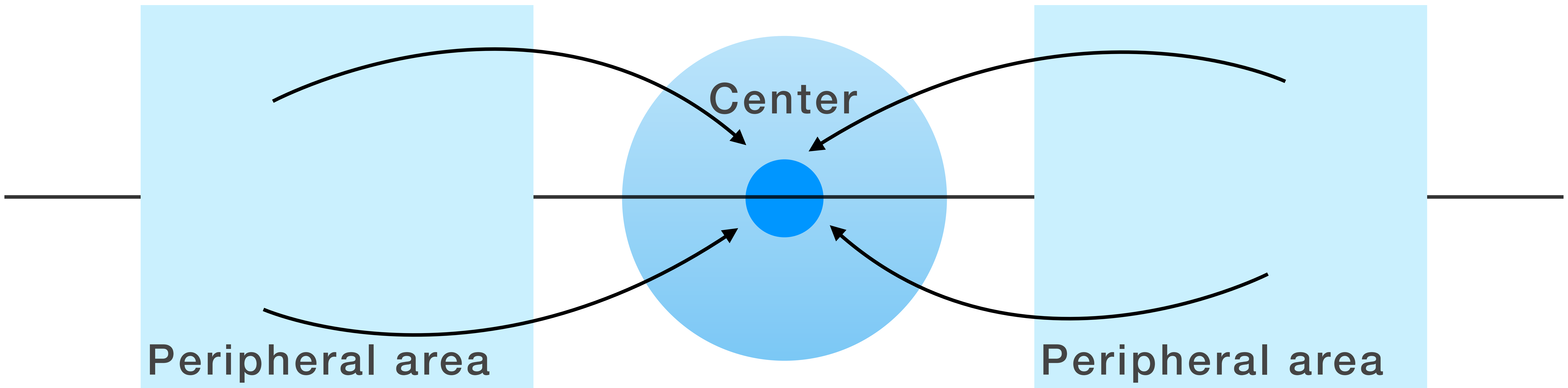
DEVELOPMENT MODELS
Polarized Development

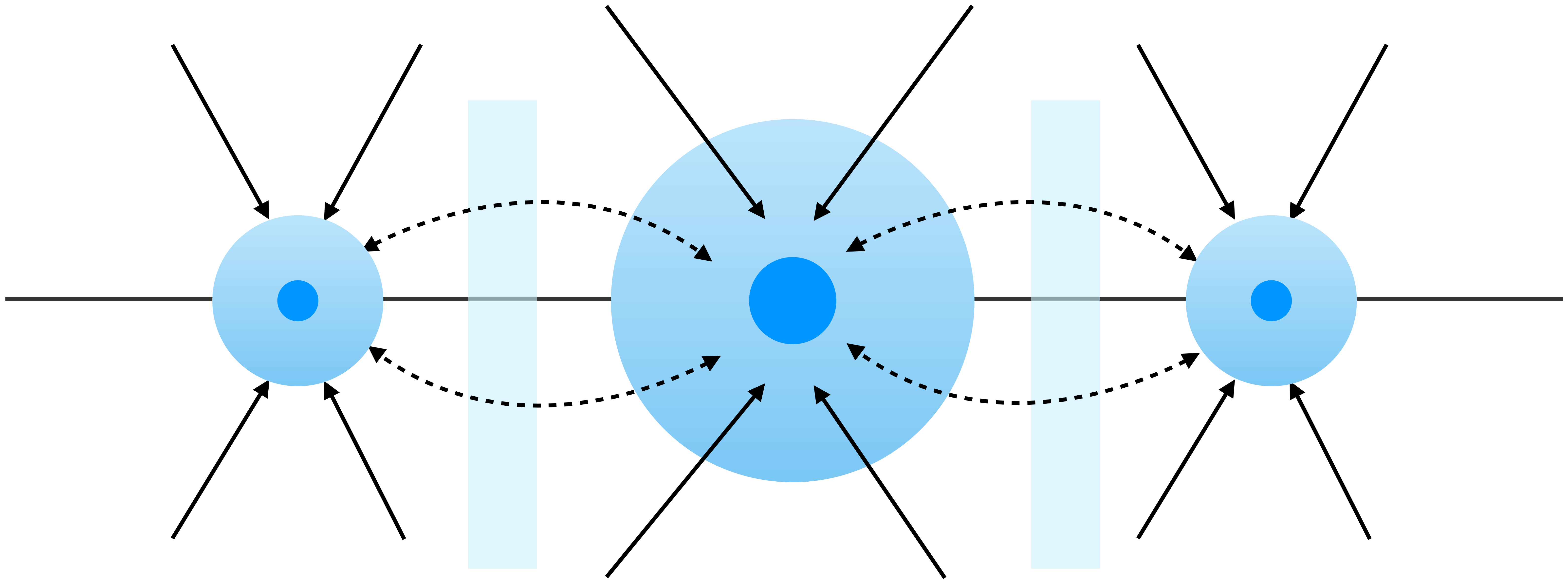
Transitional era development



Friedmann (1972).

DEVELOPMENT MODELS
Polarized Development

Industrial era development

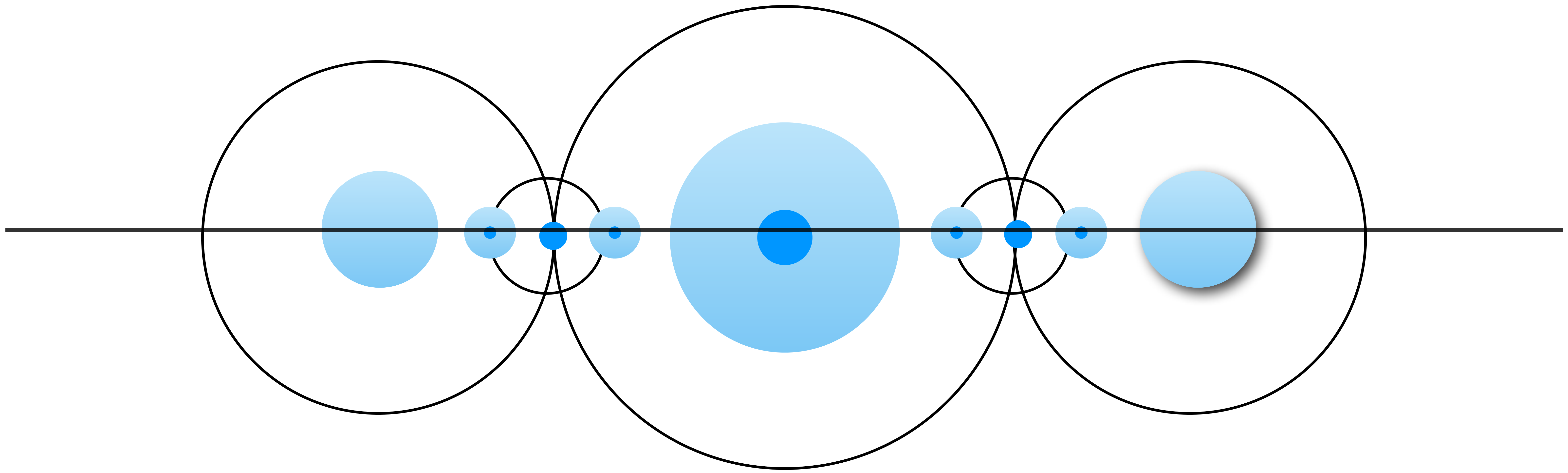


Friedmann (1972).

DEVELOPMENT MODELS

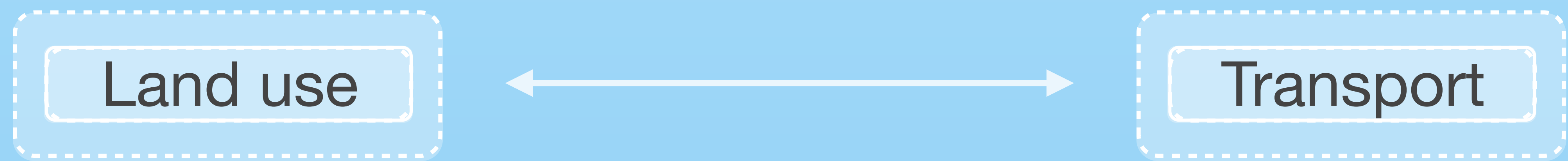
Polarized Development

Postindustrial development



Friedmann (1972).

LAND-USE TRANSPORT MODELS



(I) Spatial development, land use determines the need for spatial interaction.
(II) Spatial interaction, transport provides accessibility.
(III) Spatial interaction determines spatial development.

LAND-USE TRANSPORT MODELS

Difficult to isolate land use from transport through multitude of concurrent changes. Methods for predicting impacts:

(a) data from interviews with inhabitants scenarios like change of locations through increased transport costs, land use regulations
(b) conclusions from observed decisions ('revealed preference')
(c) simulate human decision behaviour in mathematical models

Wegener (2004). Transport Geography and Spatial Systems.

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MATHEMATICAL LAND-USE TRANSPORT MODELS

(a) based on empirical surveys
(b) conclusion are quantified
(c) results no more universally valid than empirical studies

Wegener (2004). Transport Geography and Spatial Systems.

LAND-USE TRANSPORT MODELS

Urban change process

(I) Very slow changes: Urban transport, communications and utilities
(II) Slow changes: Workplaces, housing
(III) Fast changes: Employment, population
(IV) Immediate changes: goods transport, travel

Wegener (2004). Transport Geography and Spatial Systems.

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LAND-USE TRANSPORT MODELS

9 urban subsystems
(grouped to speed of change)

Very slow changes: Urban transport, communications and utilities
Slow changes: Workplaces, housing
Fast changes: Employment, population
Immediate changes: Goods transport, travel
Complex: Urban environment

Wegener (2004). Transport Geography and Spatial Systems.

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LAND-USE TRANSPORT MODELS

Urban environment (human activities)

(a) immediate: transport noise, air pollution

(b) long-term: water or soil contamination

(c) very slow: effects to climate

Wegener (2004). Transport Geography and Spatial Systems.

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LAND-USE TRANSPORT MODELS

Urban subsystems are market driven and only partly subject to policy regulation.

Wegener (2004). Transport Geography and Spatial Systems.

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LAND-USE TRANSPORT MODELS

1950s: First efforts to study interrelationships between transport and spatial development of cities.

Example Washington, DC:

(a) locations with high access have higher chances to be developed
(b) trip and location decisions co-determine each other
(c) result: land-use transport feedback cycle

Wegener (2004). Transport Geography and Spatial Systems.

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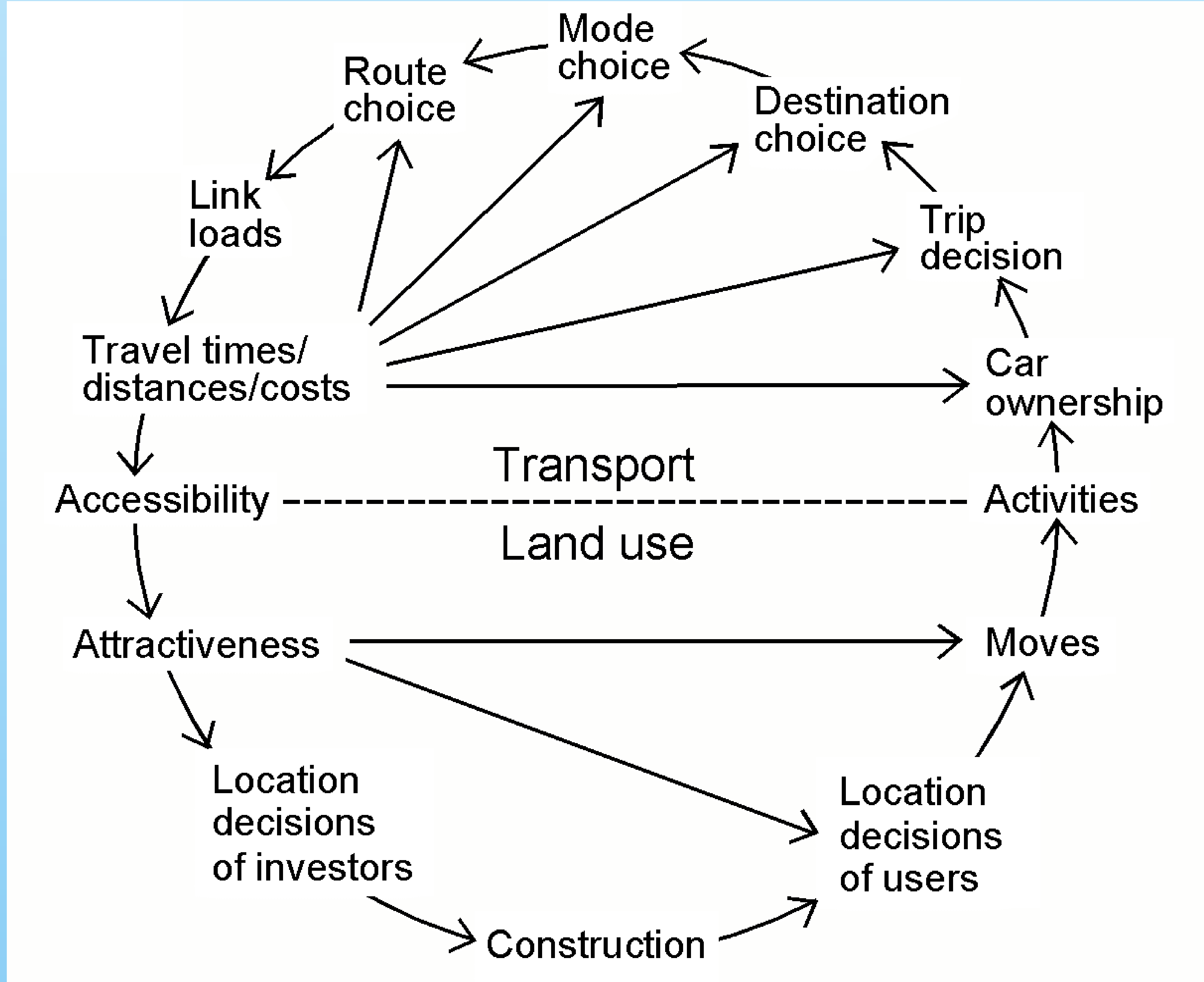
LAND-USE TRANSPORT FEEDBACK CYCLE



7 Wegener (2004).

LAND-USE TRANSPORT FEEDBACK CYCLE

Lowry (1964): Model of Metropolis first attempt of an operational model.

(a) residential location model

(b) service and retail employment location model

(c) stimulation for complex modelling approaches

Hansen (1959). Transport Geography and Spatial Systems.

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LAND-USE TRANSPORT FEEDBACK CYCLE

Contemporary models

(a) approximately 20 models in use
(b) at least 2 of urban subsystems incorporated
(c) only a few integrates 8 subsystems
(d) urban environment (architectural level) mainly neglected

Wegener (2004).

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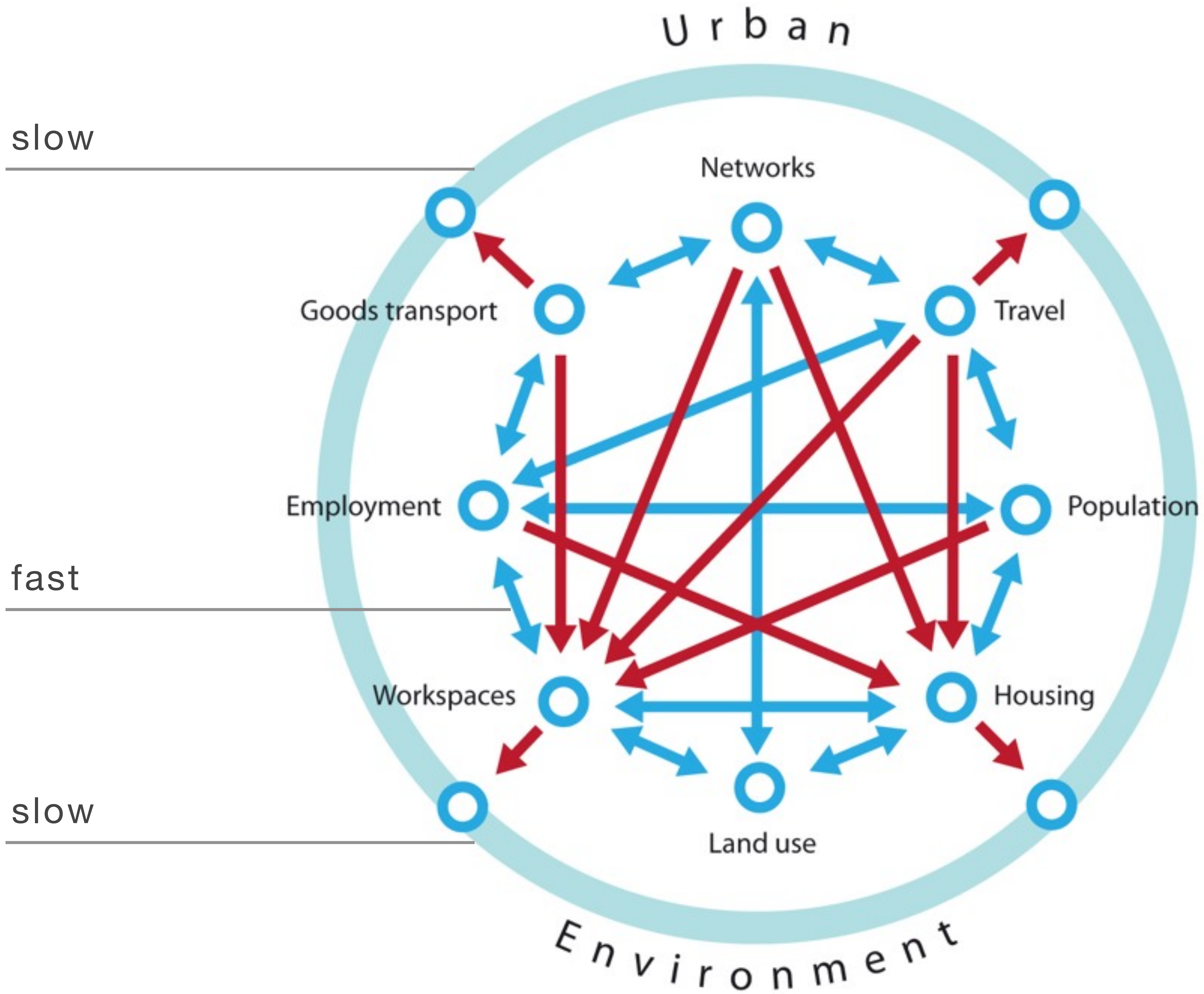
LAND-USE TRANSPORT MODELS

Contemporary models

Models	Speed of change: Very slow		Slow		Fast		Immediate	
	Networks	Land use	Work-places	Housing	Employ-ment	Popula-tion	Goods transport	Travel
BOYCE	+				+	+		+
CUFM	(+)	+	+	+	+	+		(+)
DELTA	(+)	+	+	+	+	+		(+)
ILUTE	+	+	+	+	+	+	+	+
IMREL	+	+	+	+	+	+		+
IRPUD	+	+	+	+	+	+		+
ITLUP	+	+			+	+		+
KIM	+				+	+	+	+
LILT	+	+	+	+	+	+		+
MEPLAN	+	+	+	+	+	+	+	+
METROSIM	+	+	+	+	+	+		+
MUSSA	(+)			+	+	+		(+)
PECAS	+	+	+	+	+	+	+	+
POLIS	(+)	+			+	+		(+)
RURBAN	(+)	+			+	+		(+)
STASA	+	+	+	+	+	+	+	+
TLUMIP	+	+	+	+	+	+	+	+
TRANUS	+	+	+	+	+	+	+	+
TRESIS	+	+	+	+	+	+		+
URBANSIM	(+)	+	+	+	+	+		(+)

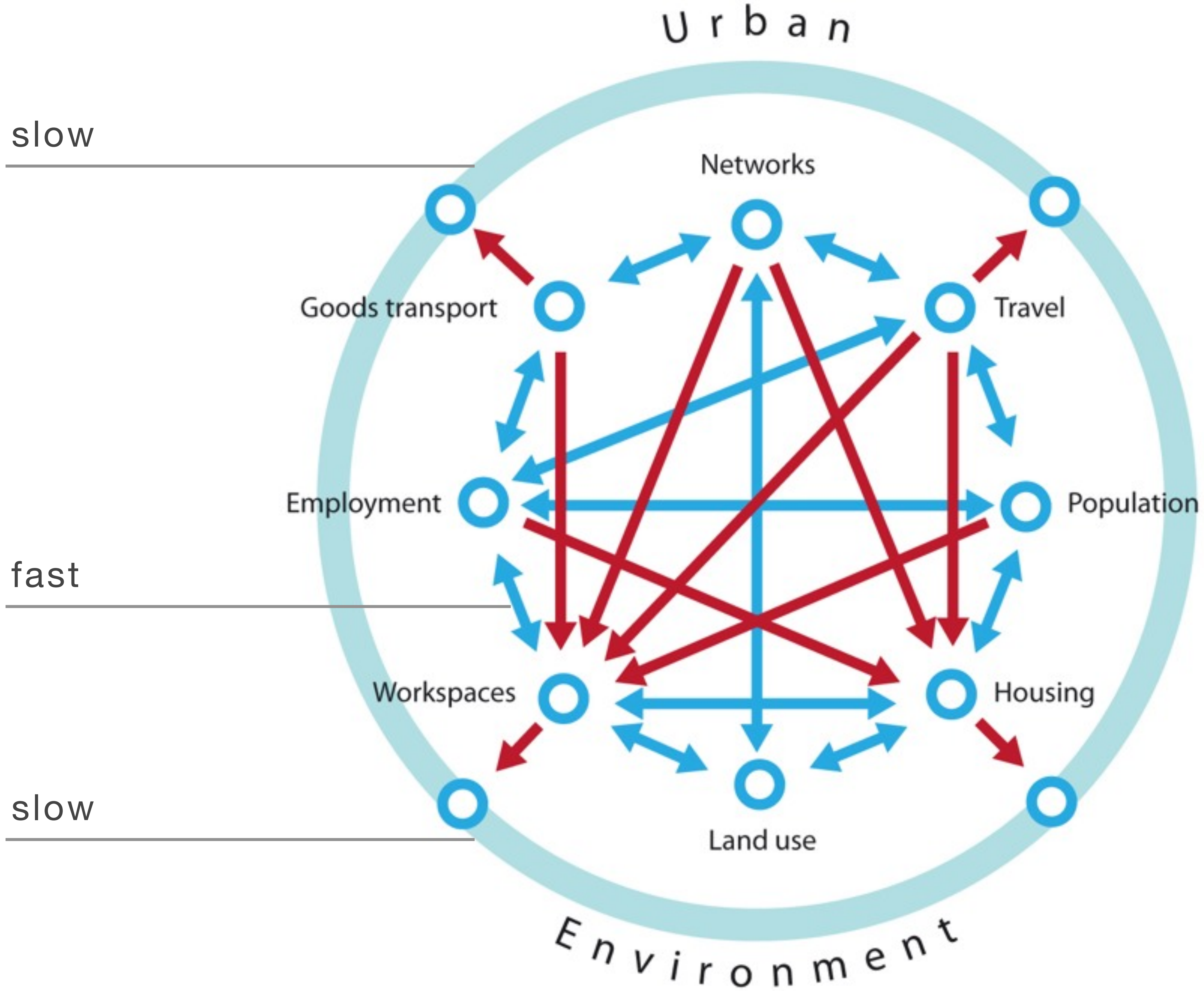
WEGENER'S MODEL FOR URBAN ENVIRONMENTS[4]

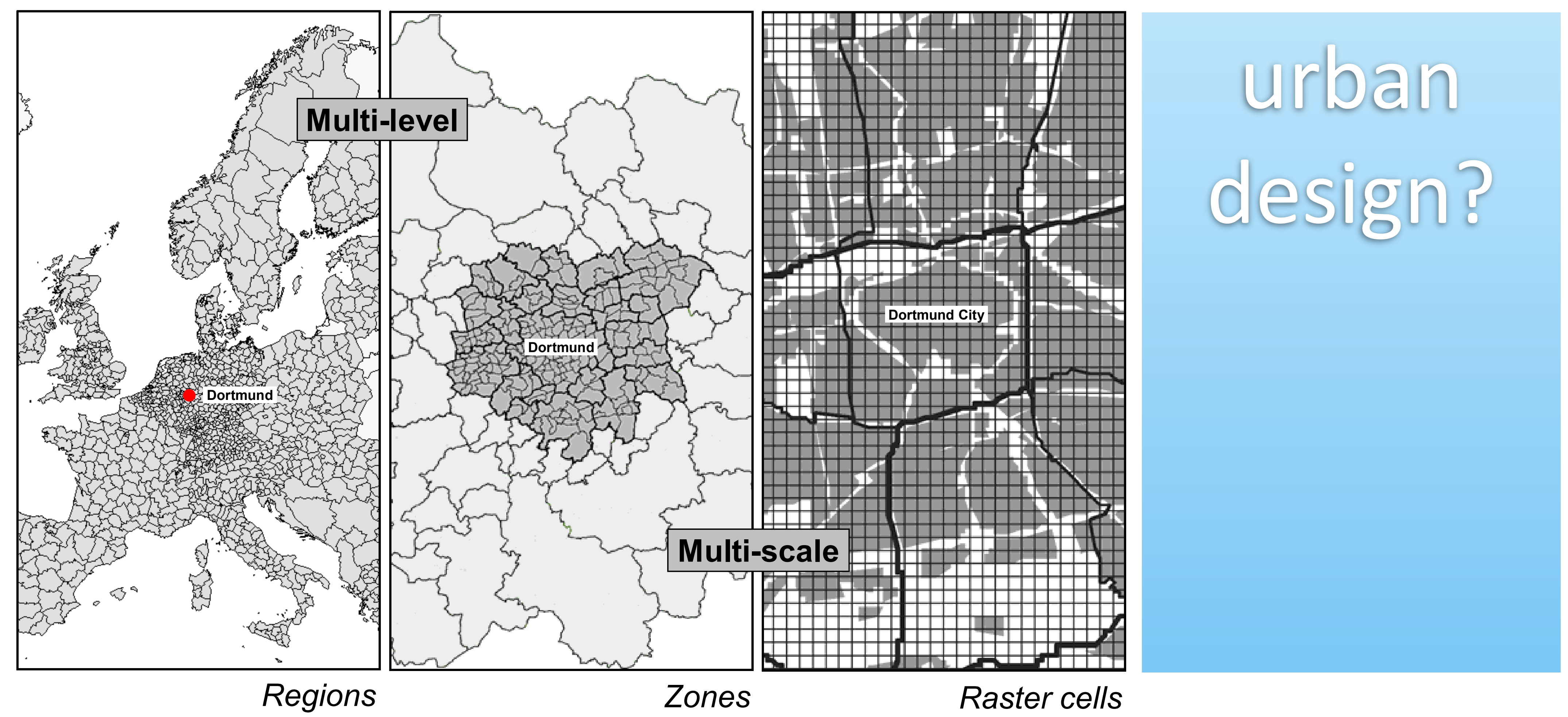


(a) Mathematical and statistical models
(b) Analysis of existing structures
(c) Prediction of structures
(d) Detection of successful city patterns (spatial relationships)
(e) Results: abstract GIS that can help regional planners

[4] Wegener (1994, 2009).

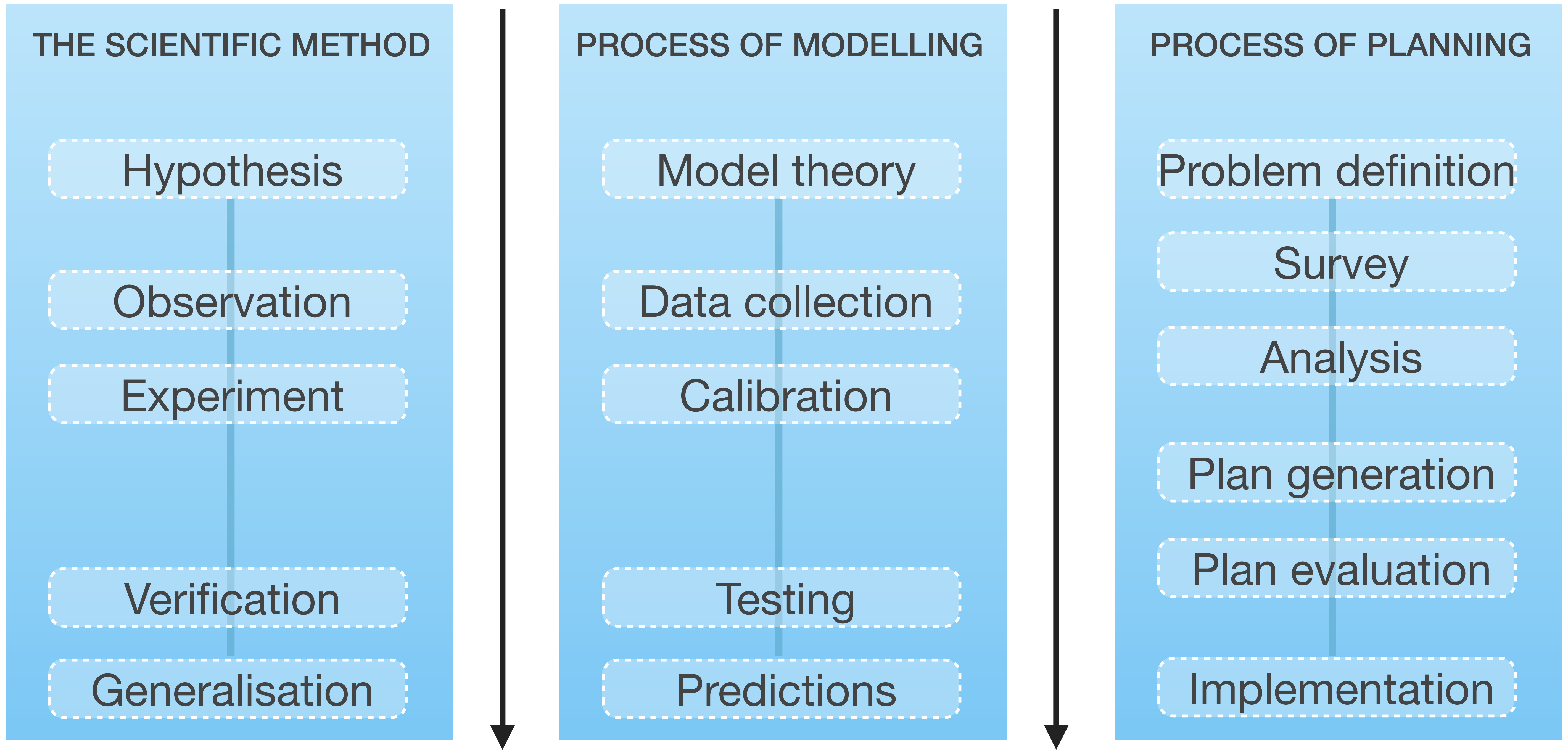
WEGENER'S MODEL FOR URBAN ENVIRONMENTS[4]





[4] Wegener (1994, 2009).

MODEL DESIGN AND PLAN DESIGN[4]



[4] Batty (1976). Urban Modelling.

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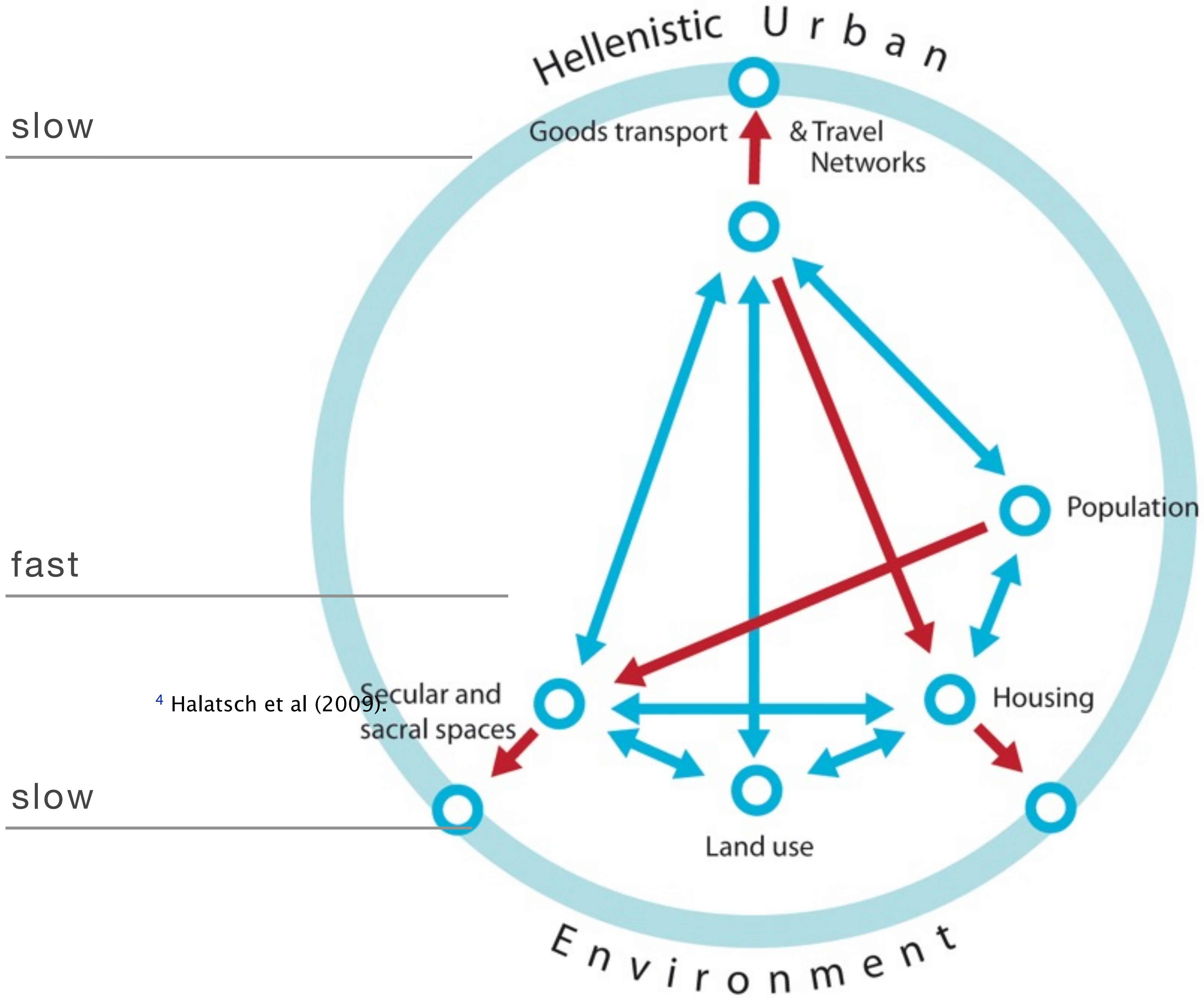
SIMPLIFICATION OF WEGENER'S SYSTEM FOR 3D CITY MODELLING



[4] Halatsch et al (2009).

- generation functions
- patterns: statistical properties
- patterns: design properties
- patterns: spatial properties

[4] Halatsch et al (2009).

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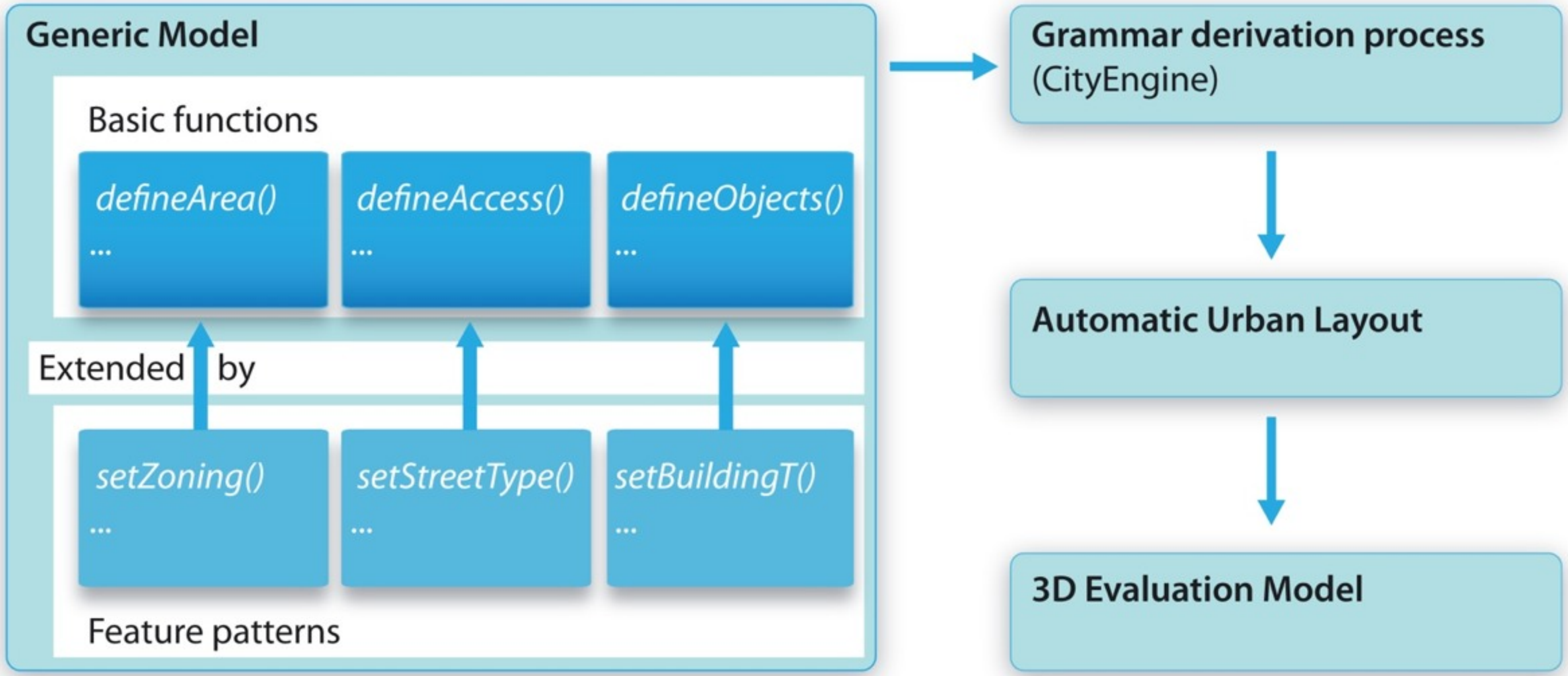
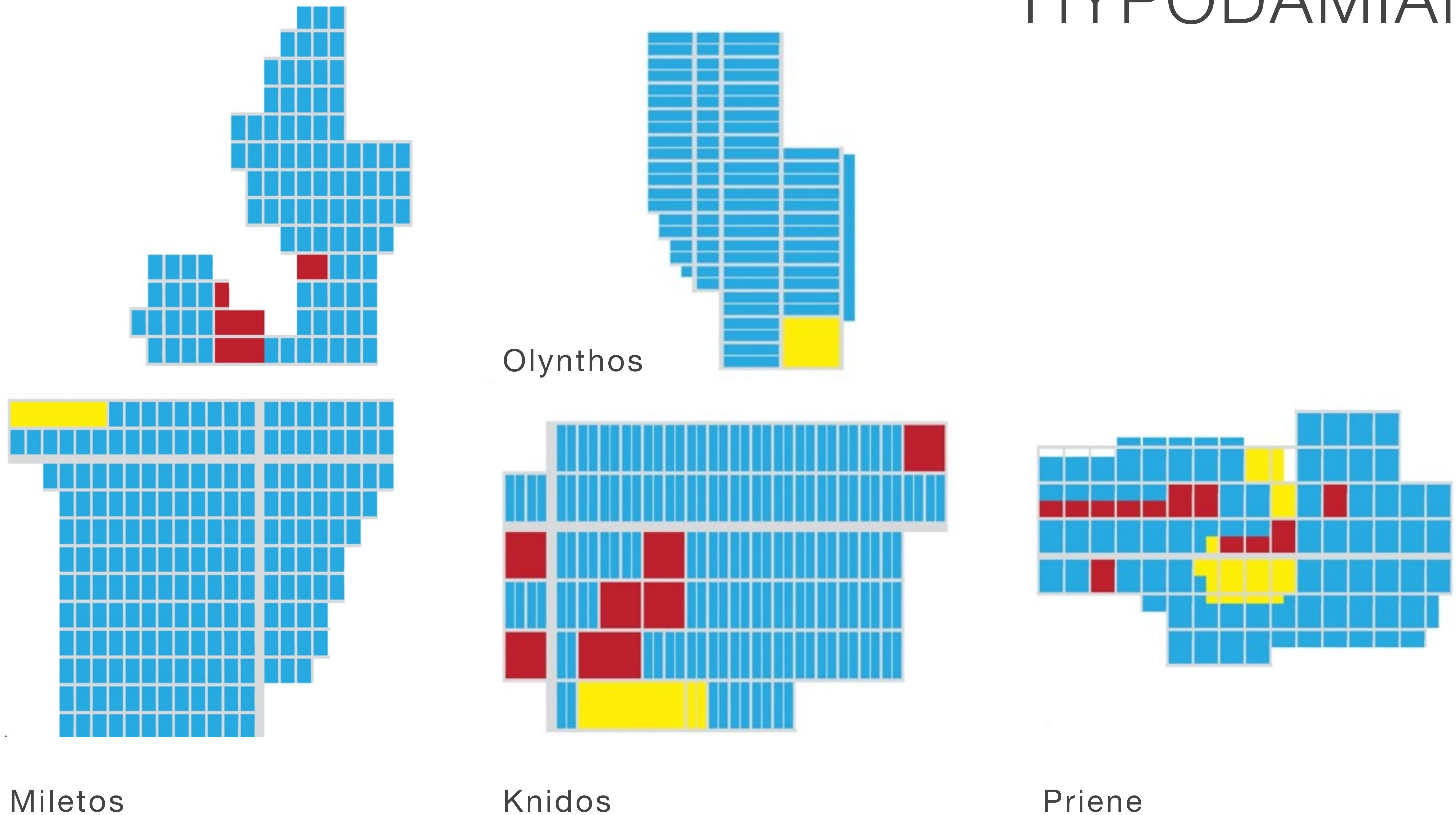
SIMPLIFICATION OF WEGENER'S SYSTEM FOR 3D CITY MODELING



[4] Halatsch et al (2009).

COMPUTED LAYOUTS BASED ON THE HYPODAMIAN PRINCIPLES



[7] Halatsch, et al. (2009).
The Hellenistic city model inspired by Koolhaas: A test case for a generic city model.

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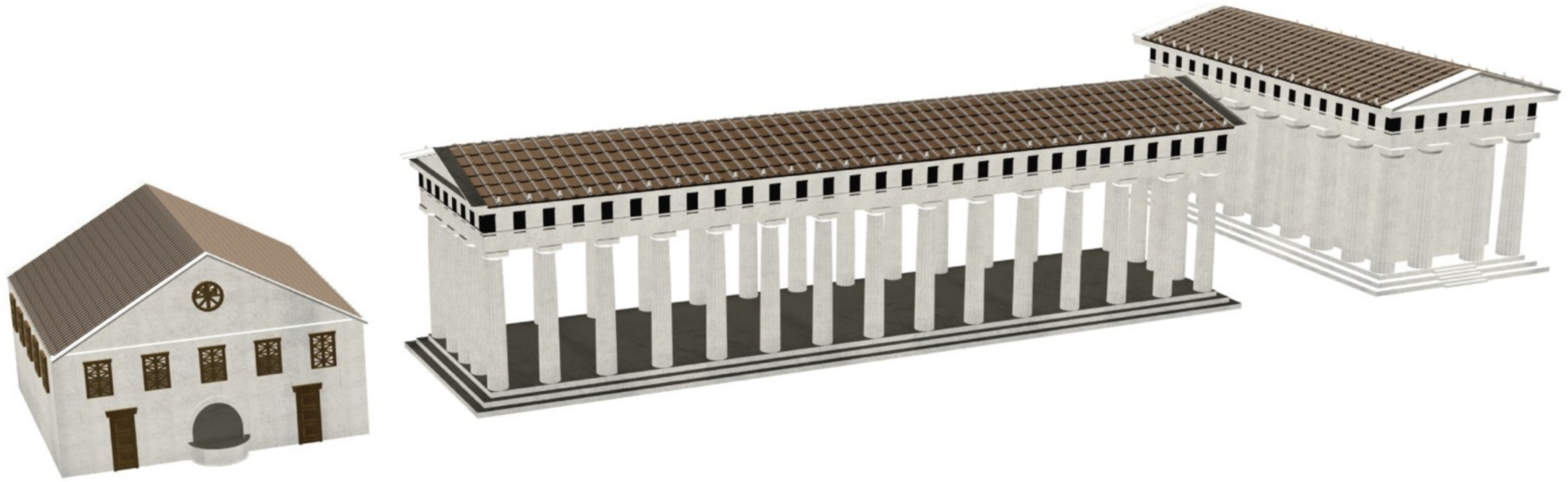

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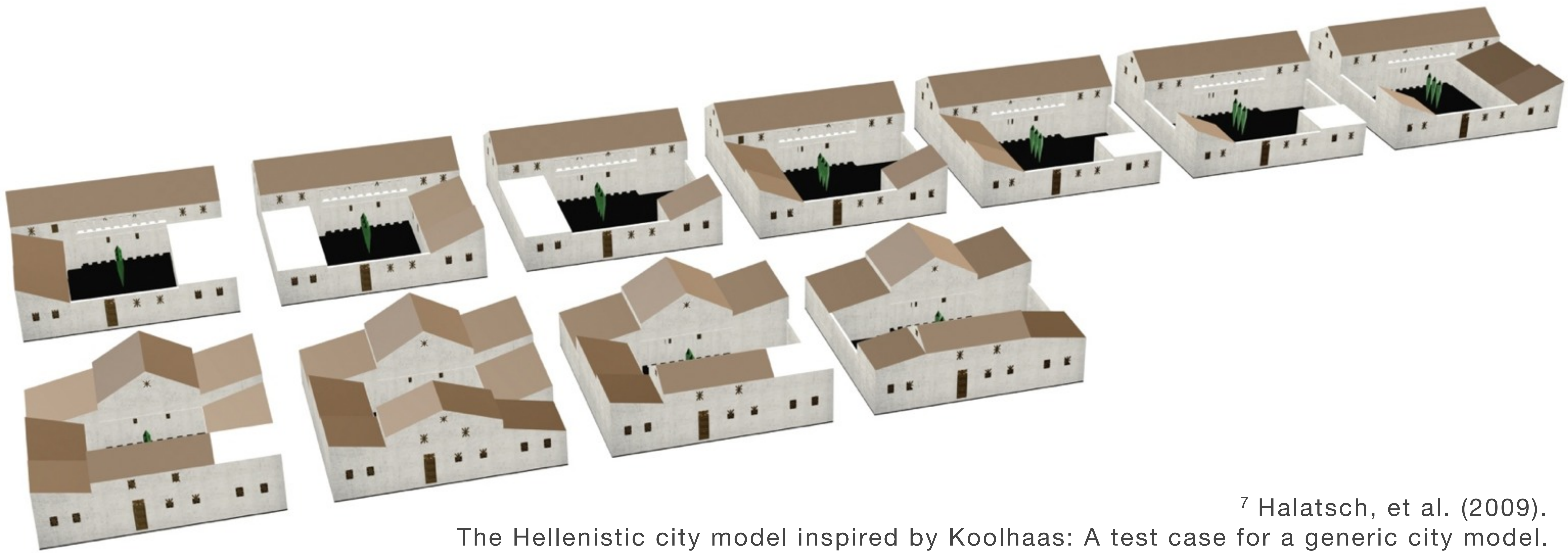

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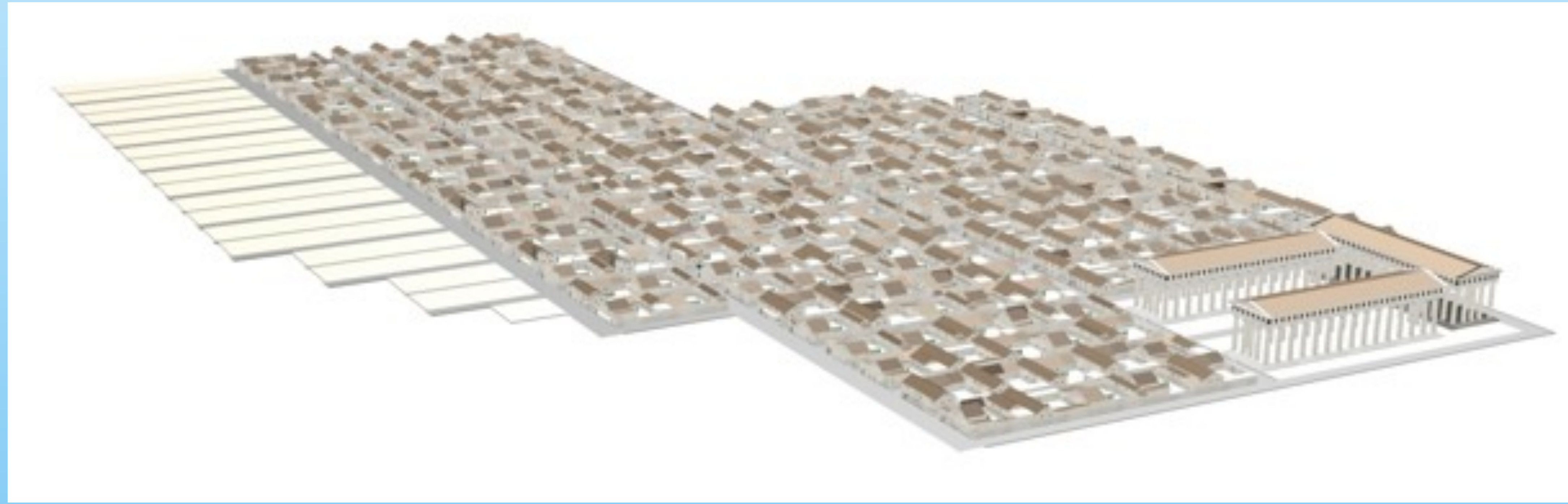
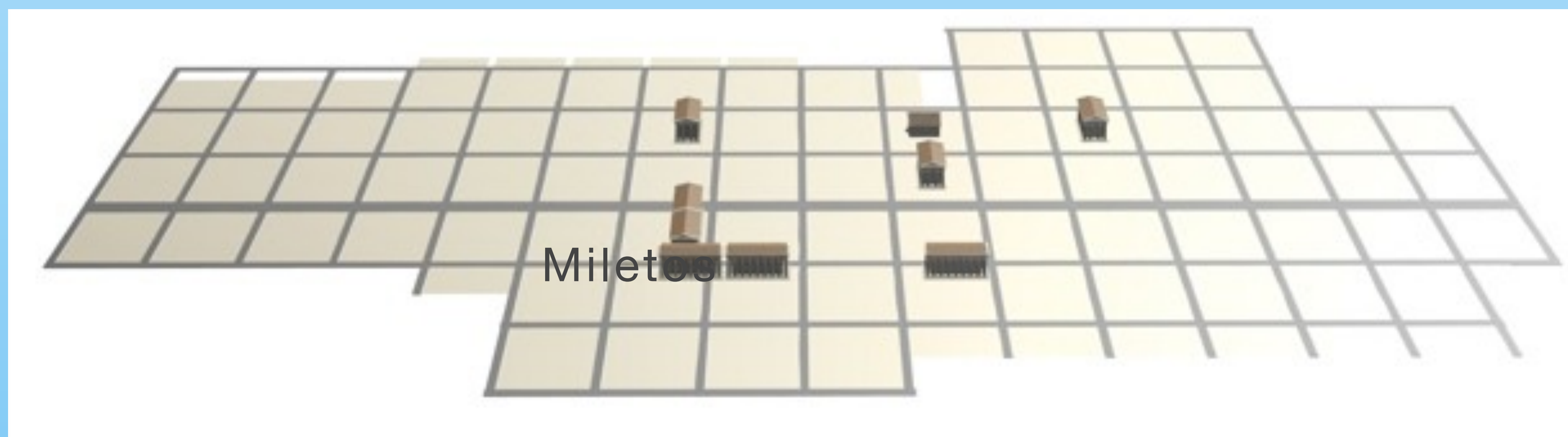


Olynthos

Knidos



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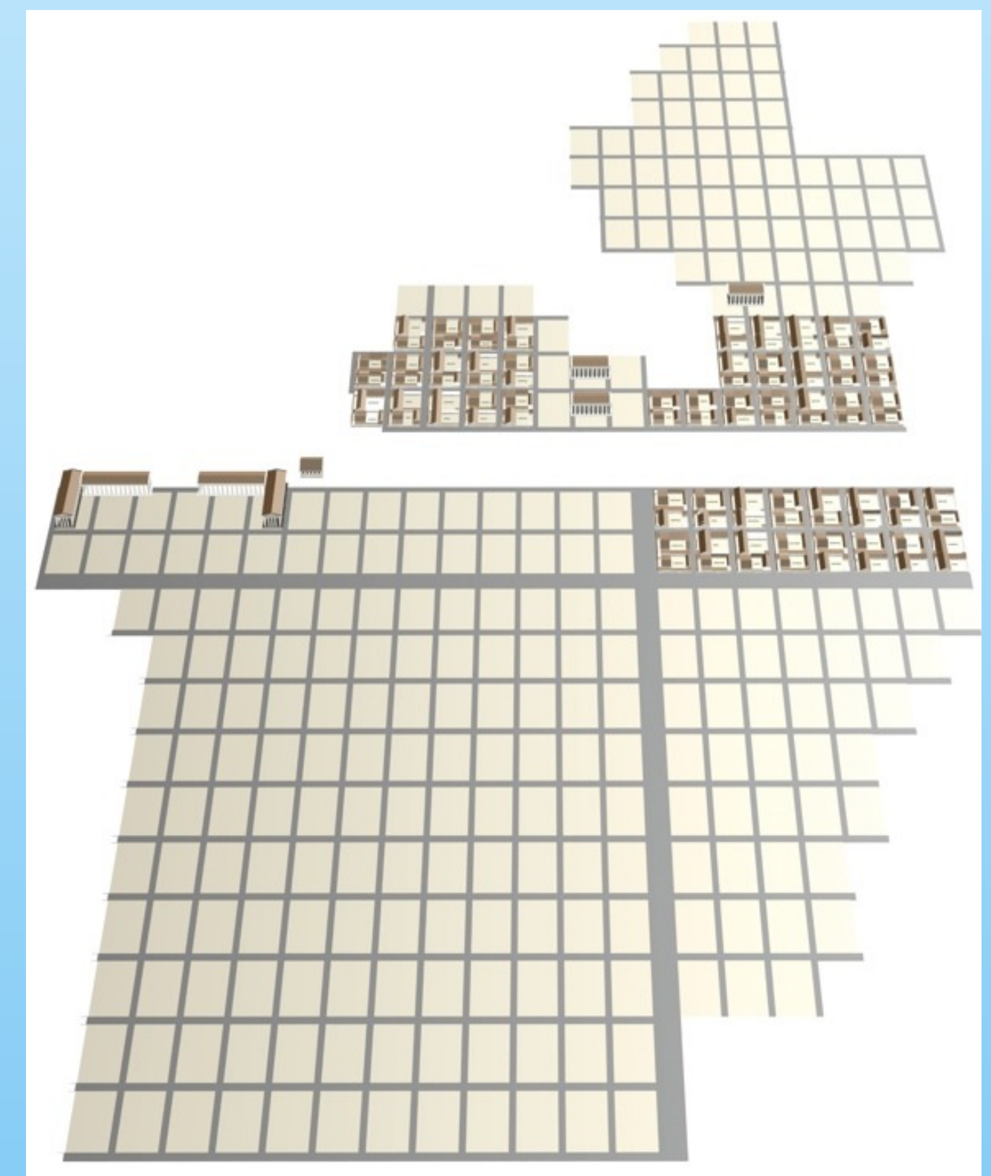

Miletos

[7] Halatsch, et al. (2009).

TARGET: COLLABORATIVE URBAN REQUIREMENT DEFINITION

Possible results of urban models

Definition of urban planning scenaria

Feedback for stakeholders

Resulting performance indicators help to understand and evaluate a certain design proposal or strategy

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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Urban Modeling

Urban Simulation

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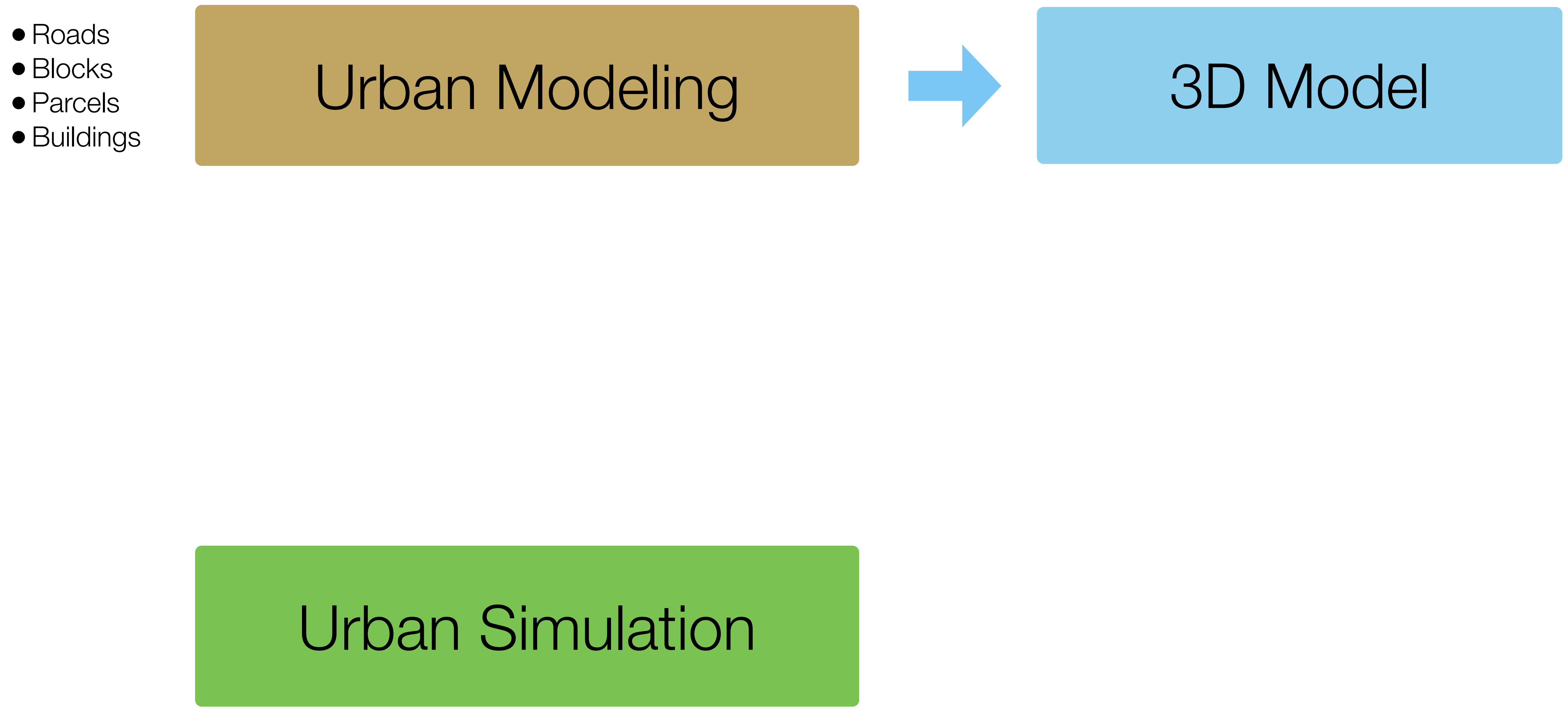
BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING



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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

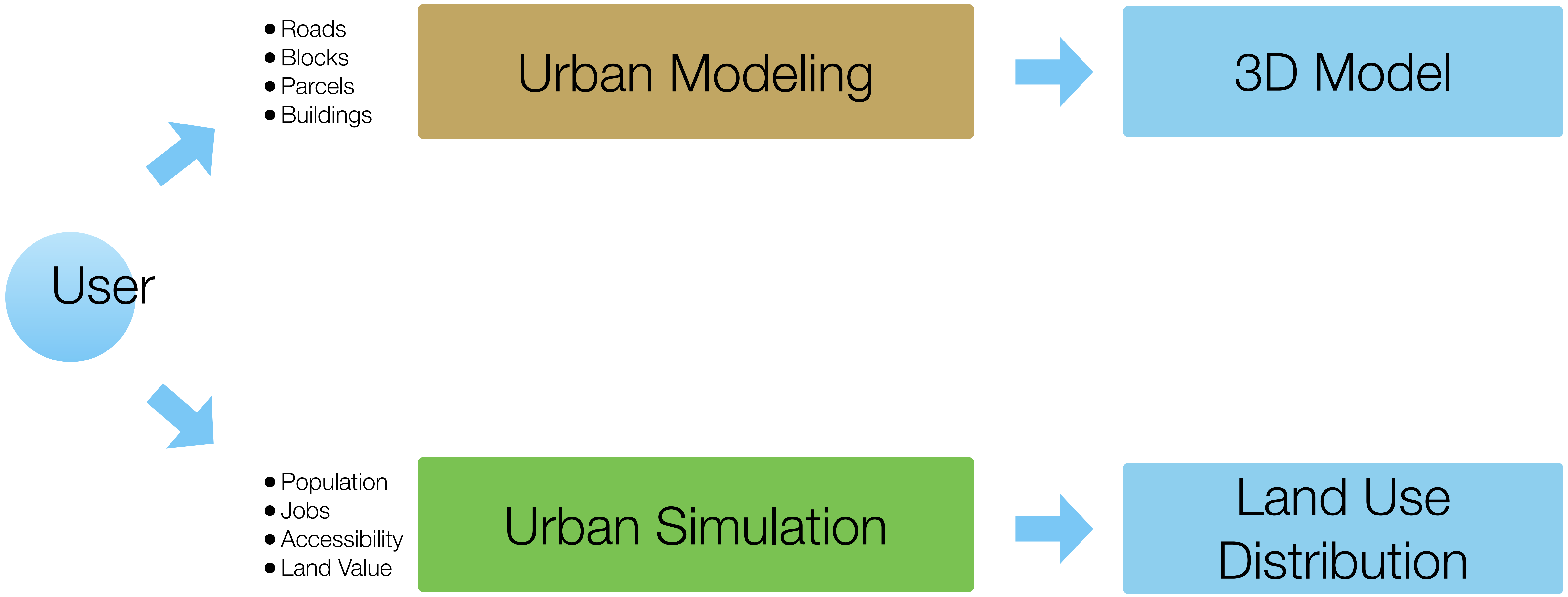
- Roads
- Blocks
- Parcels
- Buildings

Urban Modeling → 3D Model

- Population
- Jobs
- Accessibility
- Land Value

Urban Simulation → Land Use Distribution

BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING



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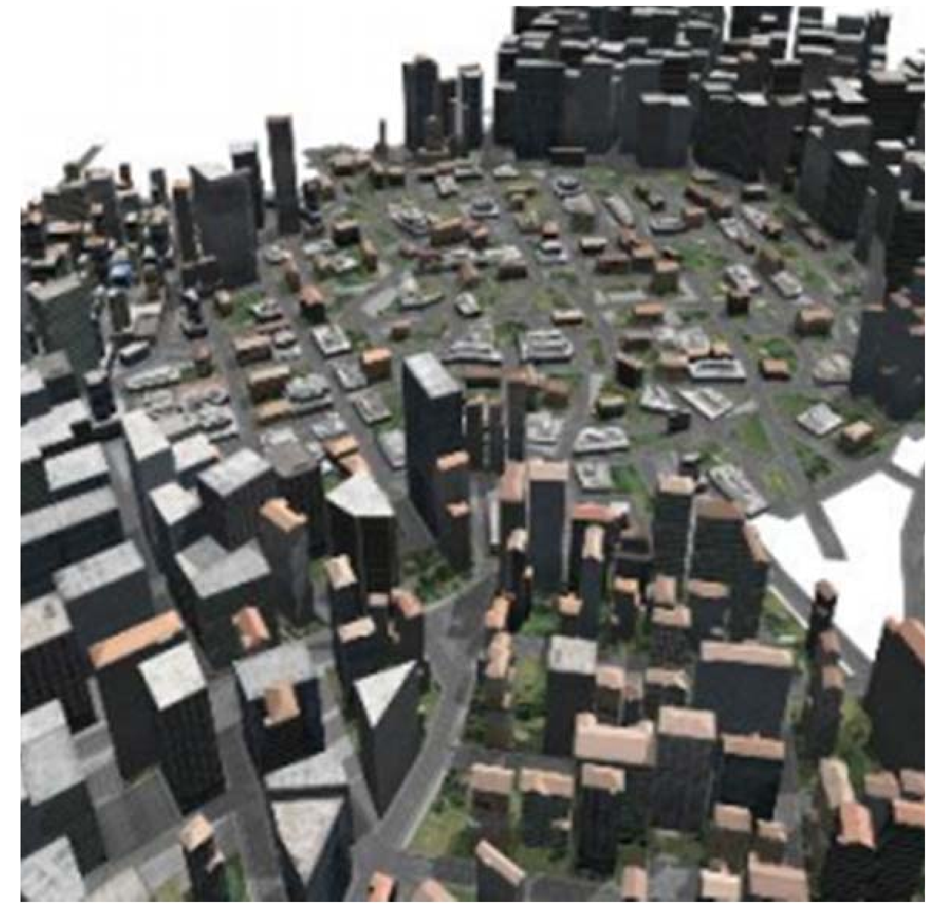
BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

User

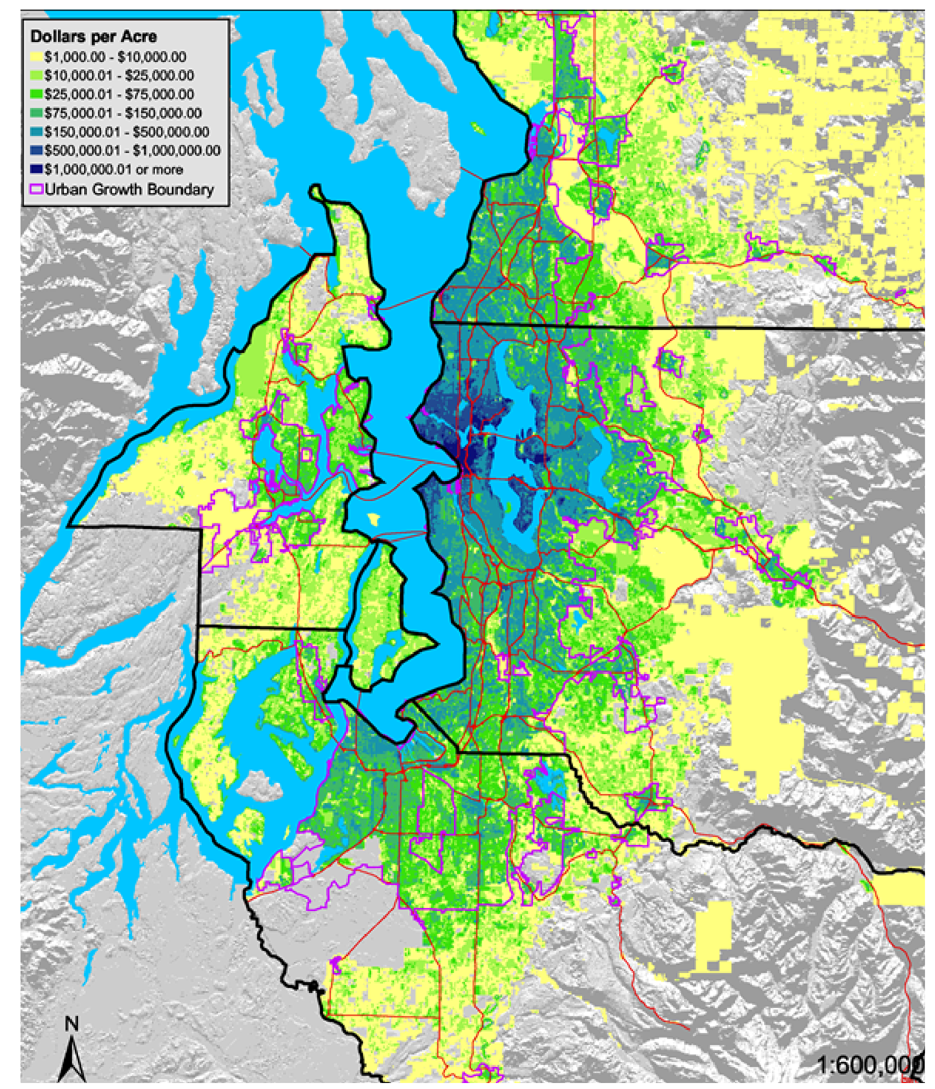
- Roads
- Blocks
- Parcels
- Buildings

Urban Modeling



- Population
- Jobs
- Accessibility
- Land Value

Urban Simulation



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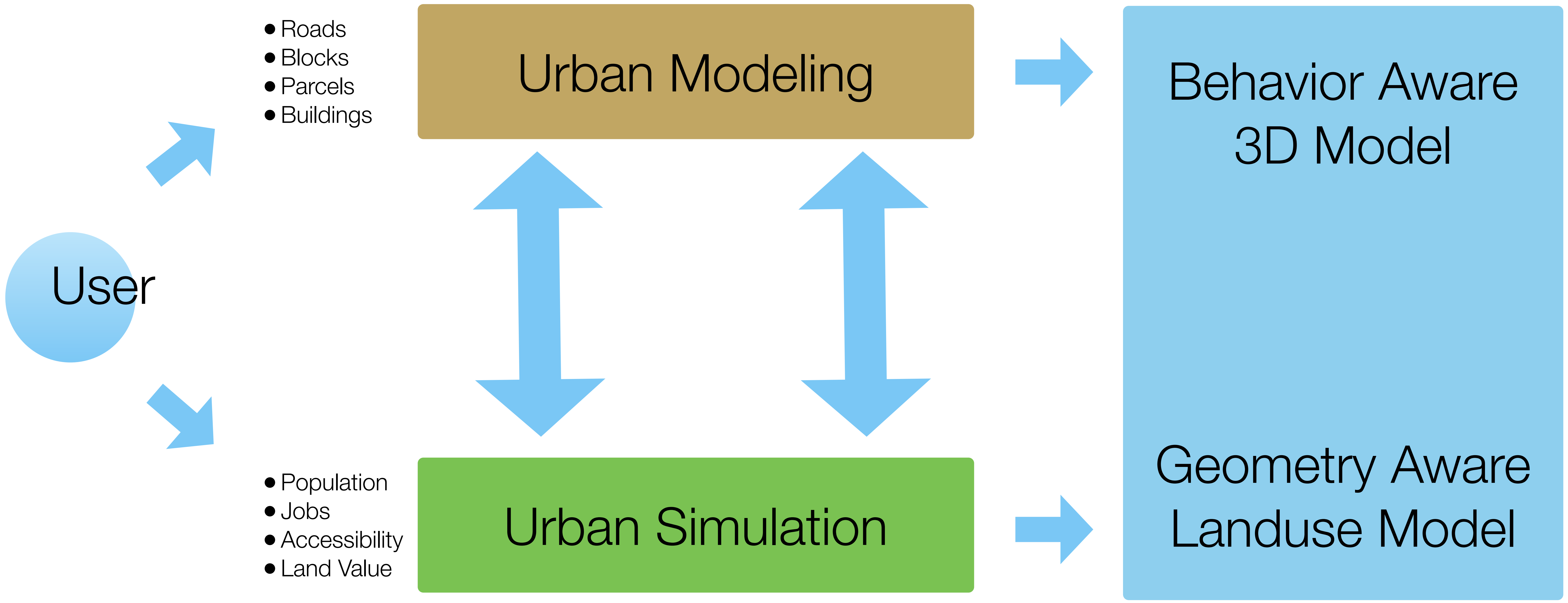

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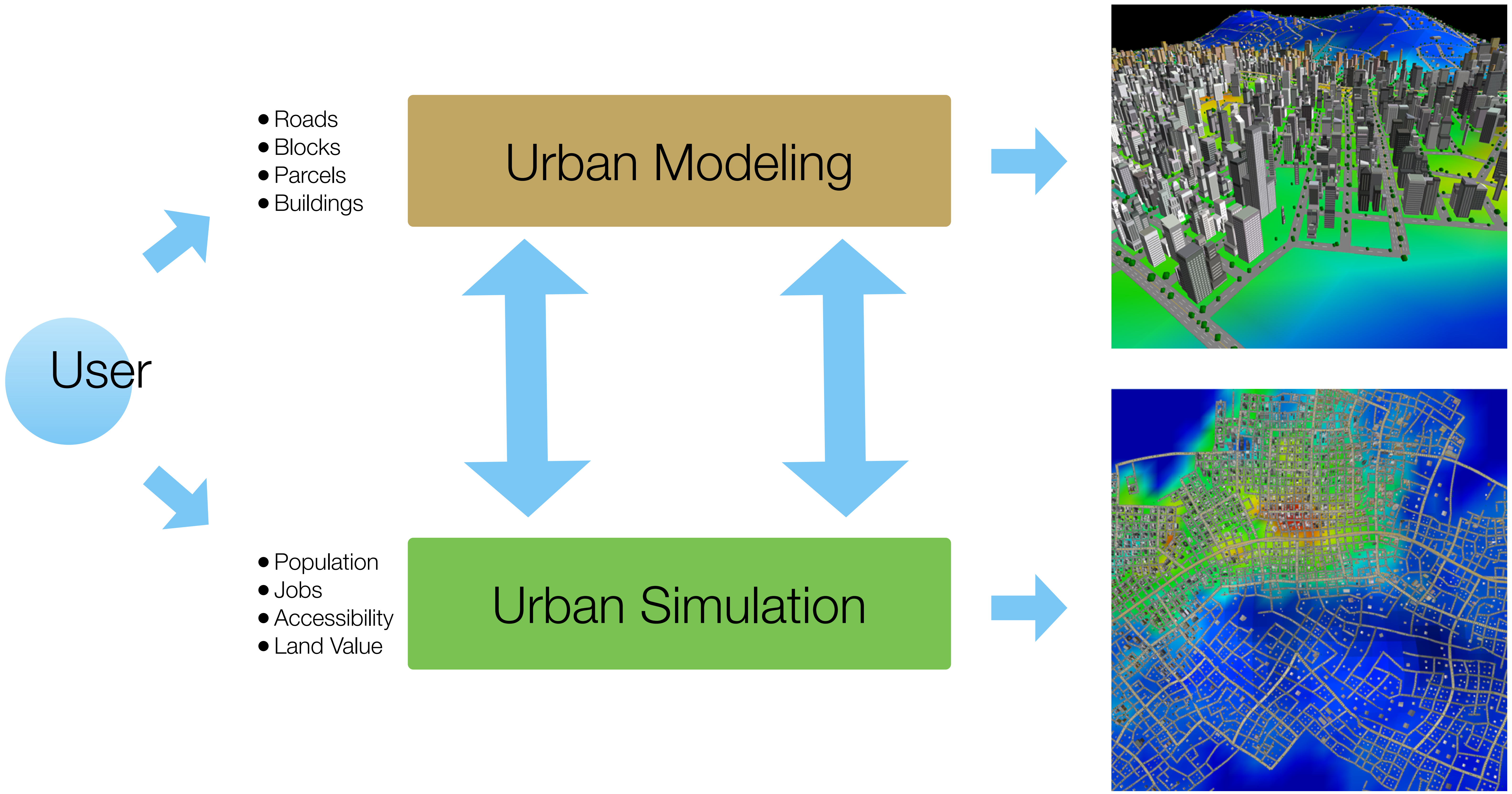

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URBAN MODELING

Overview of approaches for urban simulation

Methods in Computer Graphics that integrate urban modeling, visualization and simulation

Integrated system for real-world urban planning

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URBAN MODELING

Urban Modeling

Covered in previous lectures

URBAN SIMULATION

Brief overview

Urban Simulation

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URBAN SIMULATION

Models the behavioral and spatial patterns of urban economic agents

Jobs

Population

Housing

Land use

Aims to predict behavior of a city over time

Outputs massive spatially distributed data

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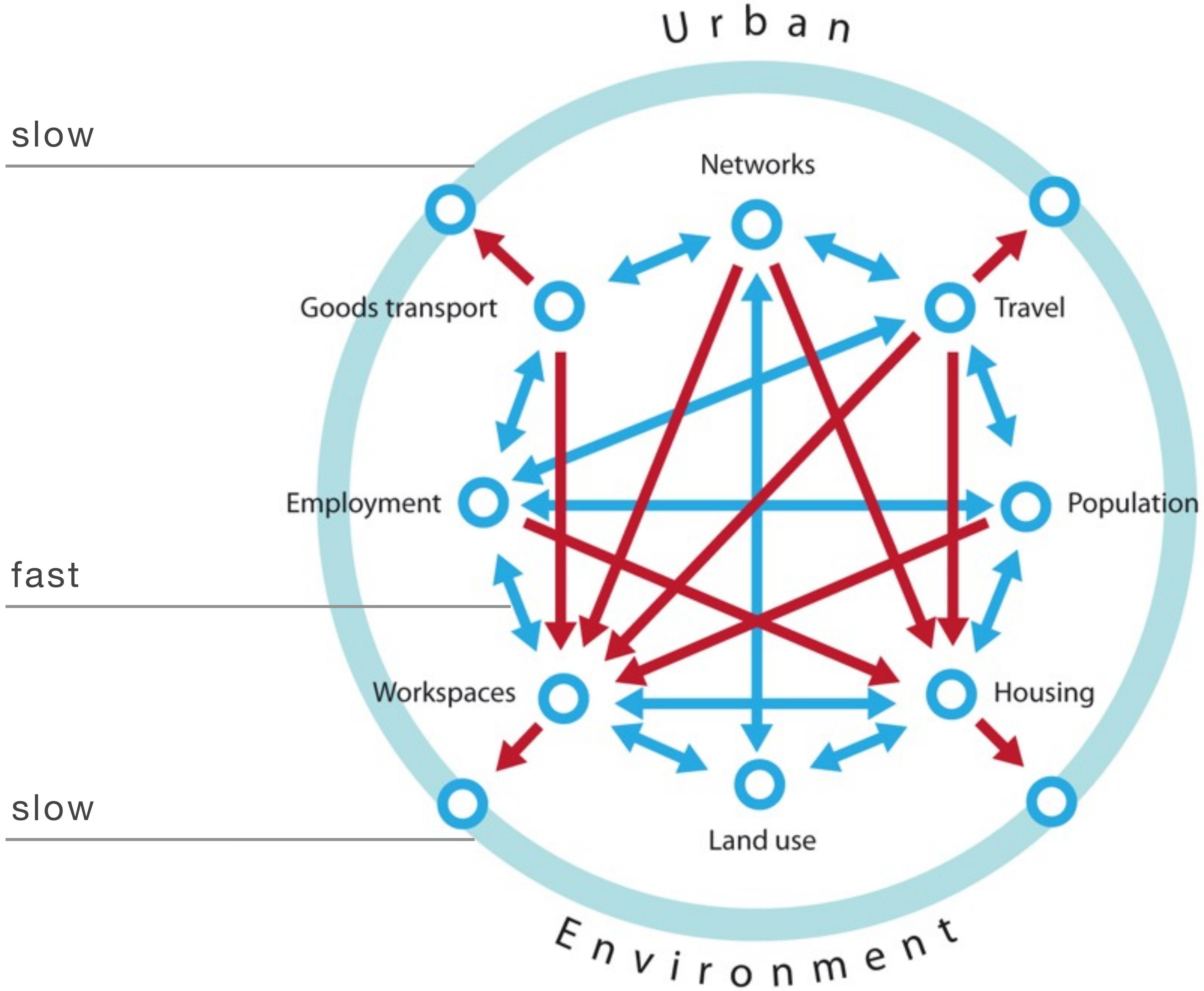
URBAN SIMULATION



Recreated from Weegener (1994, 2009).

General Simulation Model

(a) Mathematical and statistical models
(b) Analysis of existing structures
(c) Prediction of structures
(d) Detection of successful city patterns (spatial relationships)
(e) Results: abstract GIS that can help regional planners

URBAN SIMULATION

Overview of Urban Simulation Paradigms

Cellular Automata
Agent-based Models
Dynamic Microsimulation

Example System

UrbanSim

Outputs massive spatially distributed data

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URBAN SIMULATION

Cellular Automata

Simulate the conversion of non-urban land to urban use

City is represented as an arrangement of individual automata in a regular tessellated space

URBAN SIMULATION

Cellular Automata

Transition rules determine how automata states adapt over time

Information is exchanged between cells and spread through neighborhoods

Do not address changes to the built environment or the is occupants, or the travel that connects agents

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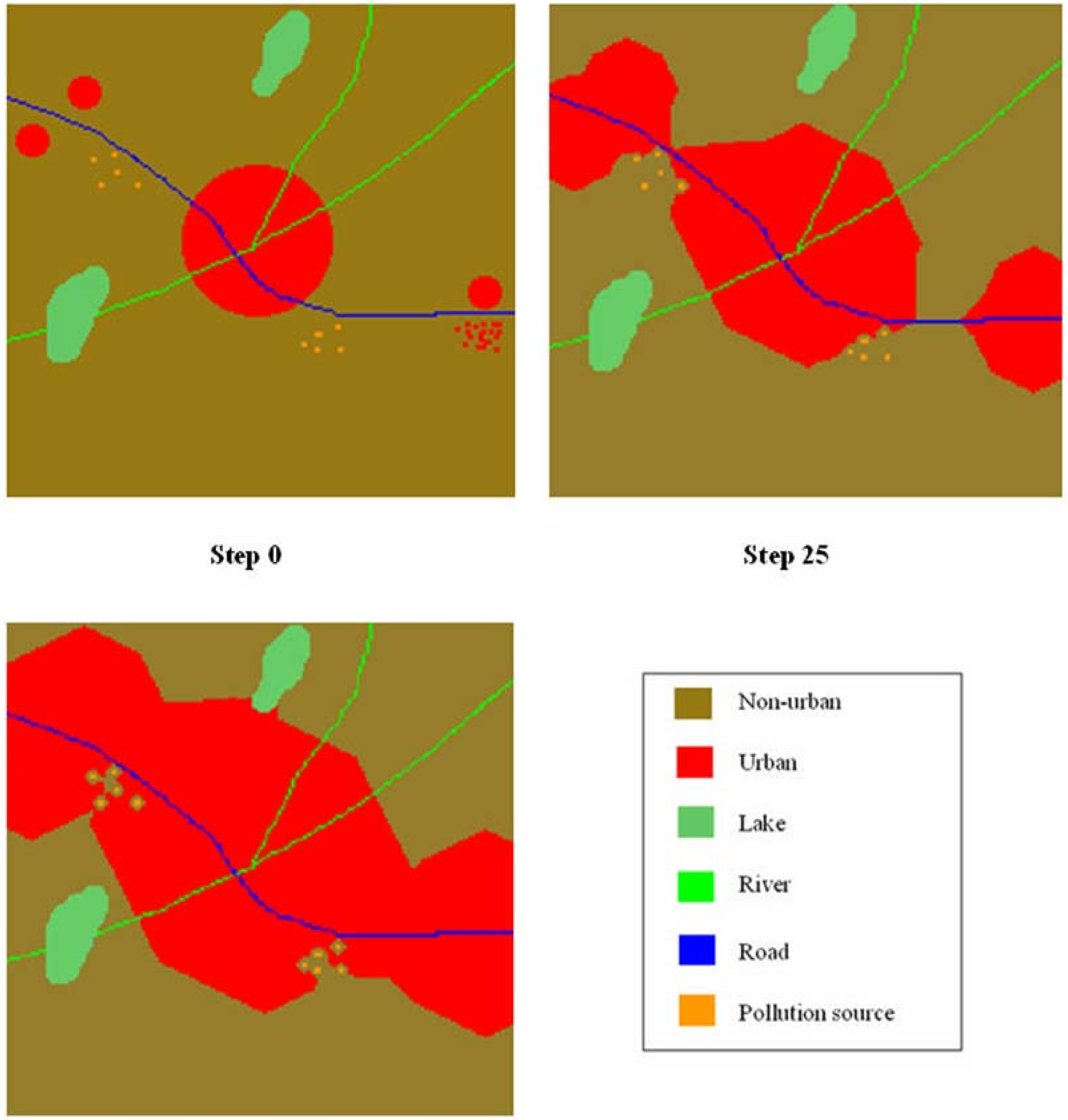
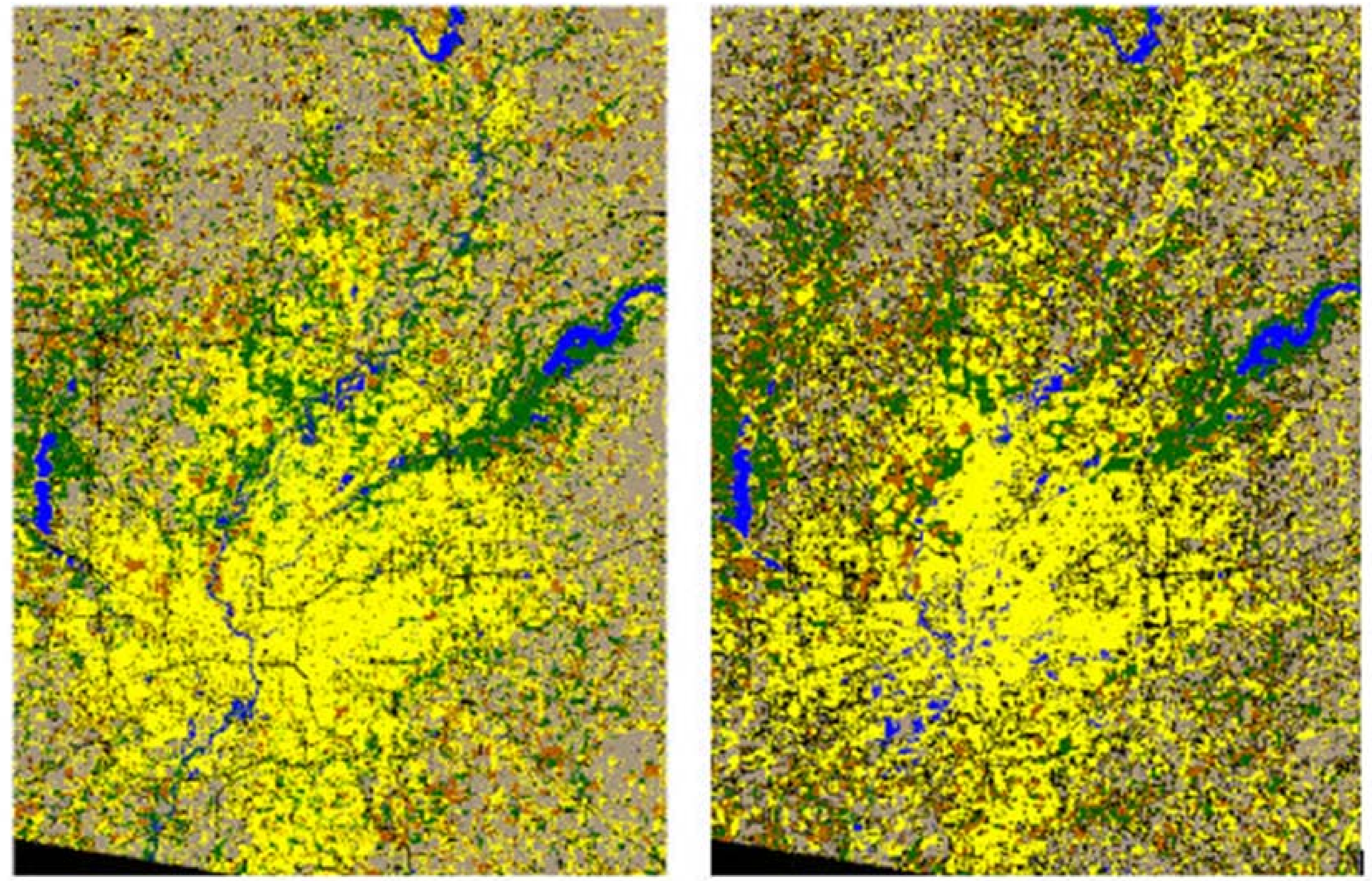
URBAN SIMULATION

Cellular Automata



Step 0 Step 25

Step 50



1982 Ground truth 1982 Simulated

Sharaf Alkheder, Jie Shan, “Cellular Automata Urban Growth Simulation and Evaluation”, 2008

URBAN SIMULATION

Cellular Automata

Cellular automata and urban simulation, Torrens, Sullivan, 2001

Loose-coupling a cellular automaton model and GIS, Clarke, 1998

Fuzzy inference guided cellular automata urbangrowth modeling, Al-Kheder, Wang, Shan, 2008

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URBAN SIMULATION

Agent-based Models

Extended cellular automata framework to include mobile, interacting agents

Examine cities as self-organizing complex systems

URBAN SIMULATION

Agent-based Models

Properties of agents explored with relatively simple behavioral rules

Most agent-based urban simulation models have behavior influenced only by localized context

URBAN SIMULATION

Dynamic Micro-Simulation

Combination of urban economic analysis with statistical modeling of choices made by agents in the urban environment

- E.g., households choosing residential location

Builds on

- Random Utility Theory (McFadden, 1974)
- Discrete choice models

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Dynamic Micro-Simulation

Integrated urban models, Putman, 1991

General equilibirium models of polycentric urban land use, Anas, Kim, 1996

A land use model for Santiago City, Martinez, 1996

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URBAN SIMULATION

Example system - UrbanSim

UrbanSim: Modeling urban development for land use, transportation, and environmental planning, Paul Waddell, 2002

URBAN SIMULATION

Example system - UrbanSim

Simulates the choices of

- Individual households
- Businesses
- Parcel landowners
- Developers

Interacting in real estate markets

URBAN SIMULATION

Example system - UrbanSim

Differs from Cellular Automata and agent-based models by integrating

- Discrete choice methods
- Explicit representation of real estate markets
- Statistical methods to estimate model parameter and to calibrate uncertainty in the model system

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URBAN SIMULATION

Visualizations of computed data sets

Used by regional planning agencies to evaluate

- Alternative transportation investments
- Land use regulations
- Environmental protection policies

URBAN SIMULATION

Visualizations of computed data sets

Interest several groups of population with different levels of expertise in handling data

- Policy makers
- The public
- Modelers running the simulation

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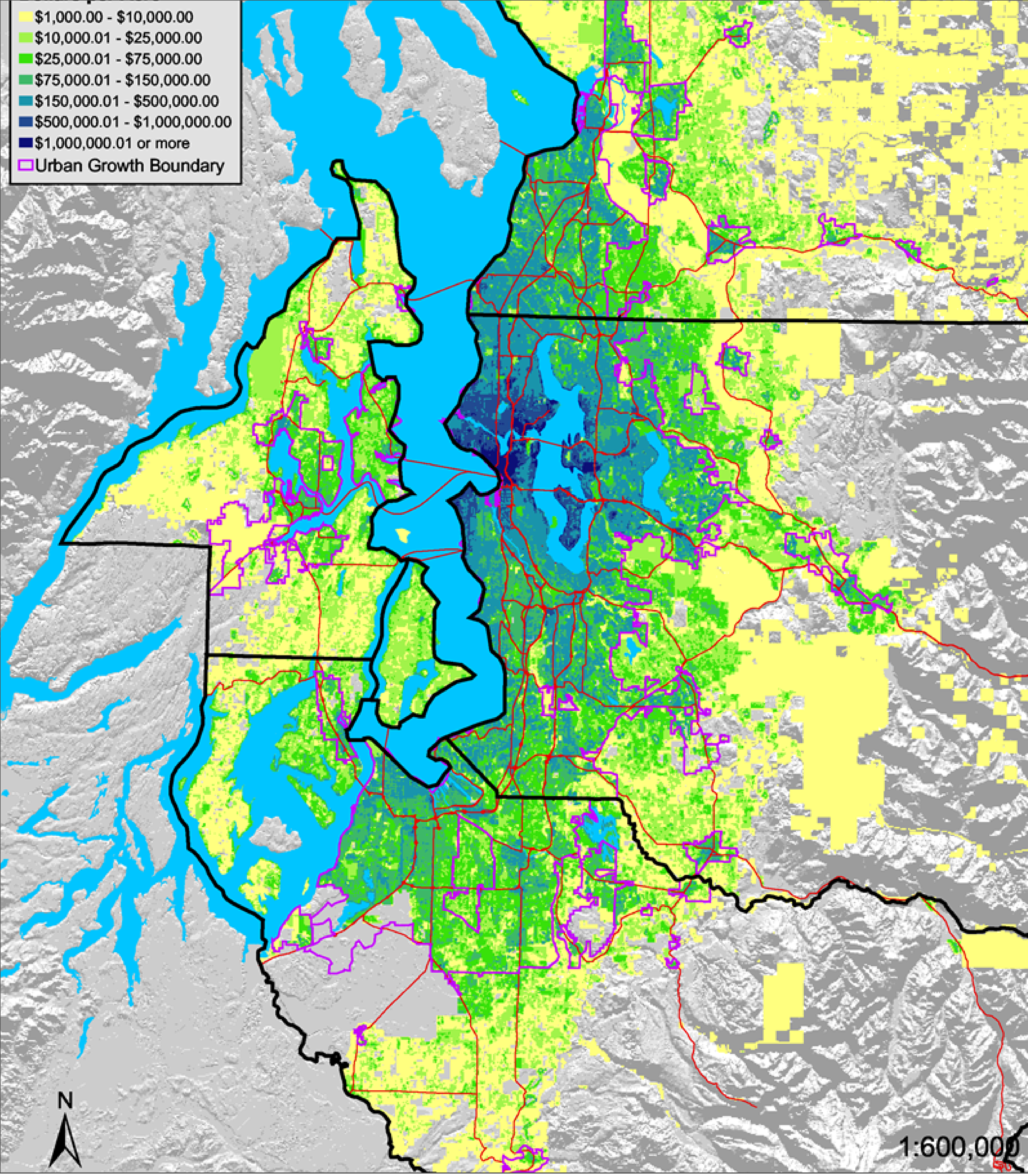
URBAN VISUALIZATION

Traditional urban visualization techniques

- Focused on handling large urban simulation data sets
- Making their analysis more intuitive to urban planners



URBAN VISUALIZATION

Traditional urban visualization techniques

Choropleth maps

- Areas shaded in the proportion to the values of the displayed varibles

Map-based indicator display for Puget Sound region
(Total land value per acre, 2000)
Image from: Alan Borning, University of Washington

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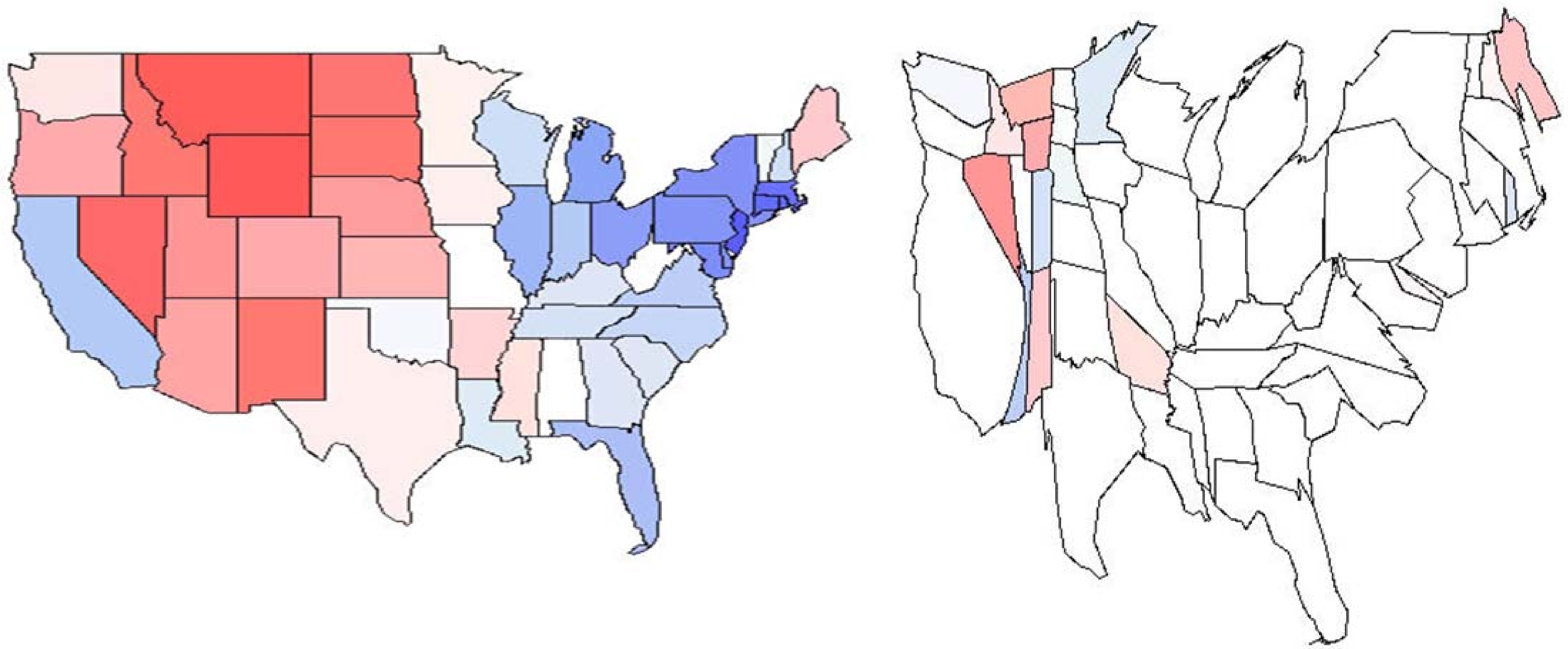
URBAN VISUALIZATION



Daniel Keim, Stephen North, Christian Panse, “CartoDraw: A Scanline based Cartogram Algorithm”, 2004.

Traditional urban visualization techniques

Cartograms

- Distort a map by resizing its regions according to the values of the displayed variable, but keeping the map recognizable

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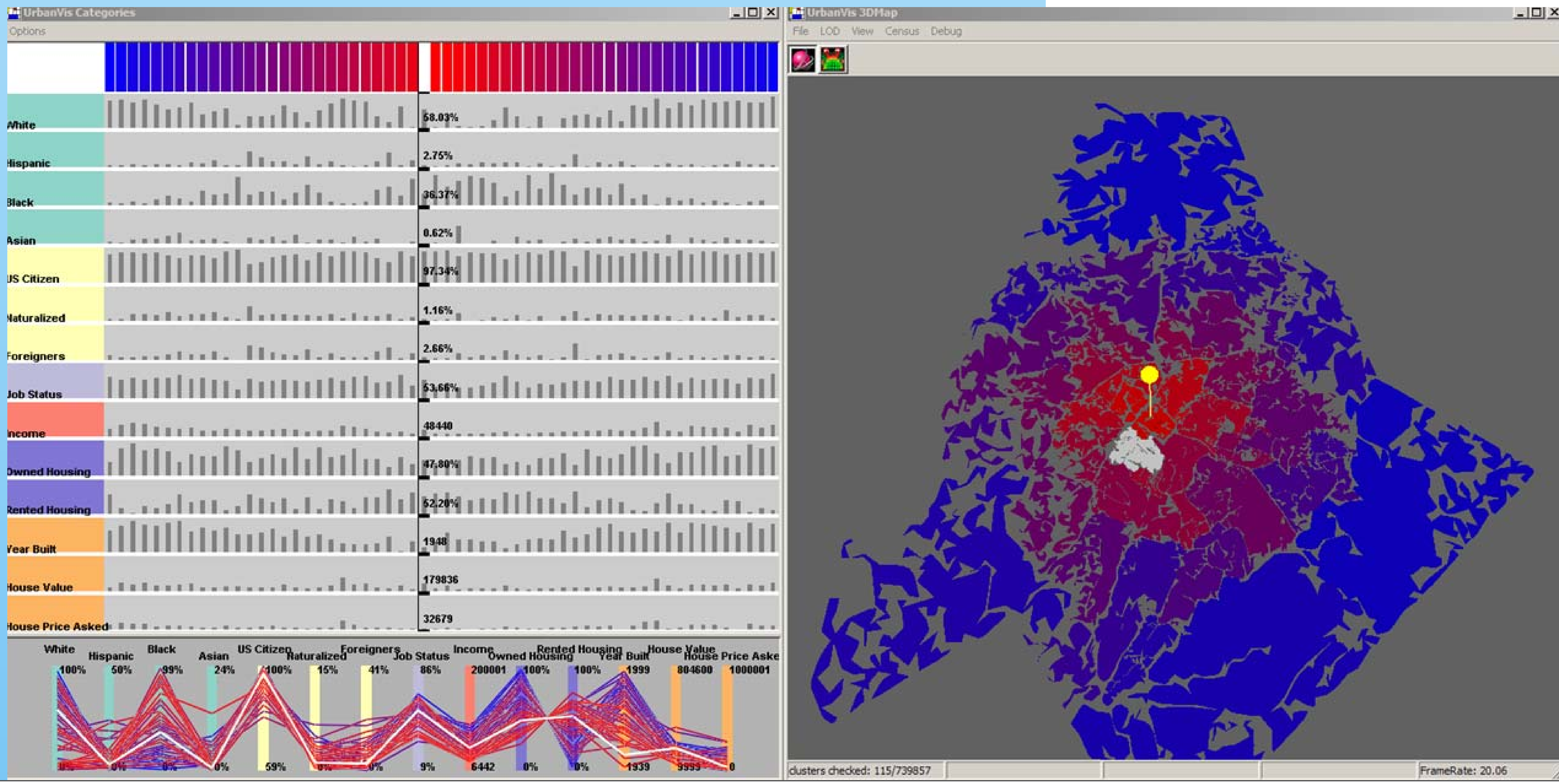
URBAN VISUALIZATION

Legible Cities, Chang, Wessel, Kosara, Sauda, Ribarski, TVCG 2007



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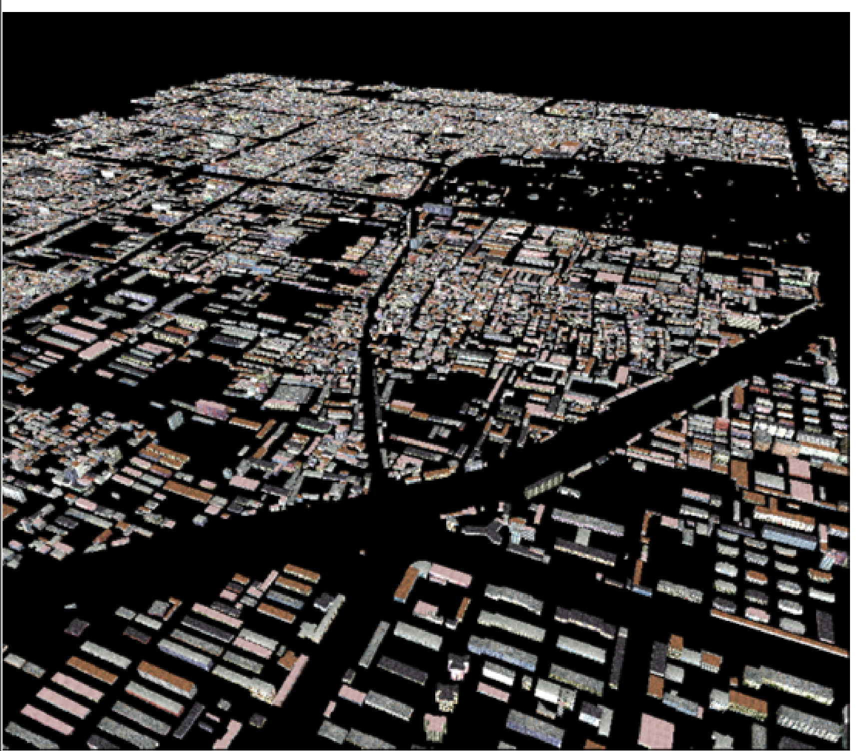
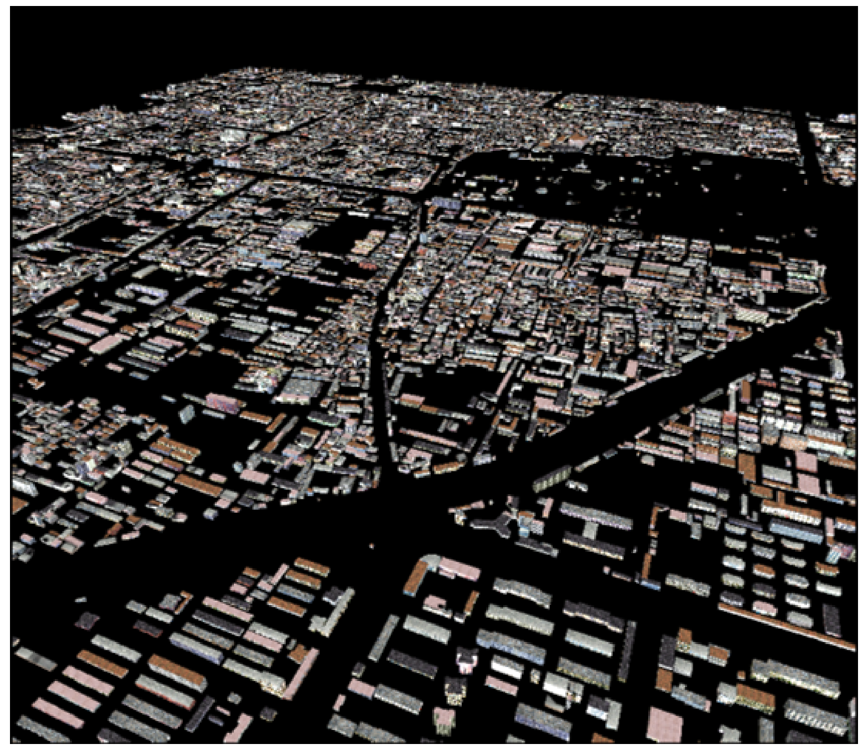
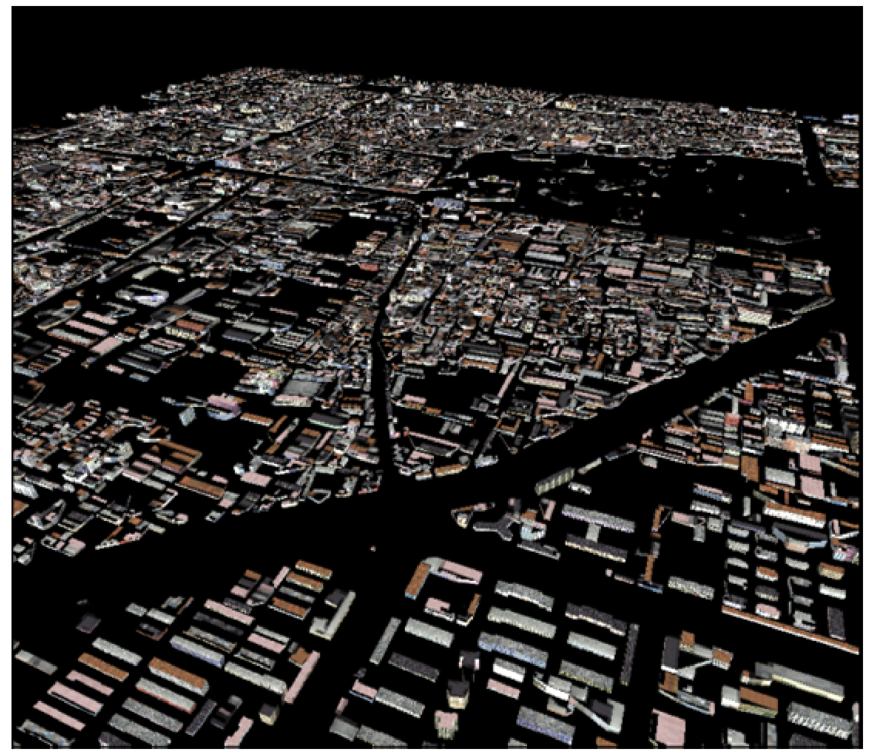
URBAN VISUALIZATION



Original Model



45% polygons



18% polygons

Legible Cities, Chang, Wessel, Kosara, Sauda, Ribarski, TVCG 2007

- Goal: Visualize an urban model in a focus-dependent, multi-resolution fashion, while retaining the legibility of the city

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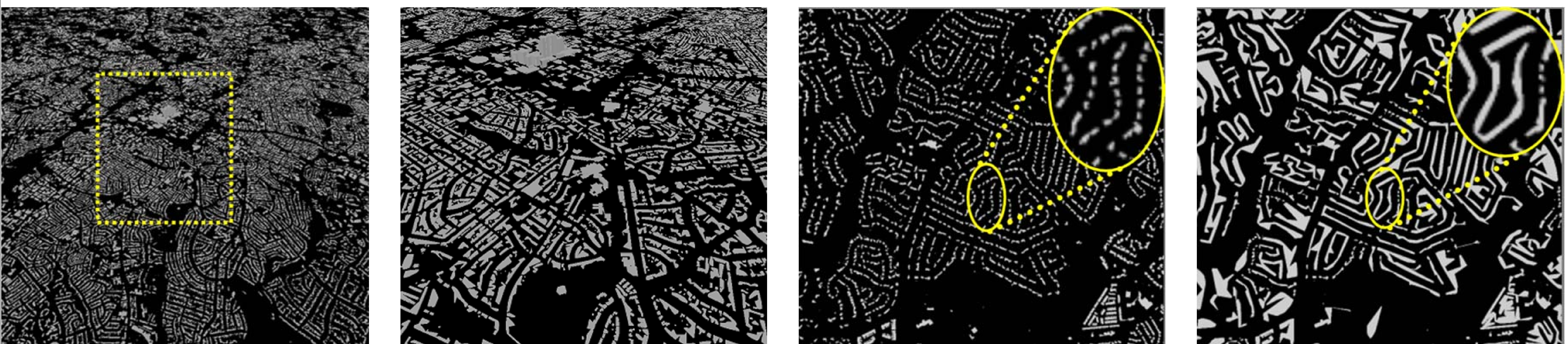
URBAN VISUALIZATION

Legible Cities, Chang, Wessel, Kosara, Sauda, Ribarski, TVCG 2007

- Integrate 3D model view and data view
- Relationships between the geospatial information of the urban model and the related urban data can be more intuitively identified



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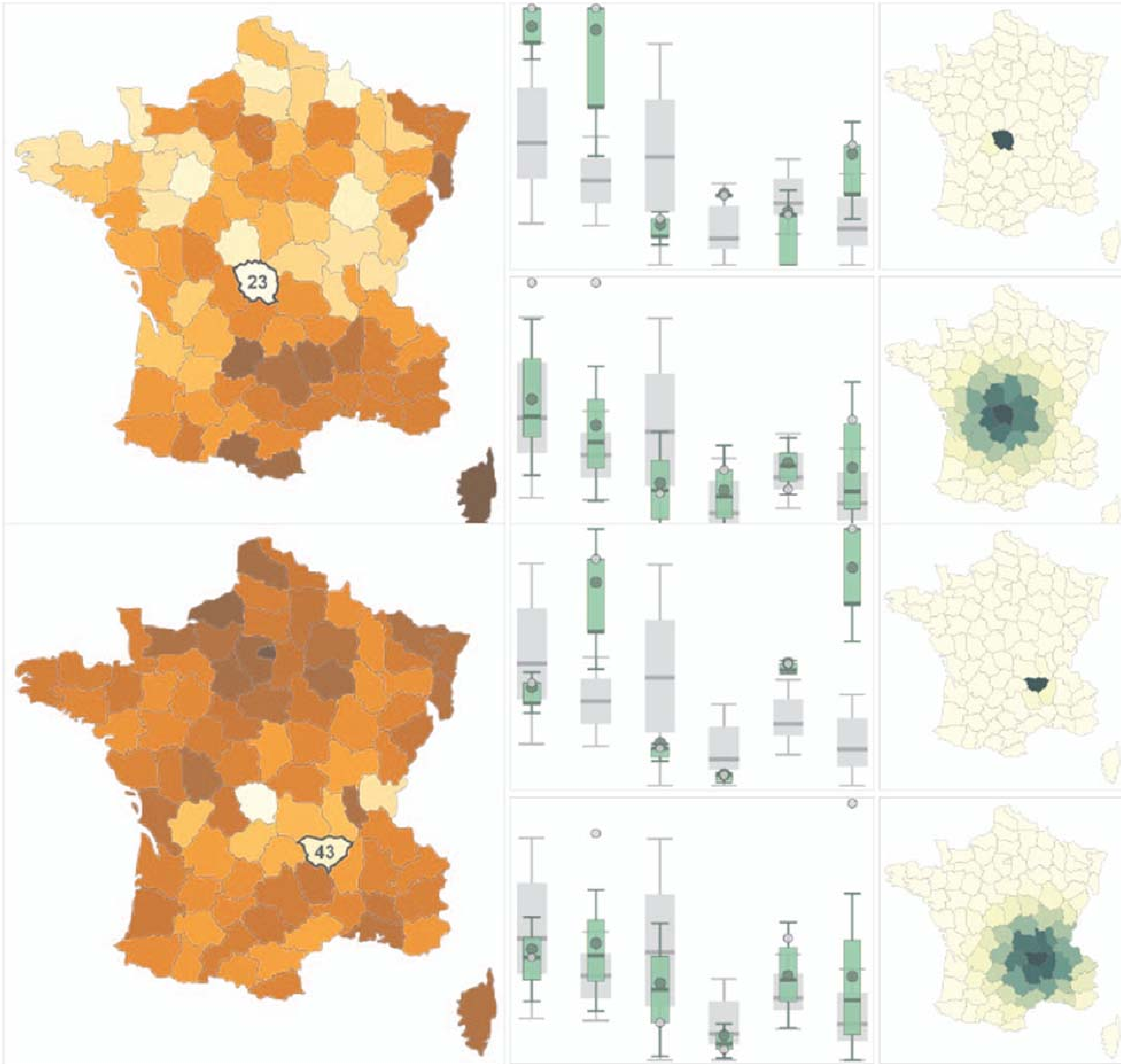

Geographically Weighted Visualization,
Dykes, Brunsdon, TVCG 2007

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URBAN VISUALIZATION

Geographically Weighted Visualization,
Dykes, Brunsdon, TVCG 2007

Visually encode information about geographic and statistical proximity and variation through

- geographically weighted (GW)-choropleth maps
- multivariate GW-boxplots
- GW-shading and scalograms

New graphic types reveal information abut GW statistics at several scales concurrently

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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Visualization of Simulated Urban Spaces,
Vanegas, Aliaga, Benes, Waddell, TVCG 2007

BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Visualization of Simulated Urban Spaces, Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Infer an urban layout

- Images (aerial view) + Structure (streets, parcels)

from the values of a set of simulation variables at any given time step

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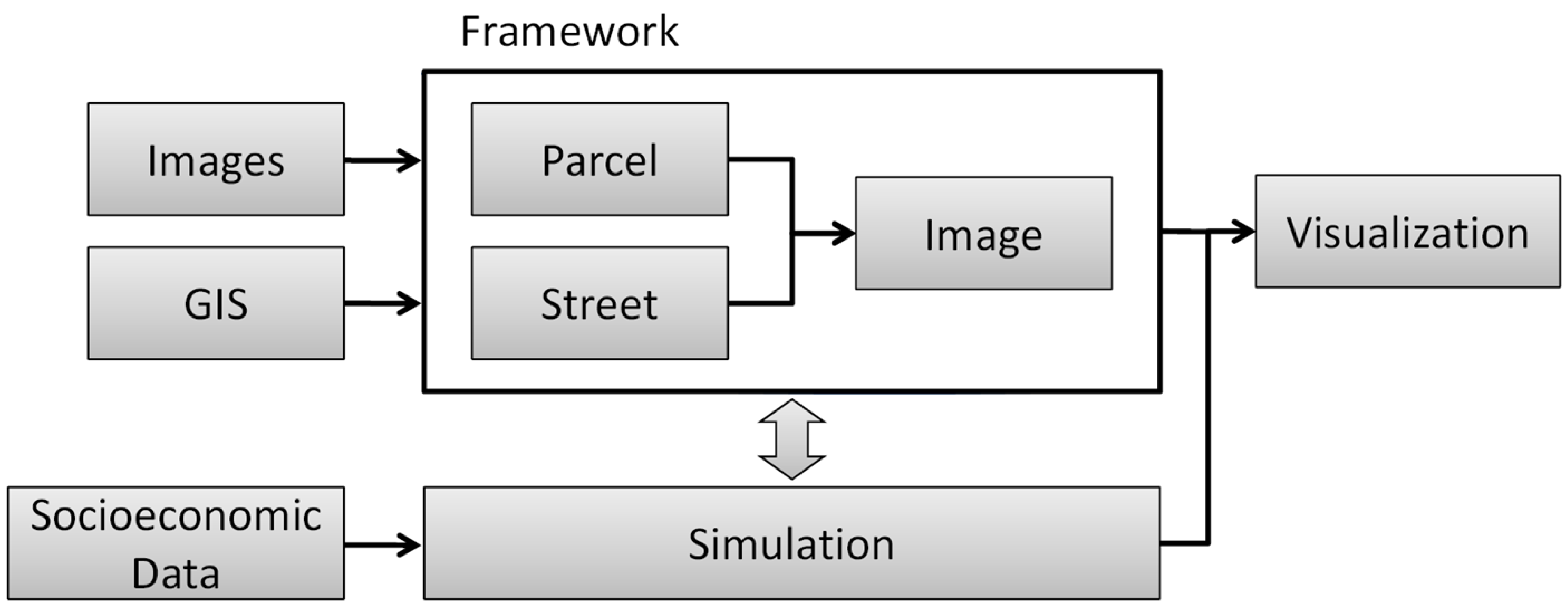

Visualization of Simulated Urban Spaces,
Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Approach

- Spatially match socioeconomic data set with input aerial imgaes and structure of the urban space

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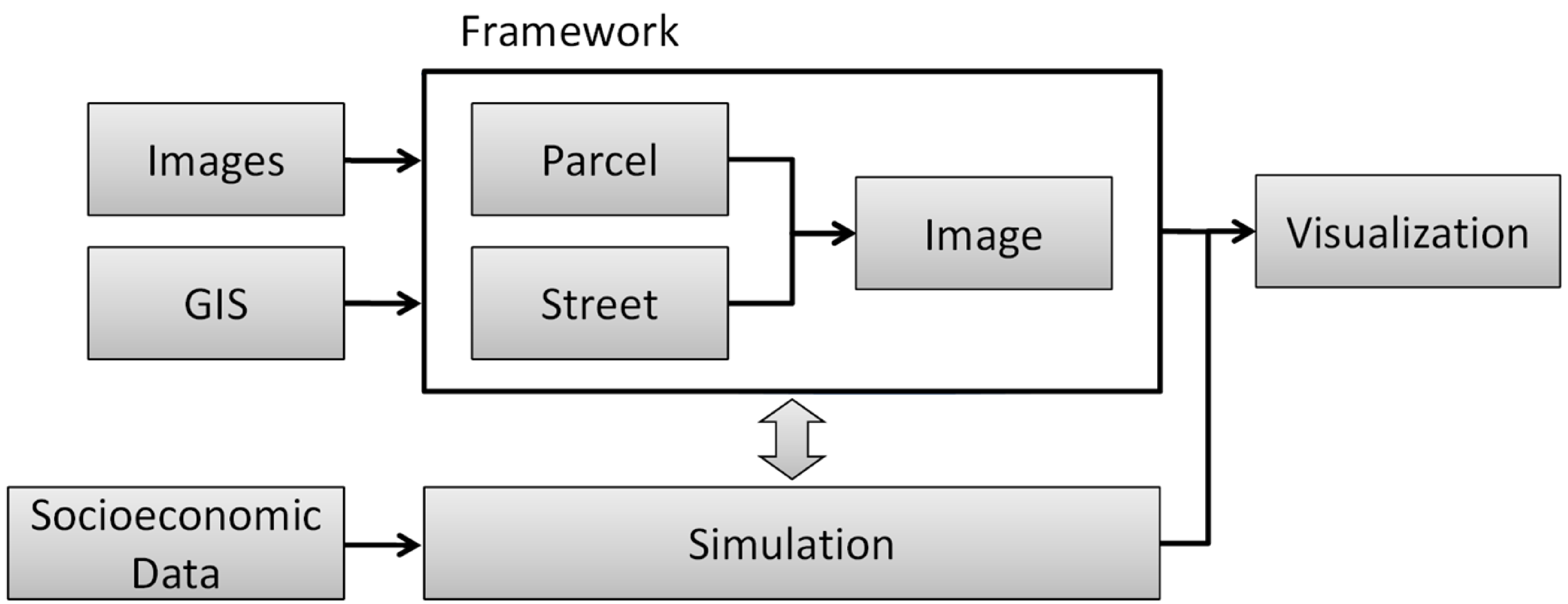

Visualization of Simulated Urban Spaces,
Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Approach

- Create new structure that matches a set of attributes inferred from simulation variables
- New blank lots are created

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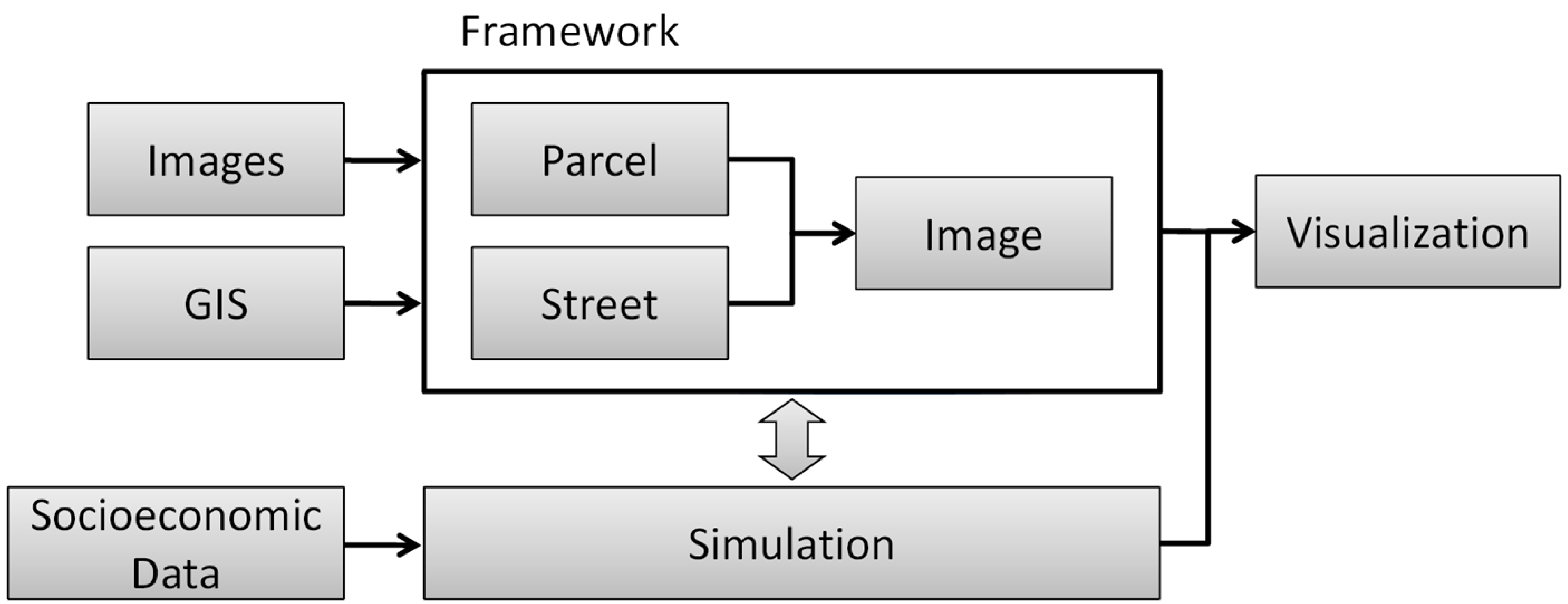

Visualization of Simulated Urban Spaces,
Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Approach

- Aerial imagery is "borrowed" from existing lots of the city with similar socioeconomic attributes as the new blank lot

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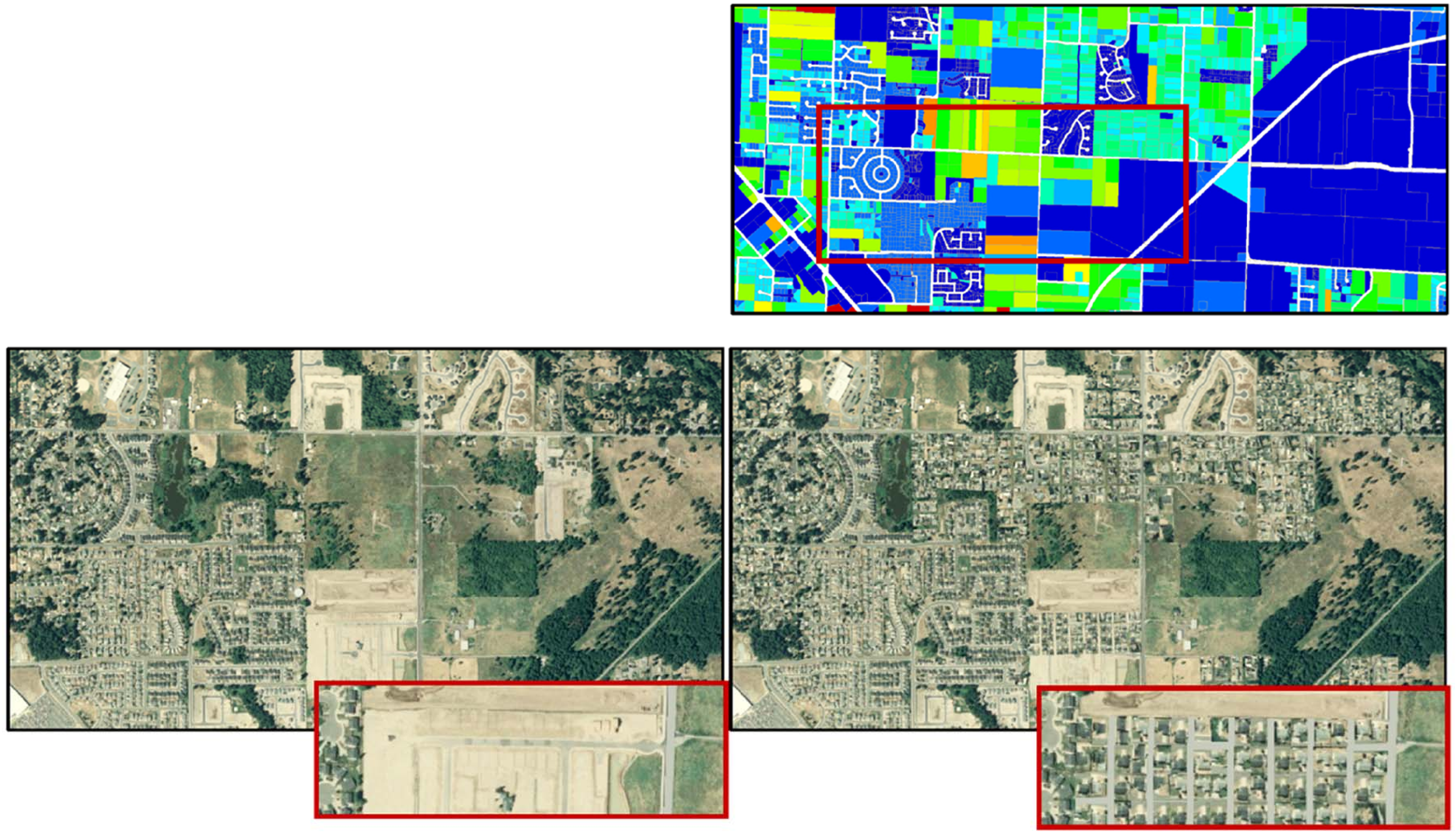
Visualization of Simulated Urban Spaces, Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Example Result



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Visualization of Simulated Urban Spaces,
Vanegas, Aliaga, Benes, Waddell, TVCG 2007

Example Result

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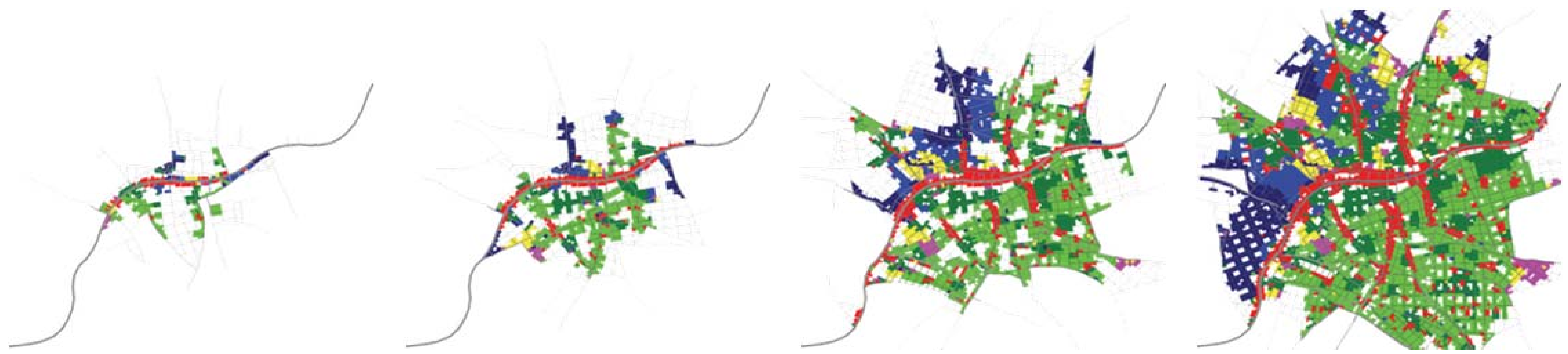
Interactive Geometric Simulation of 4D Cities,
Weber, Müller, Wonka, Gross,
Eurographics 2009



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Interactive Geometric Simulation of 4D Cities,
Weber, Müller, Wonka, Gross,
Eurographics 2009

- How to model cities that are changing over time?
- How to use the urban simulation data to infer the geometry of the city (roads, lots, buildings)?

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Interactive Geometric Simulation of 4D Cities,
Weber, Müller, Wonka, Gross,
Eurographics 2009
Traffic simulation for street generation

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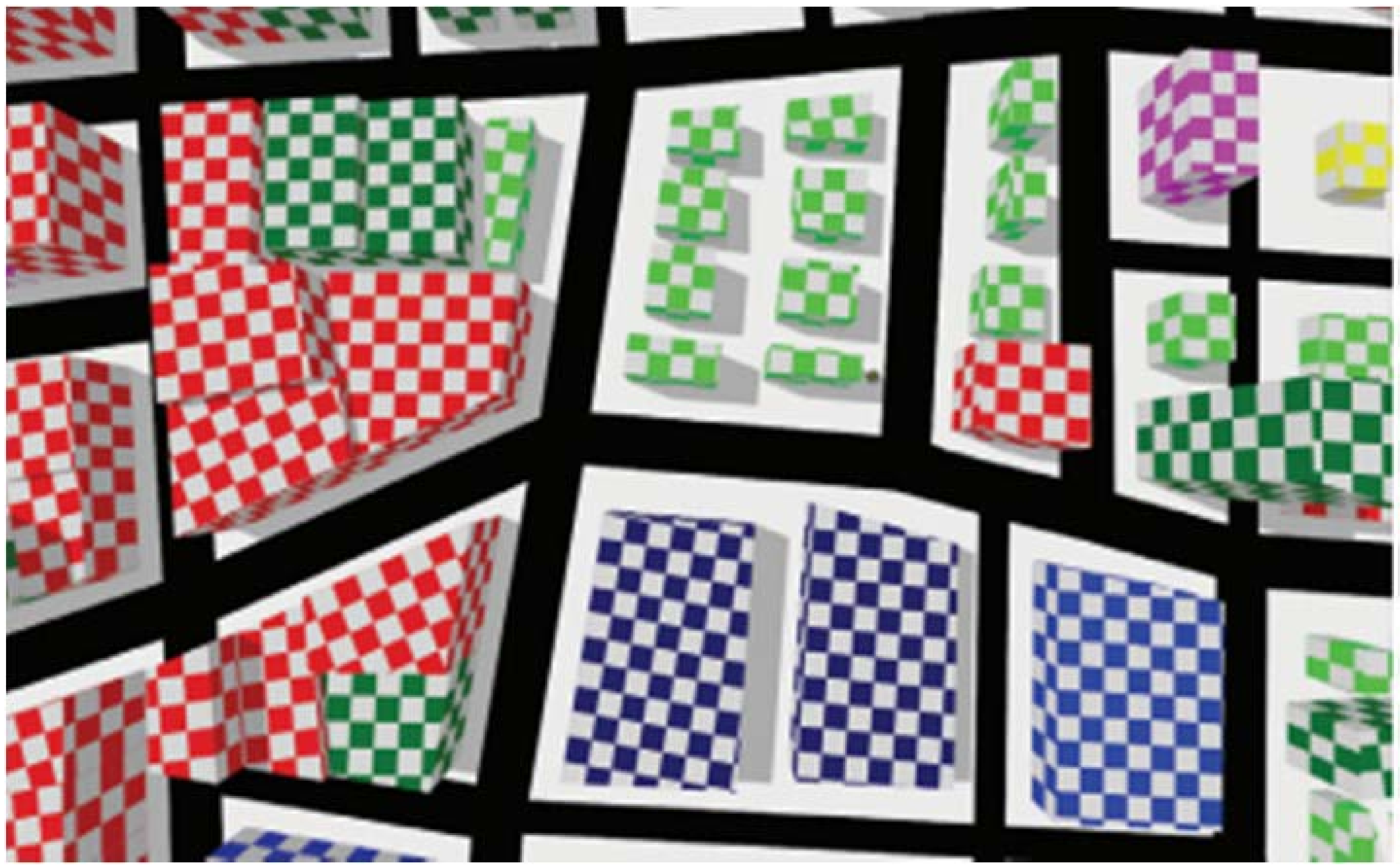

Interactive Geometric Simulation of 4D Cities

Weber, Müller, Wonka, Gross,
Eurographics 2009

Land use simulation

- Optimization of a land use value function

$$luv = \lambda_{global} \cdot luv_{global} + \lambda_{local} \frac{\sum_{\forall i} lot[i].area \cdot lot[i].luv}{\sum_{\forall i} lot[i].area}$$

- Global and local land use goals

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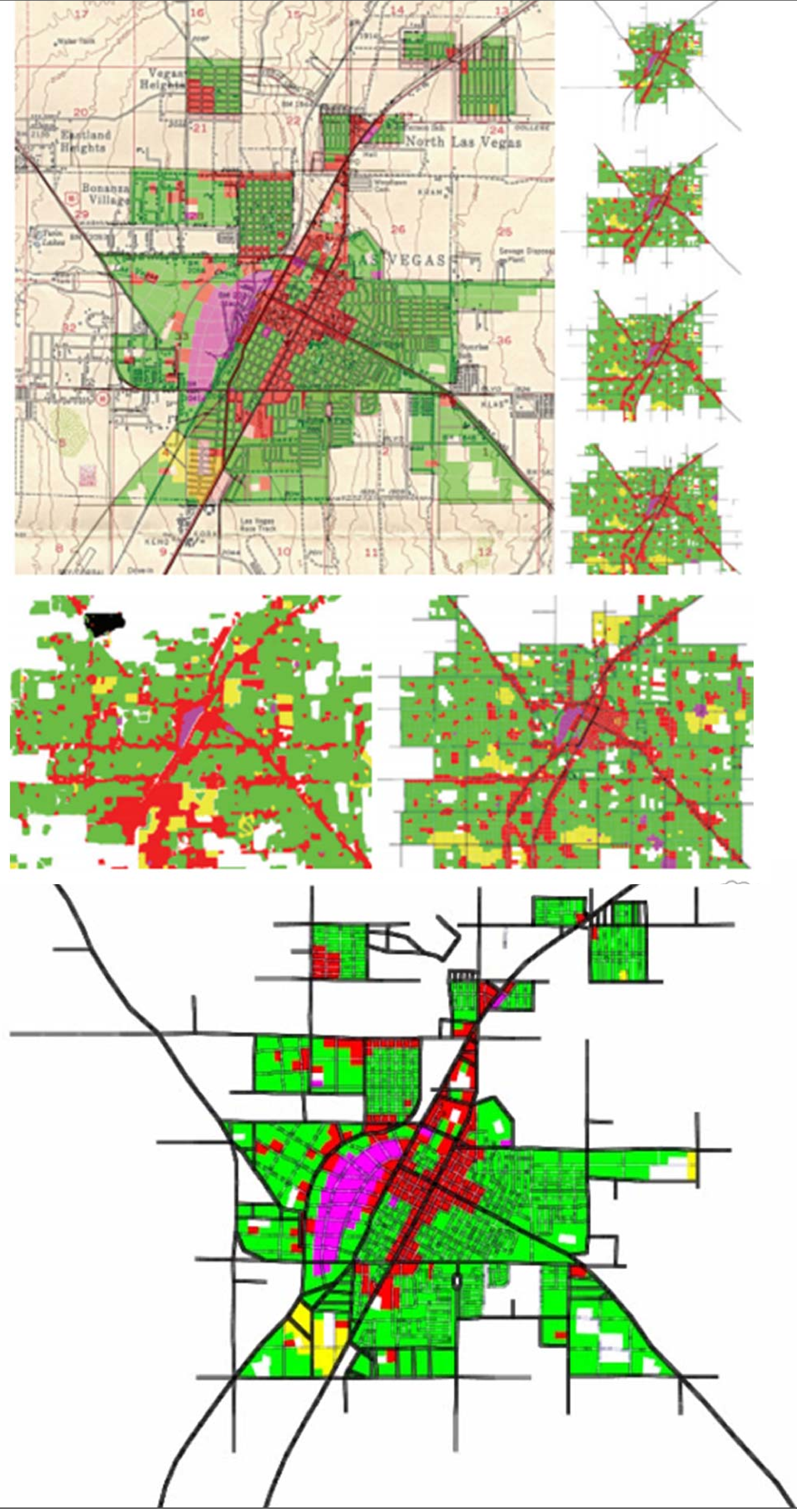

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Interactive Geometric Simulation of 4D Cities

Weber, Müller, Wonka, Gross,
Eurographics 2009

Validation

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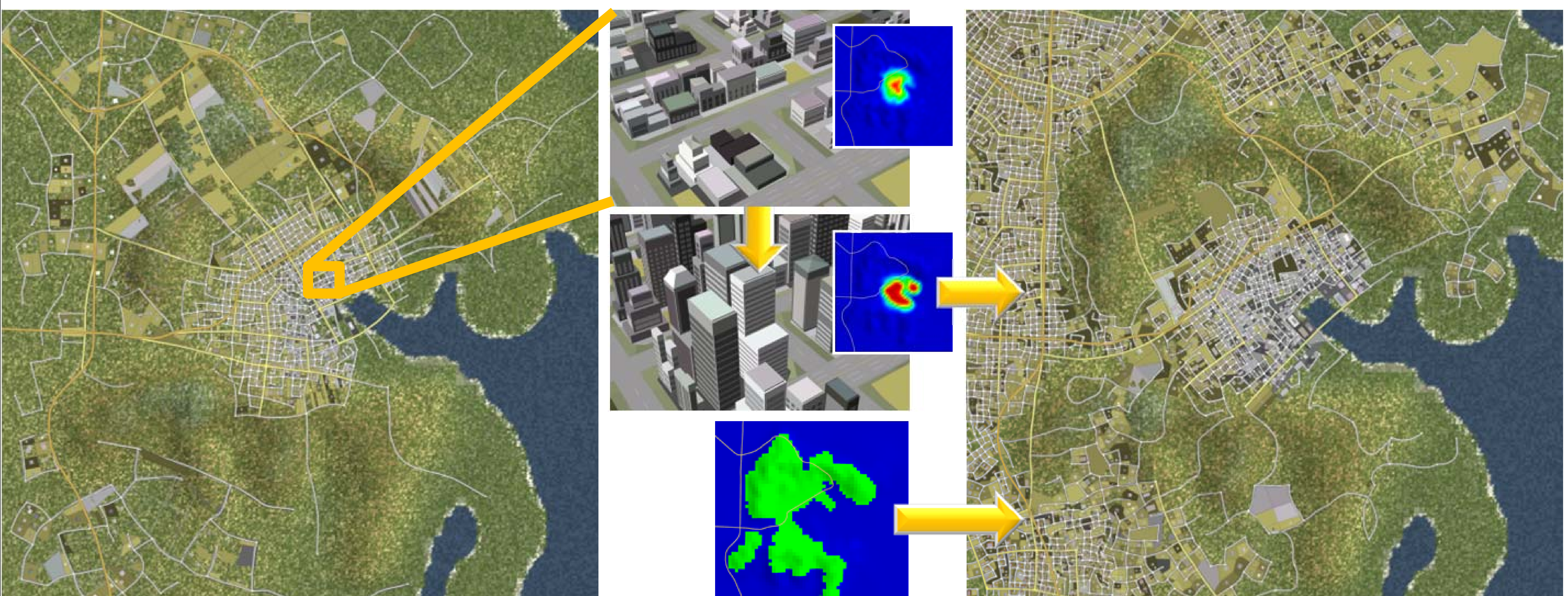
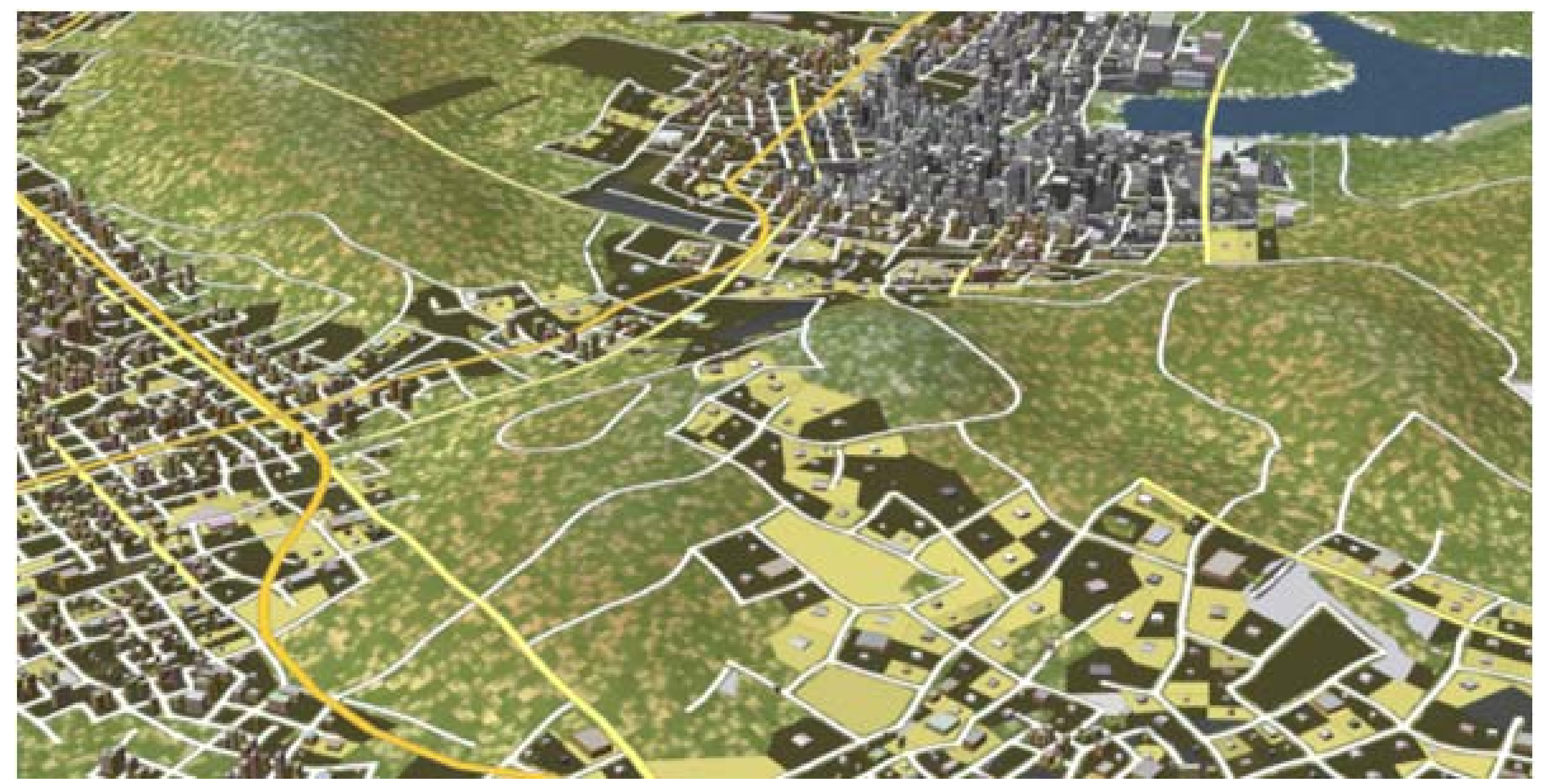
Interactive Geometric Simulation of 4D Cities

Vanegas, Aliaga, Benes, Waddell,

SIGGRAPH Asia 2009





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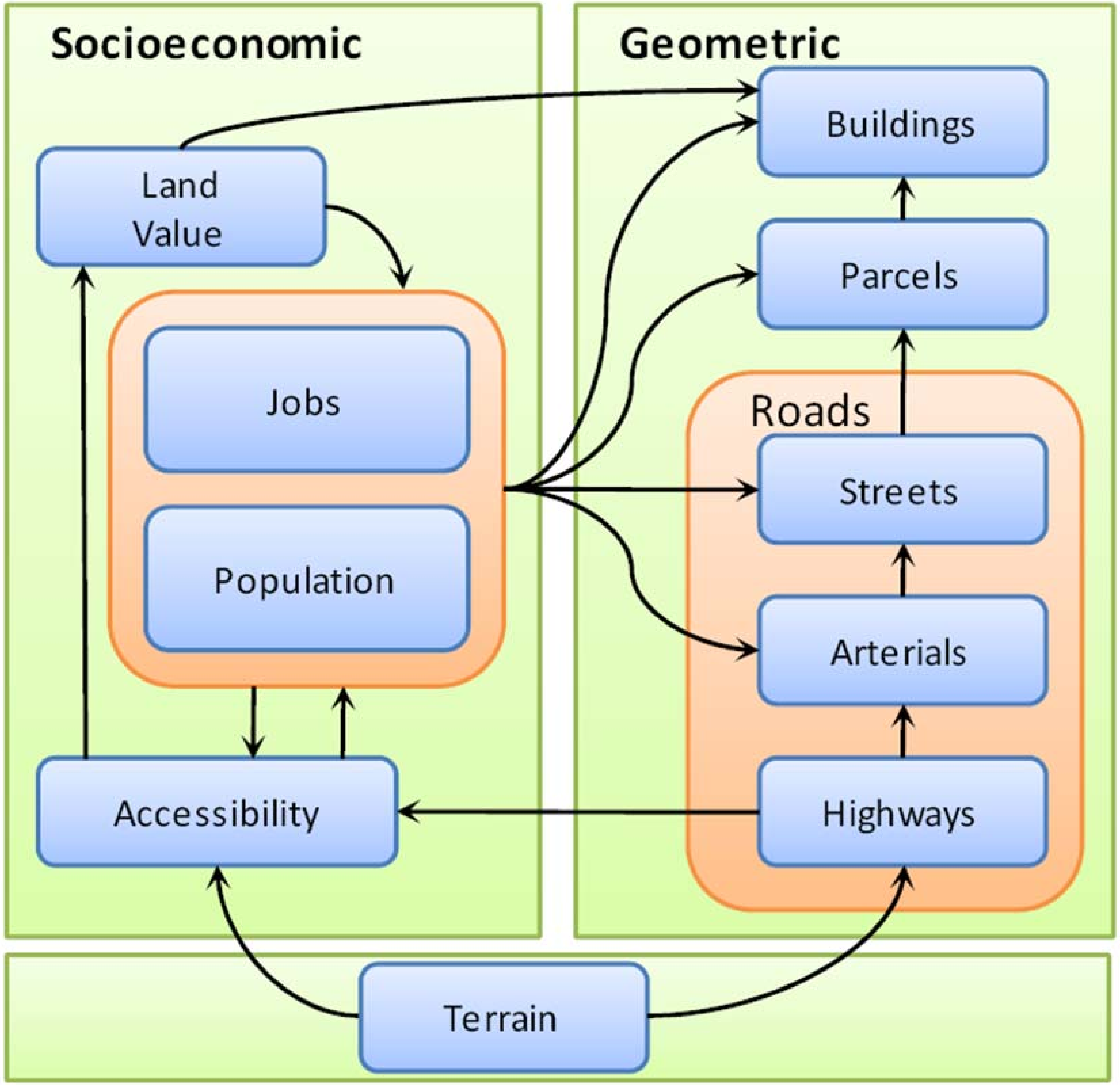

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Interactive Geometric Simulation of 4D Cities
Vanegas, Aliaga, Benes, Waddell,
SIGGRAPH Asia 2009

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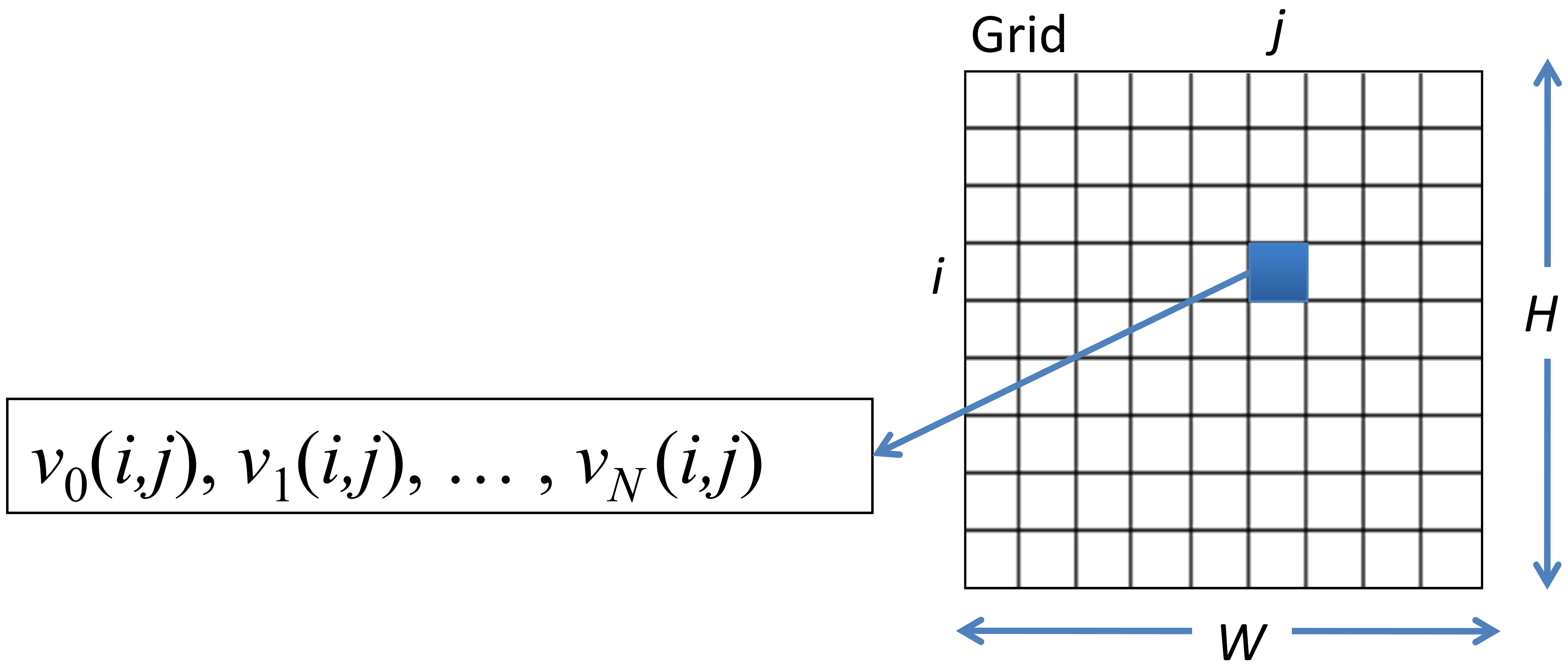

Interactive Geometric Simulation of 4D Cities

Vanegas, Aliaga, Benes, Waddell, SIGGRAPH Asia 2009

System

- Consists of N variables defined over a spatial domain
- Each variable sampled over a 2D spatial grid ***G*** of Size *W* x *H*
- $v_k(i,j)$ denotes the value of *k*-th variable at grid cell (*i*,*j*)

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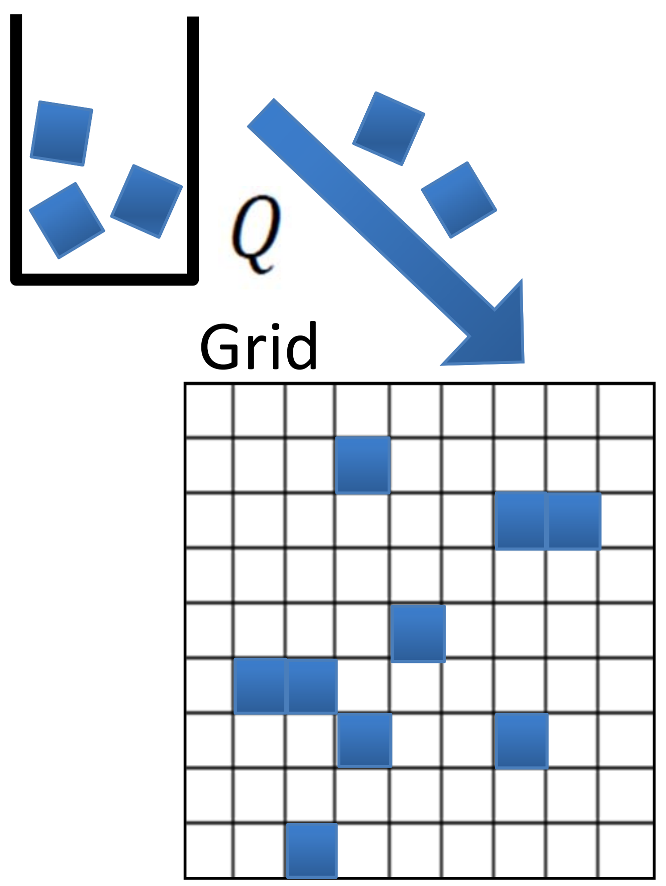

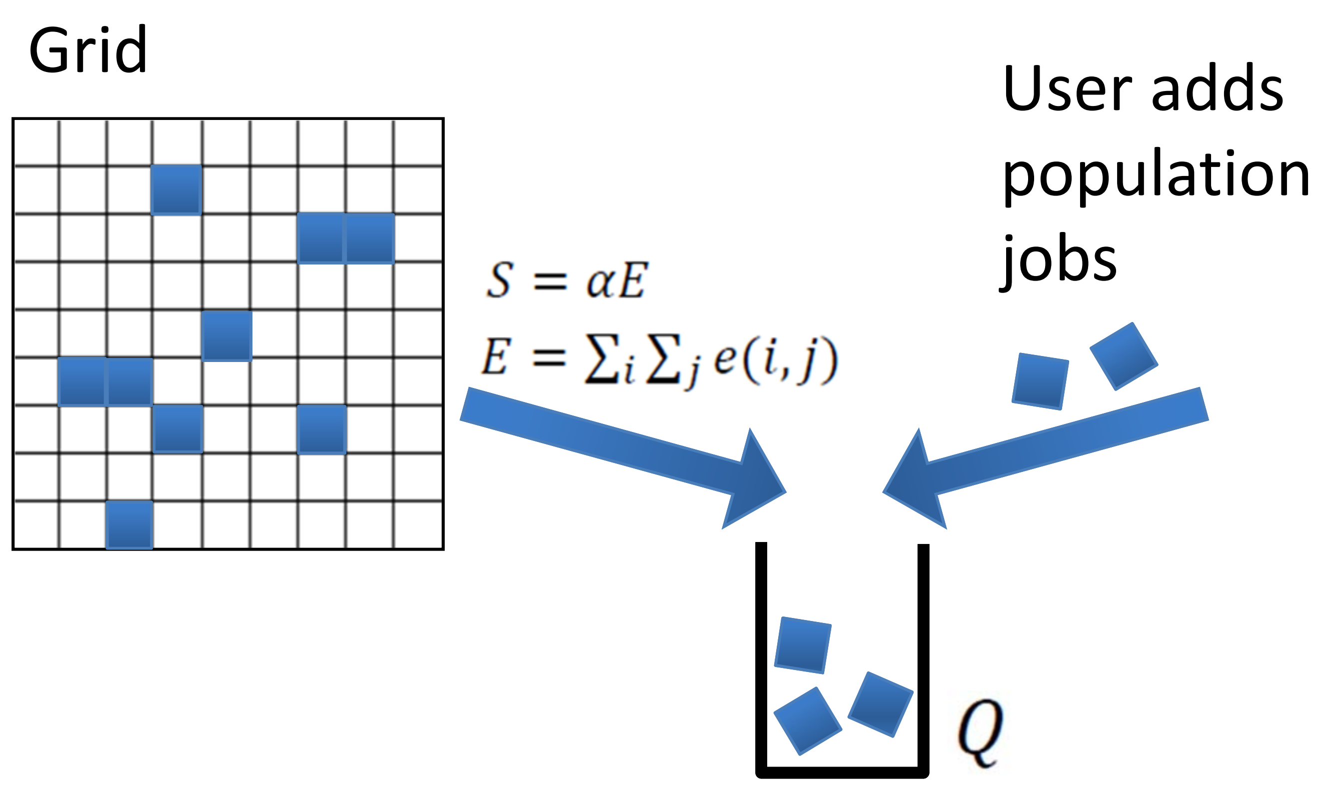

Interactive Geometric Simulation of 4D Cities

Vanegas, Aliaga, Benes, Waddell, SIGGRAPH Asia 2009

Operations

- Location an de-location of behavioral variables using location choice and mobility algorithms

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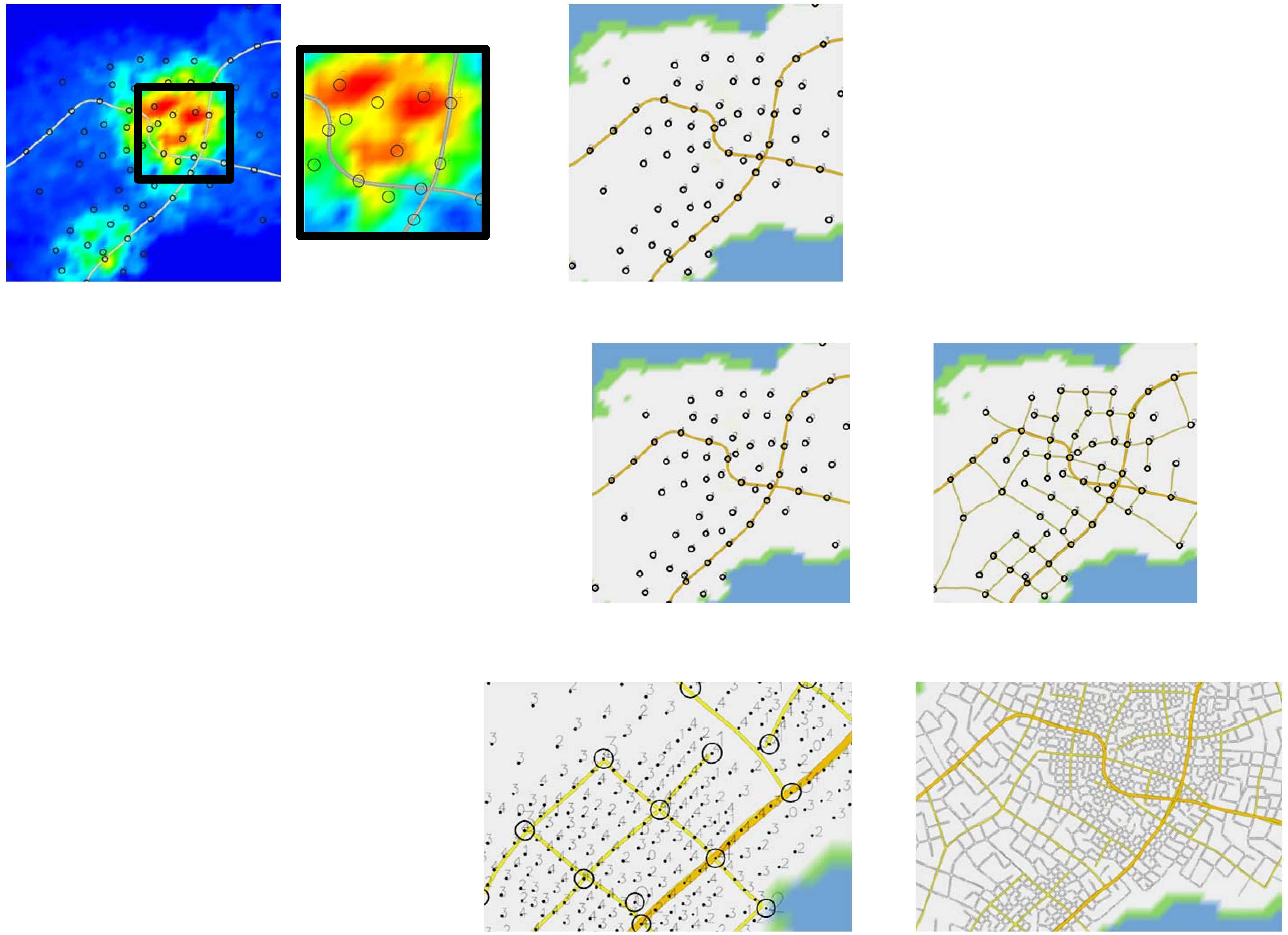
(A)

(B)

(C)



Interactive Geometric Simulation of 4D Cities

Vanegas, Aliaga, Benes, Waddell, SIGGRAPH Asia 2009

Operations

(A) Seeds

(B) Expansion of Arterials

(C) Expansion of Streets

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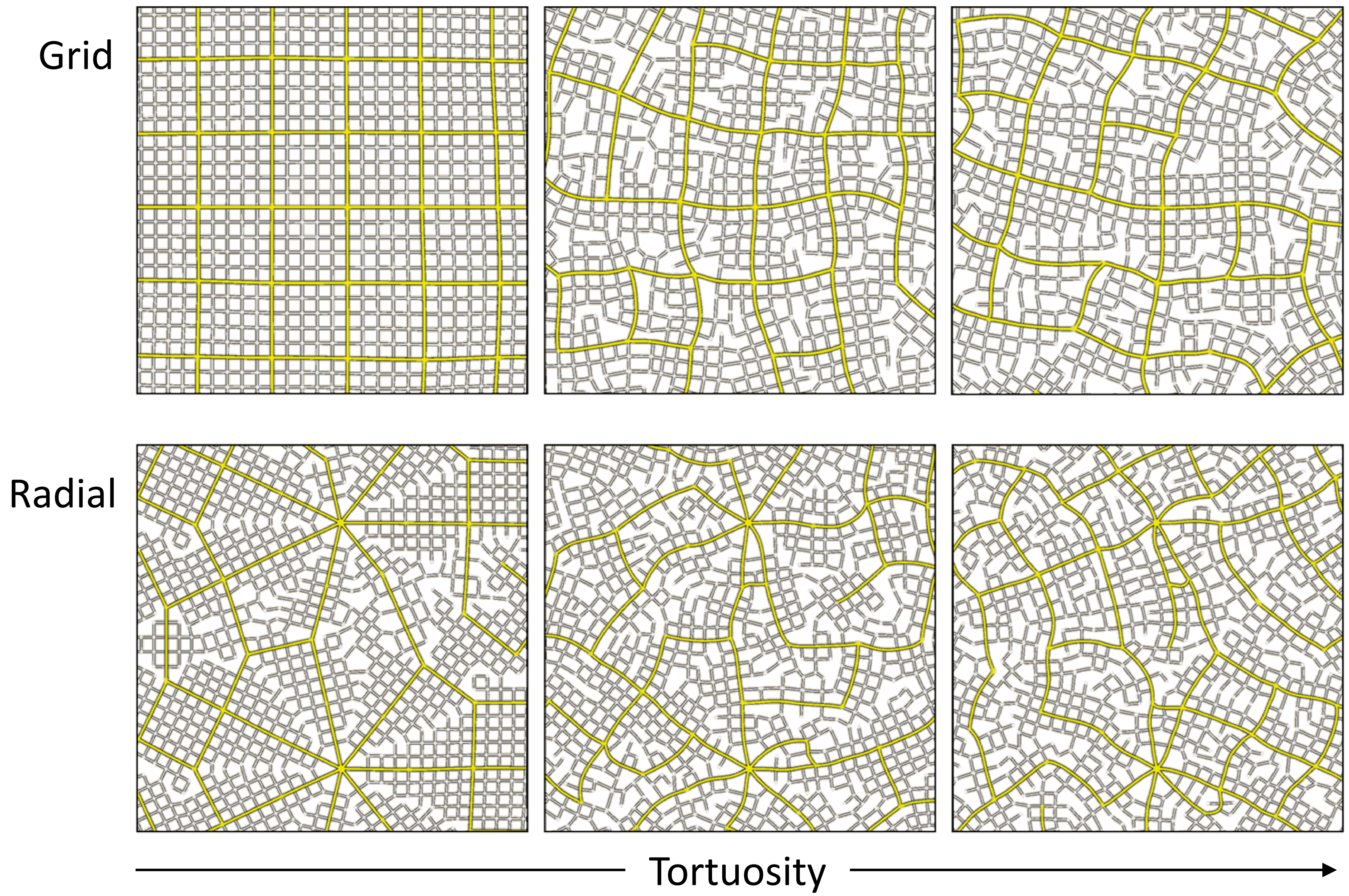

Interactive Geometric Simulation of 4D Cities

Vanegas, Aliaga, Benes, Waddell,
SIGGRAPH Asia 2009

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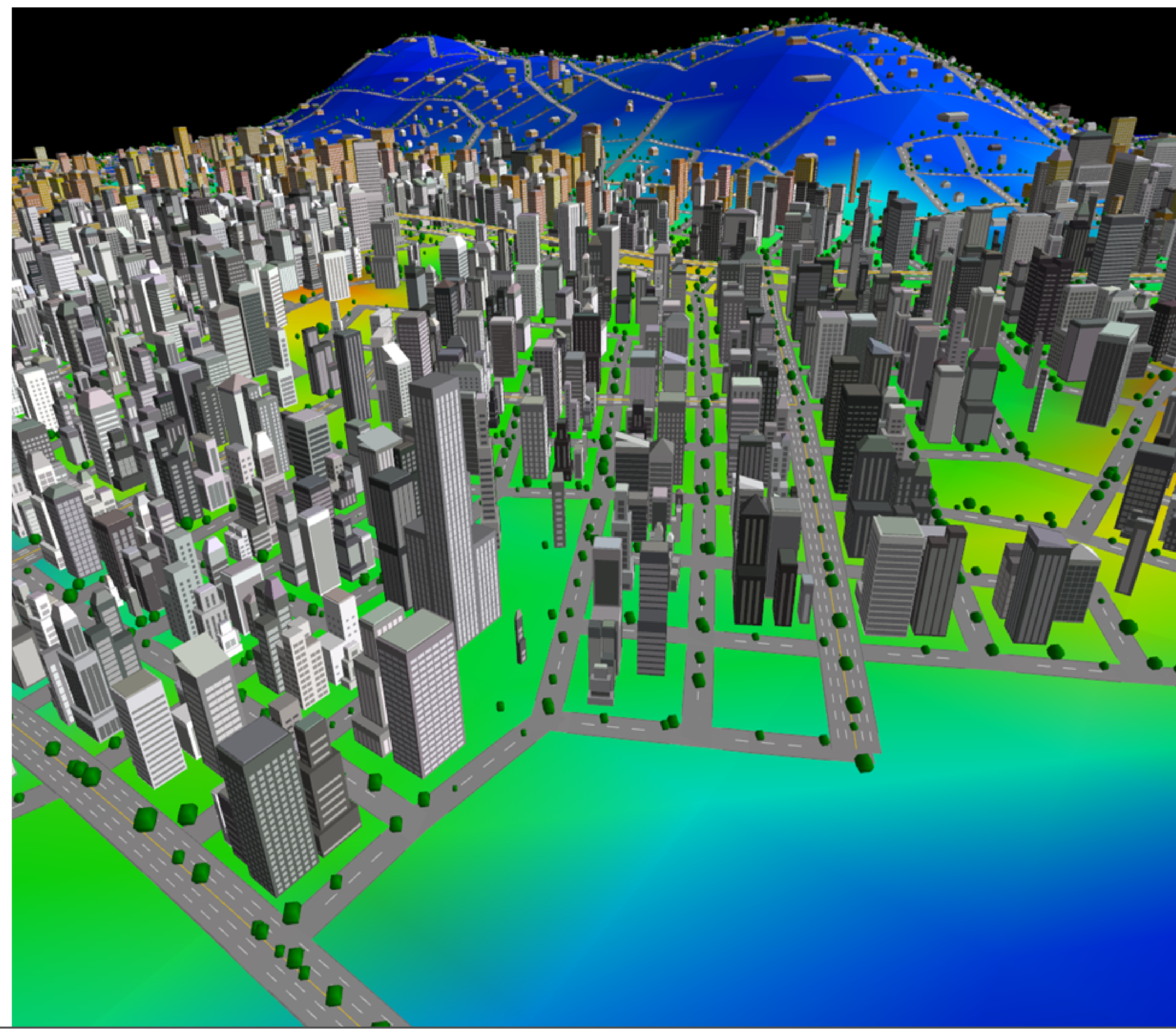
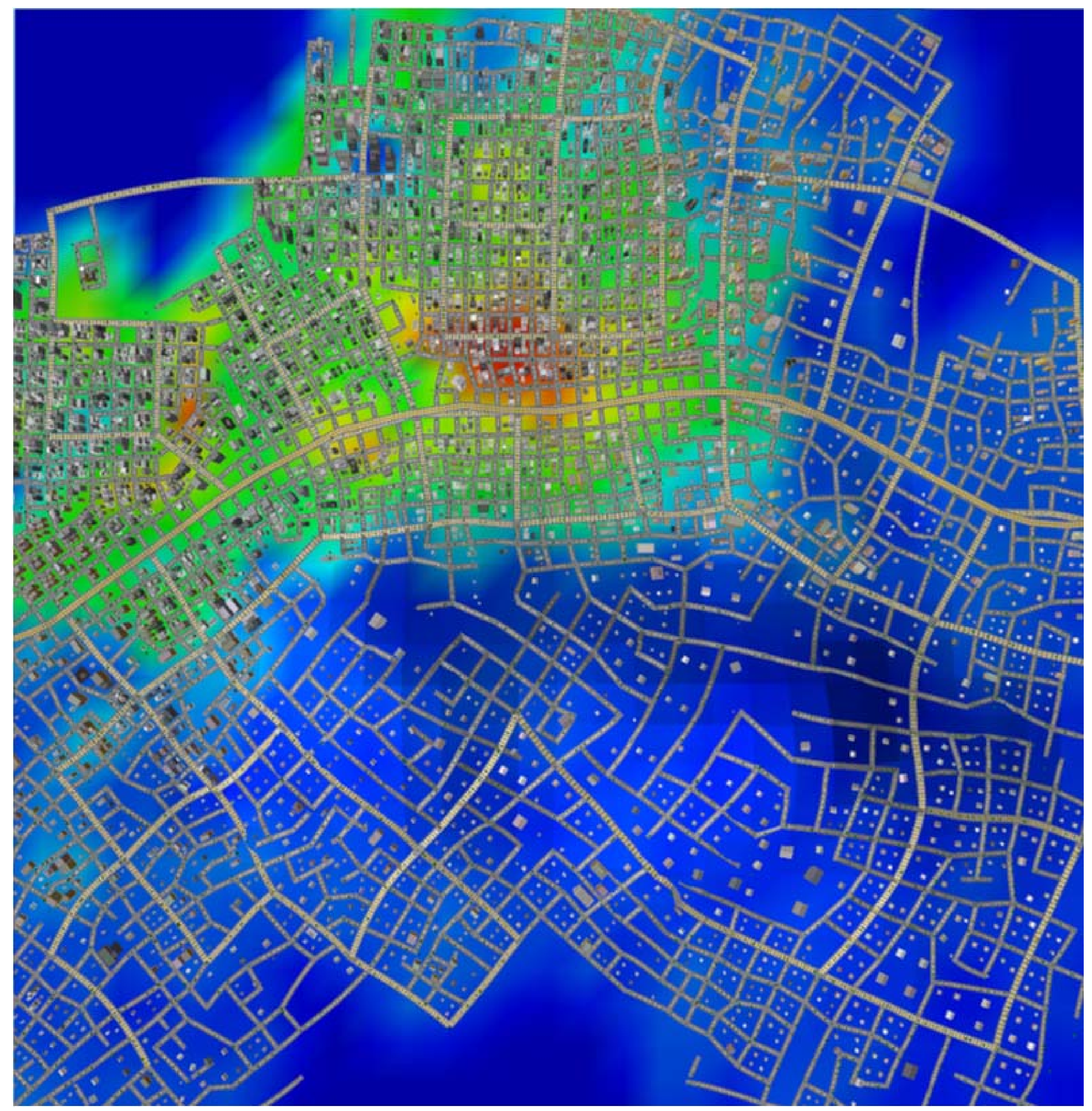
Interactive Geometric Simulation of 4D Cities
Vanegas, Aliaga, Benes, Waddell,
SIGGRAPH Asia 2009





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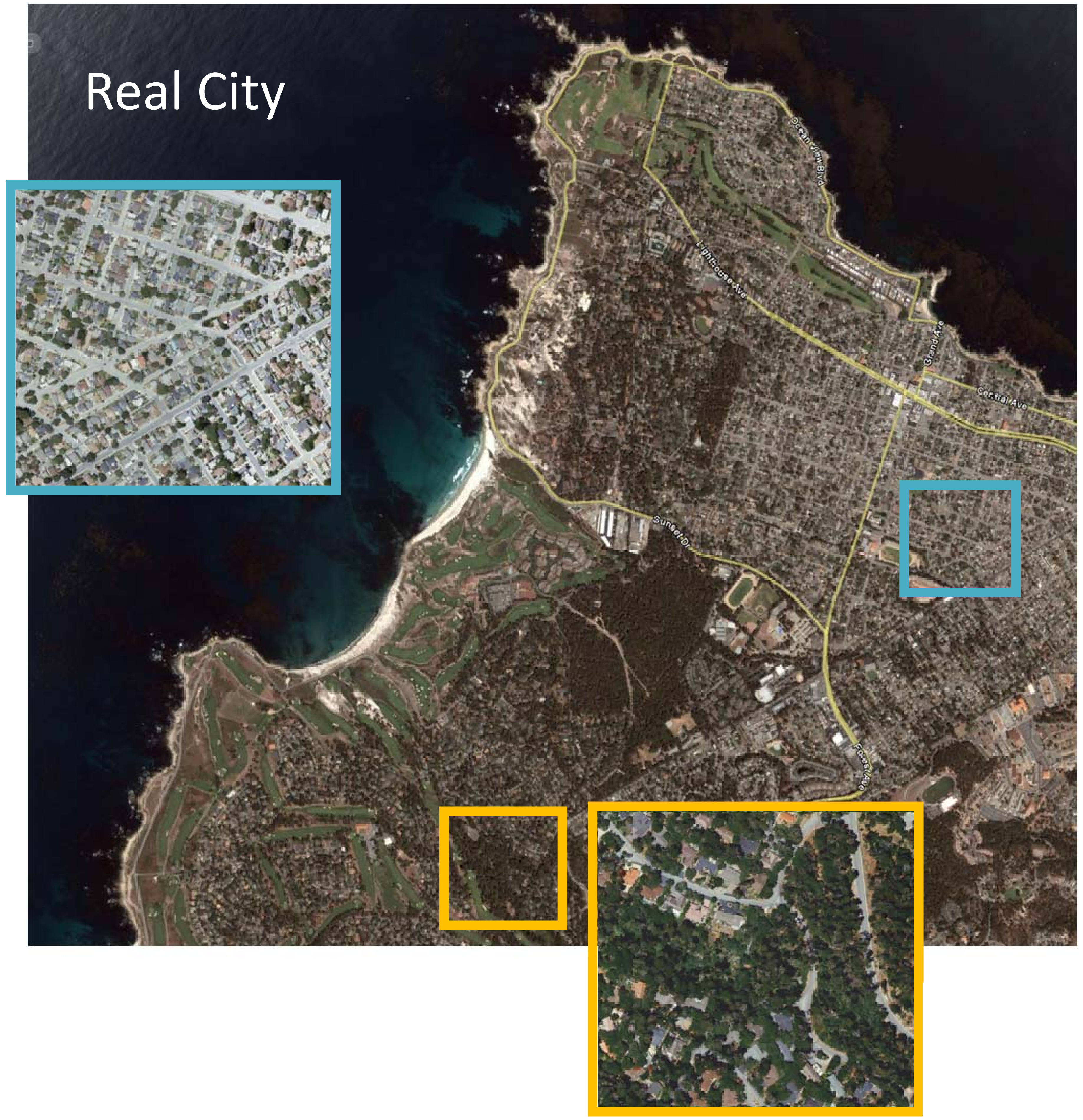

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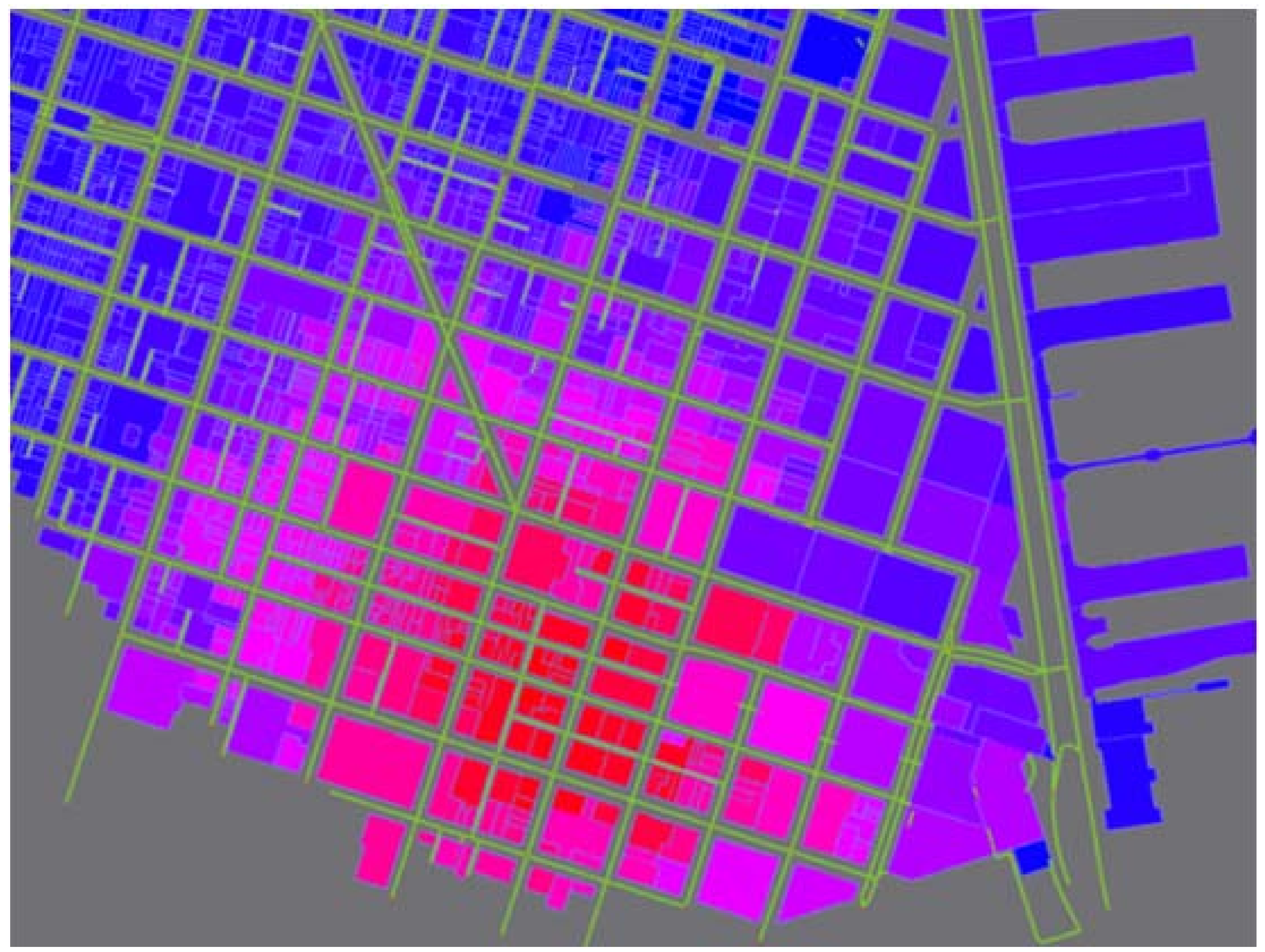
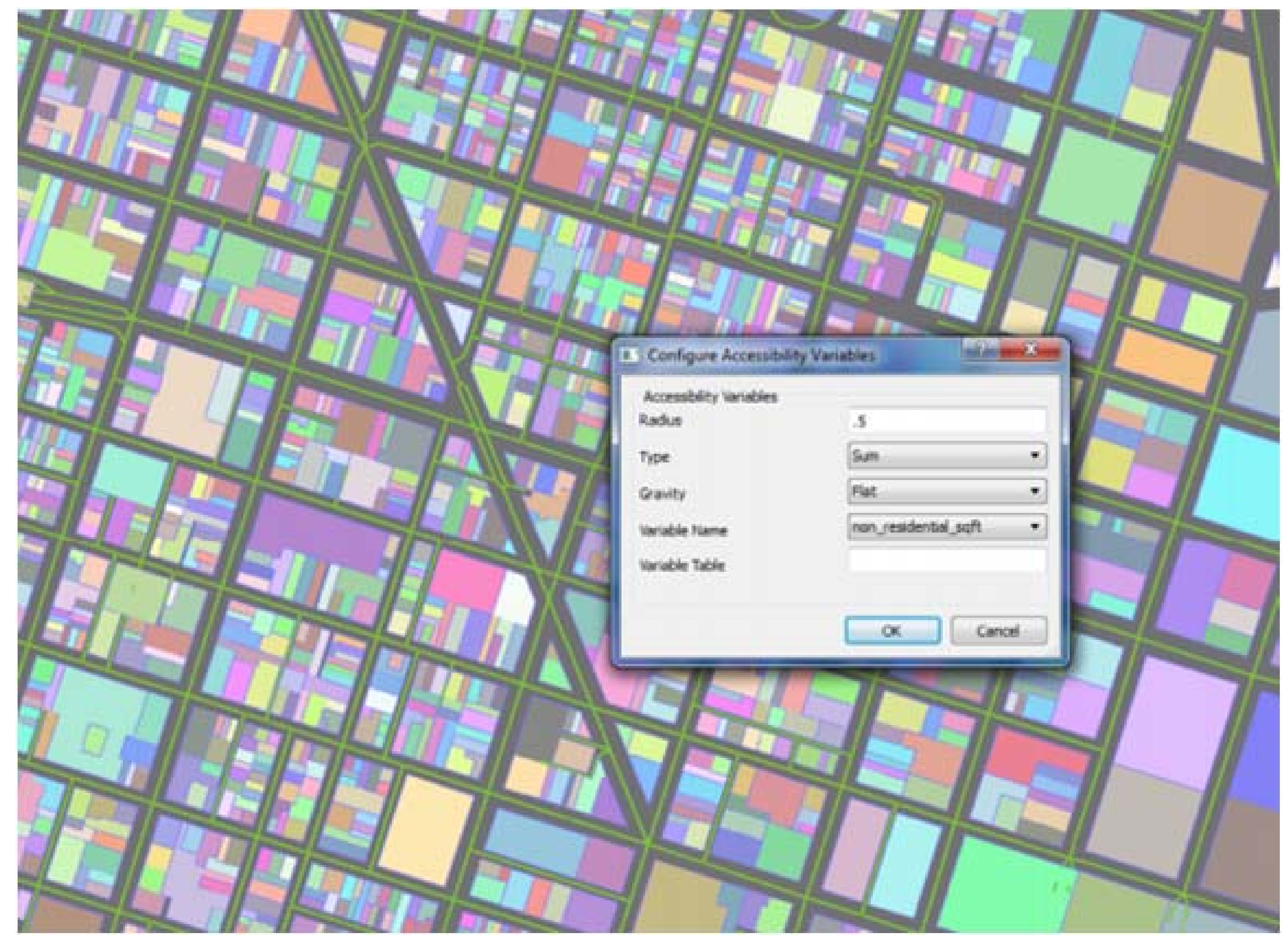
UrbanVision

Develop an open-source extension to UrbanSim to include geometric modeling for use in urban planning scenarios





BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Deployment - San Francisco Bay Area

7+ million people, 1.5 million parcels, 7000 square miles

Purdue University, UCL Berkeley

BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Limitations of existing urban simulation systems

Difficult to specify what is to be simulated

(A) Simulation scenario (time)

(B) Area of interest (space) - e.g., Real Estate

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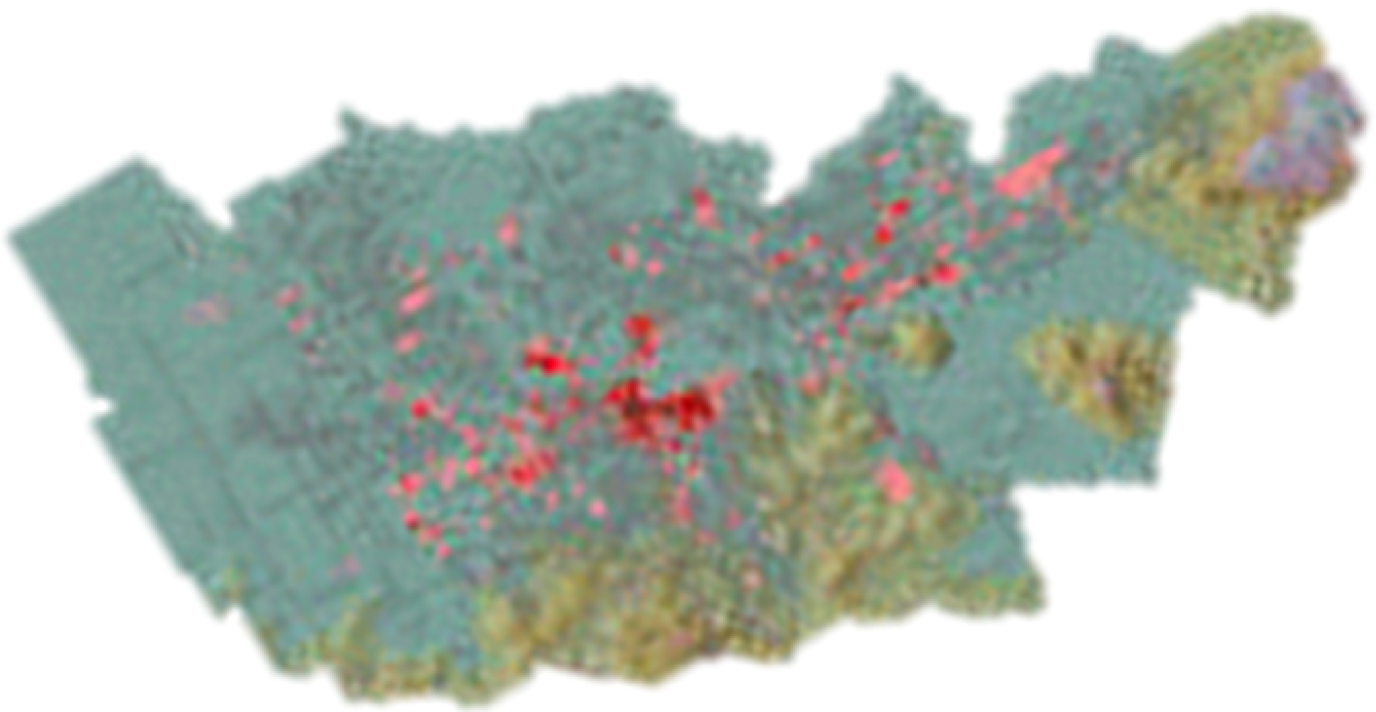

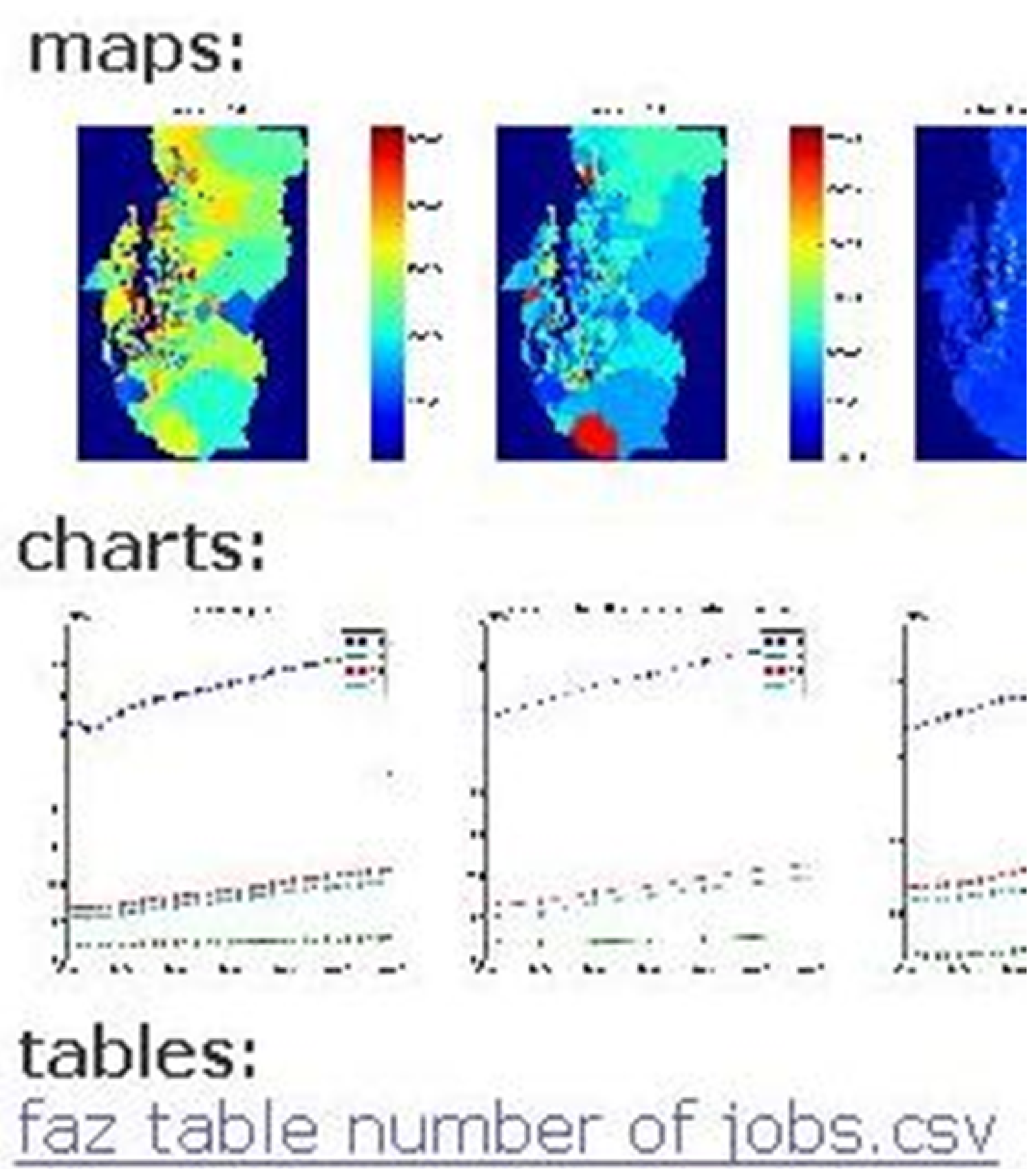

Limitations of existing urban simulation systems

Visualization of results

(A) Offline

(B) Lacks 3D content

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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Limitations of existing urban simulation systems

User interaction

(A) Limited to tables in databases

(B) Lacks "immersive" navigation

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Limitations of existing urban simulation systems

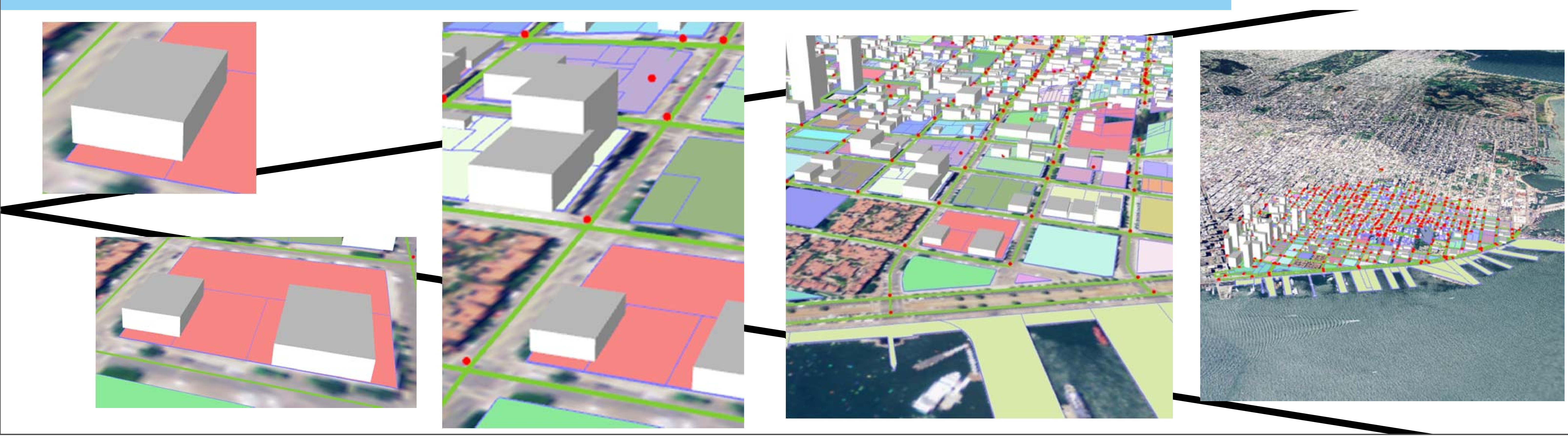
Isolation

No common framework for integration of different behavioral and geometric simulation models

BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Goals (1) - Open Source

Develop an open-source platform for a high-resolution representation and simulation of future urban landscapes for use in urban planning, design and simulation



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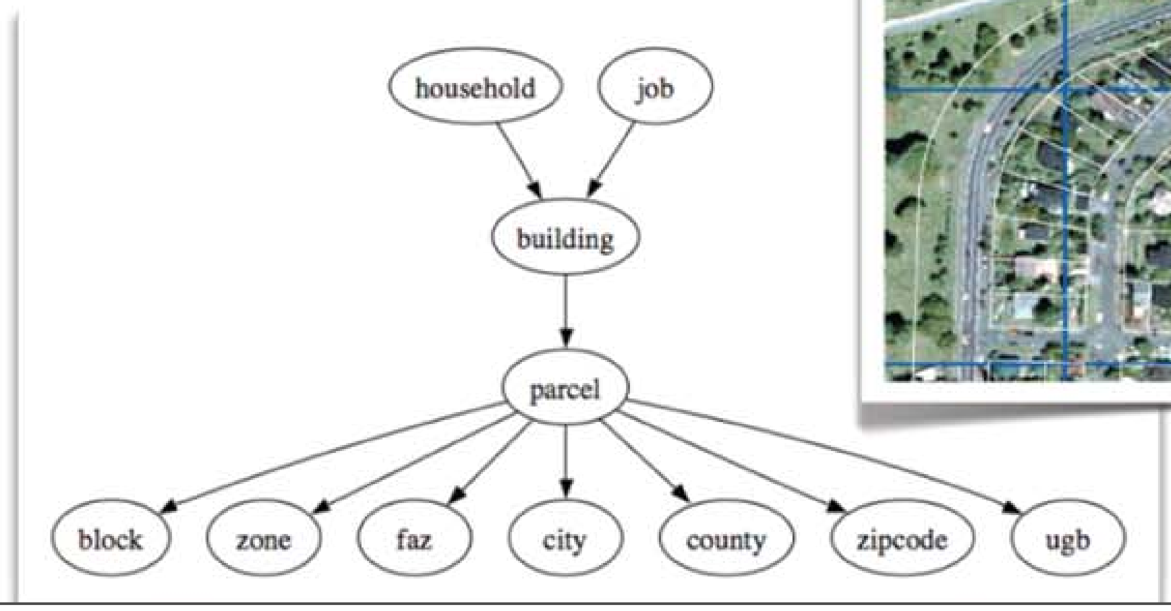
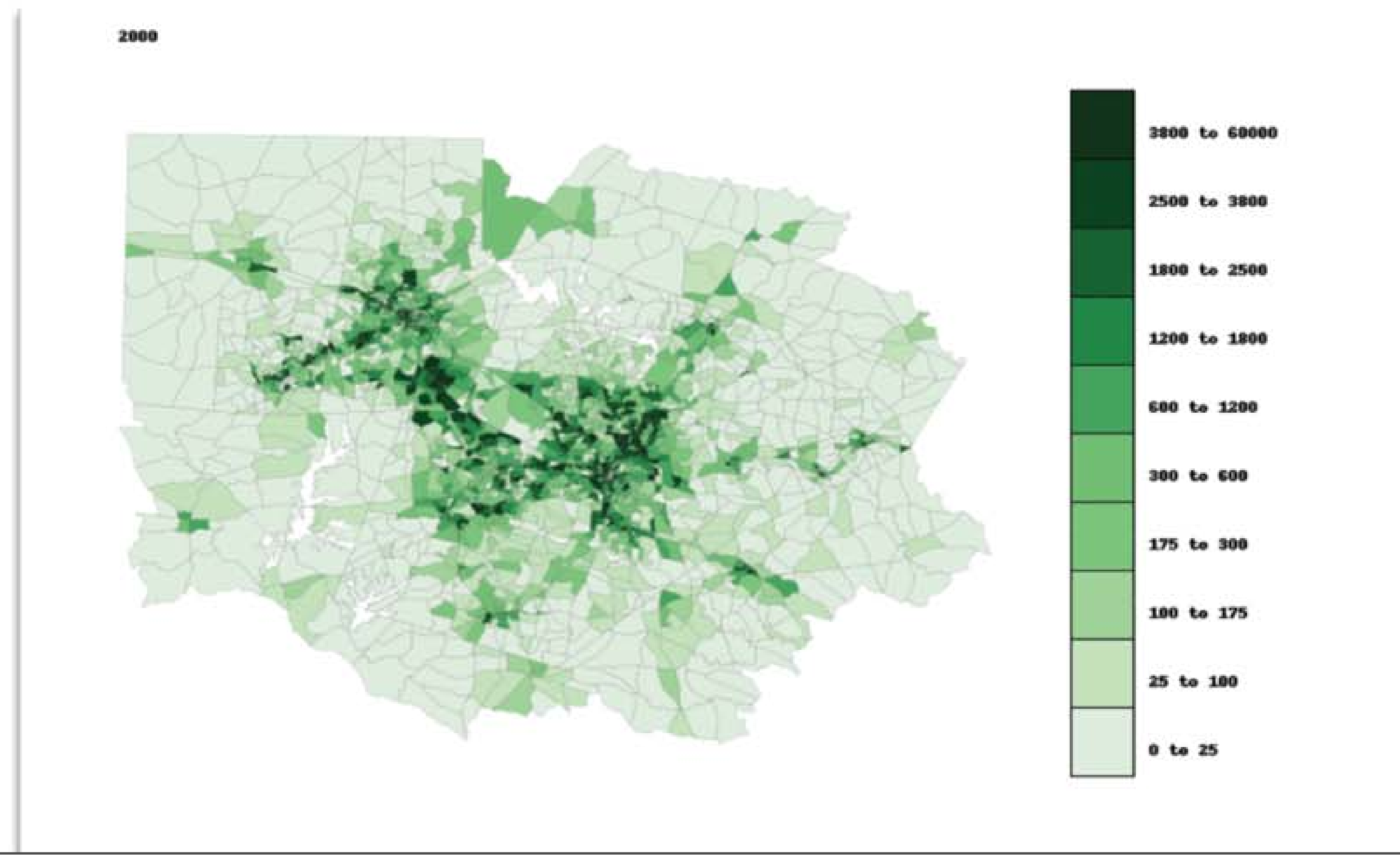
Goals (2) - Behavioral Simulation

Read, write, and simulate changes to buildings, streets, and patterns of urban development and transportation and environmental conditions over time





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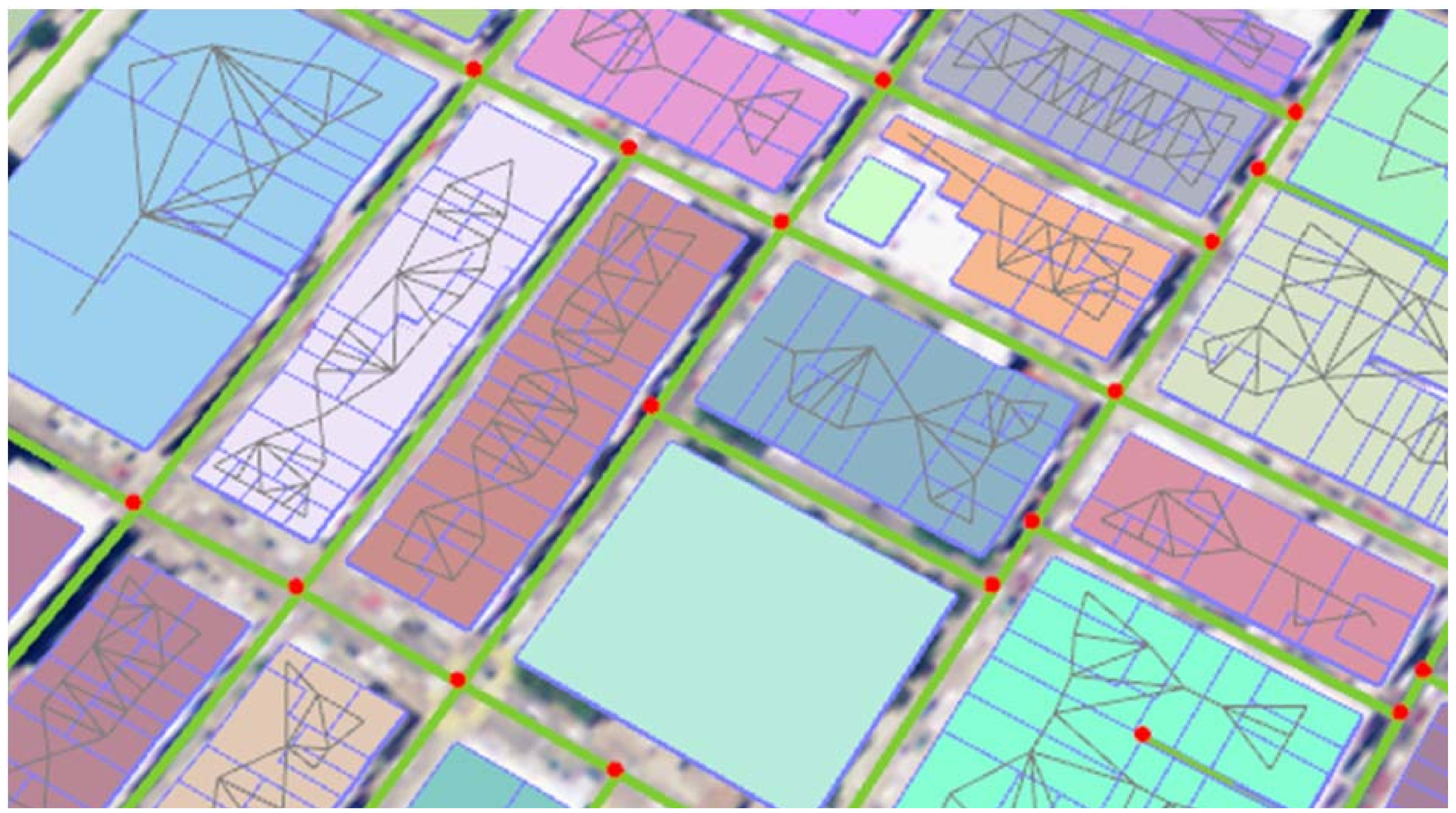
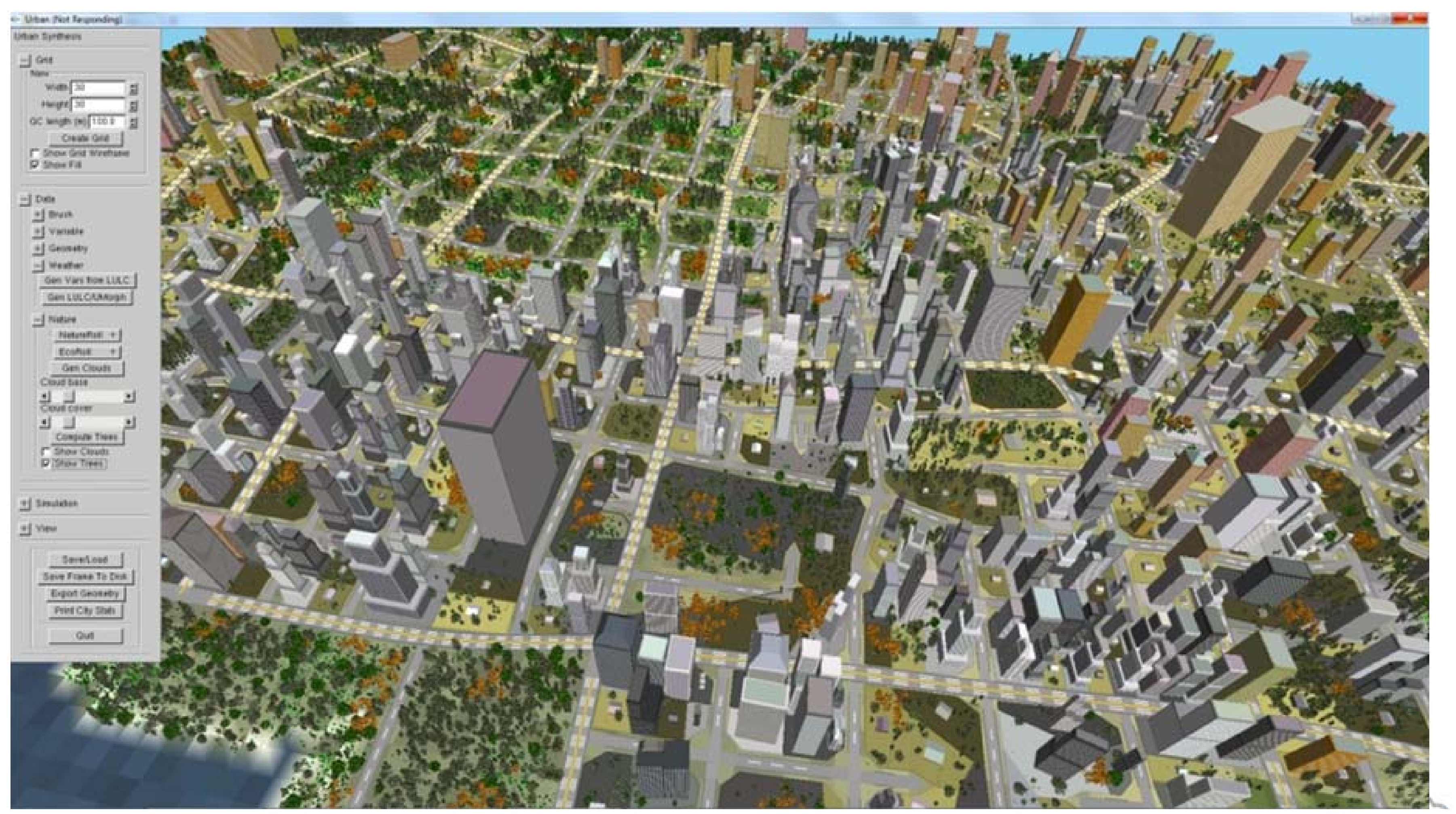
Goals (3) - Geometric Simulation

Model current and future simulated scenarios with geometric structures including streets, buildings, vegetation, pedestrians and vehicles.





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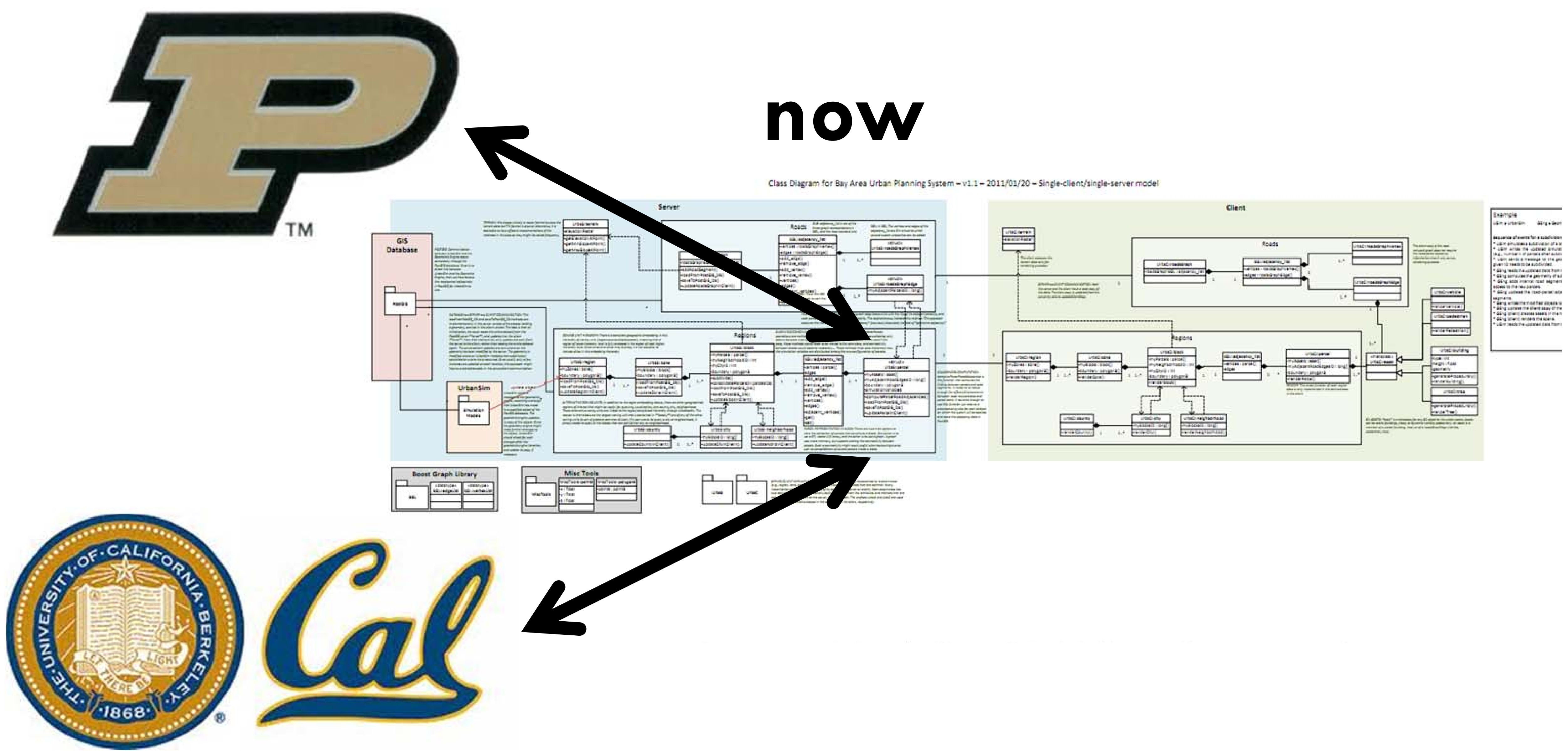
Goals (4) - Robust Integration

Develop a common API to make it easy to interface current and future models and visualization functionality in ways that are (fast) and modular



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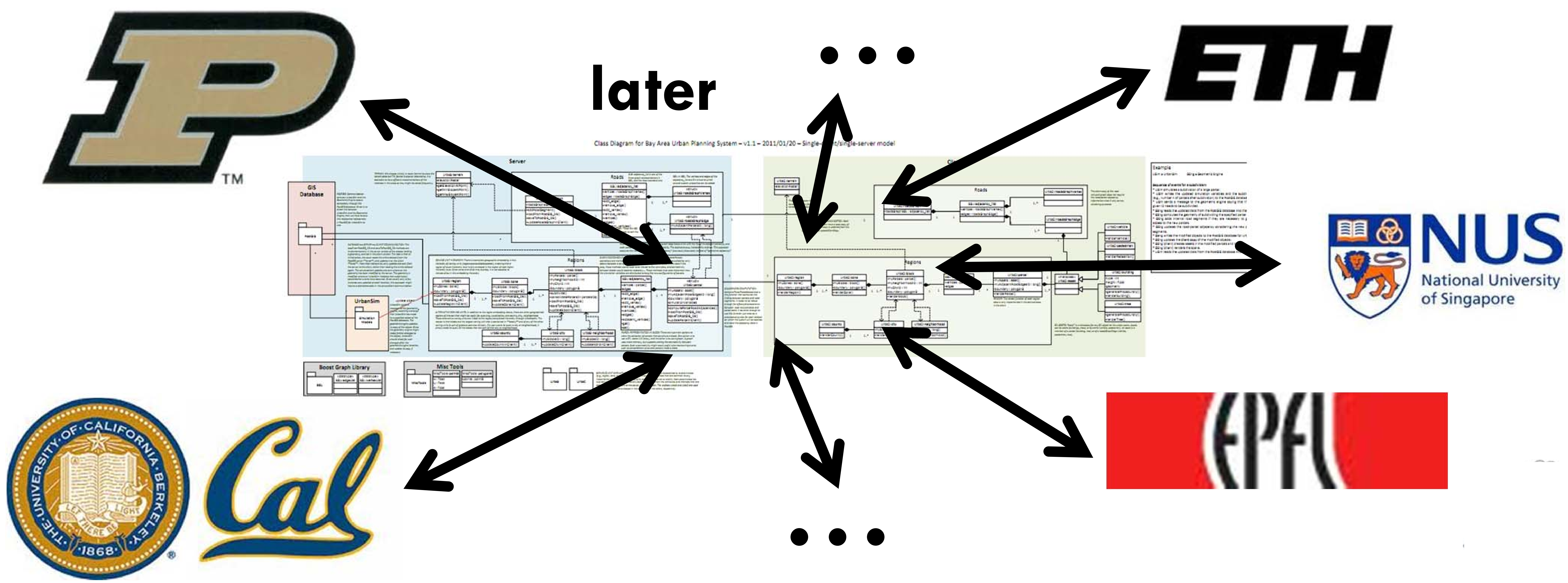
Goals (4) - Robust Integration



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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Who will use this system?

Initially
Metropolitan Transportation Commission
Association of Bay Area Governments

What for?
To support public engagement in the Sustainable Communities Strategies planning process

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BRIDGING THE GAP BETWEEN URBAN SIMULATION AND URBAN MODELING

Who will use this system?

Later
City Governments and planning agencies

Community

Other research projects in urban simulation, modeling

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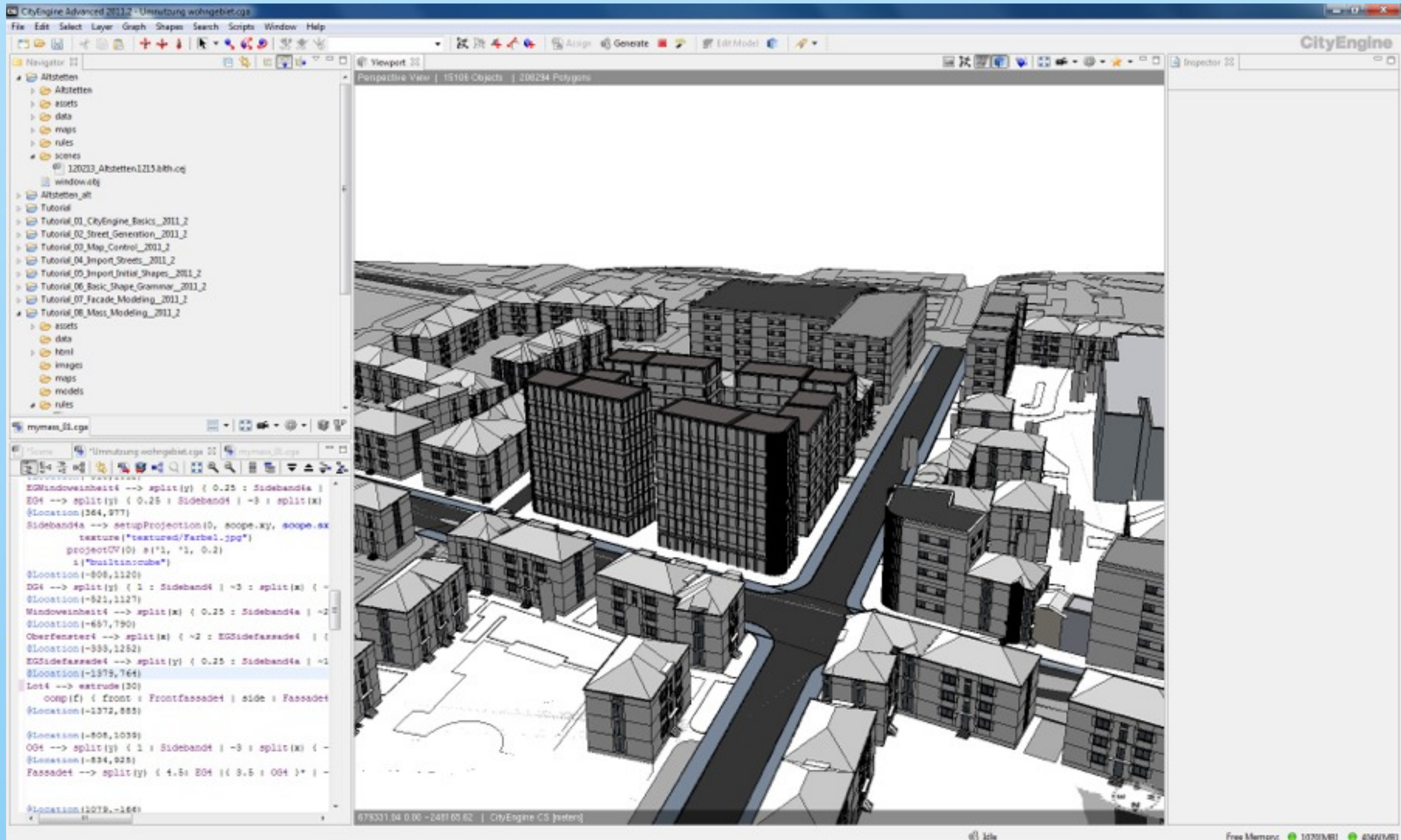
STUDENT WORK
E04 ECOTECT



City Engine Scene
Source: Student Arpad Hetey

City Engine Scene

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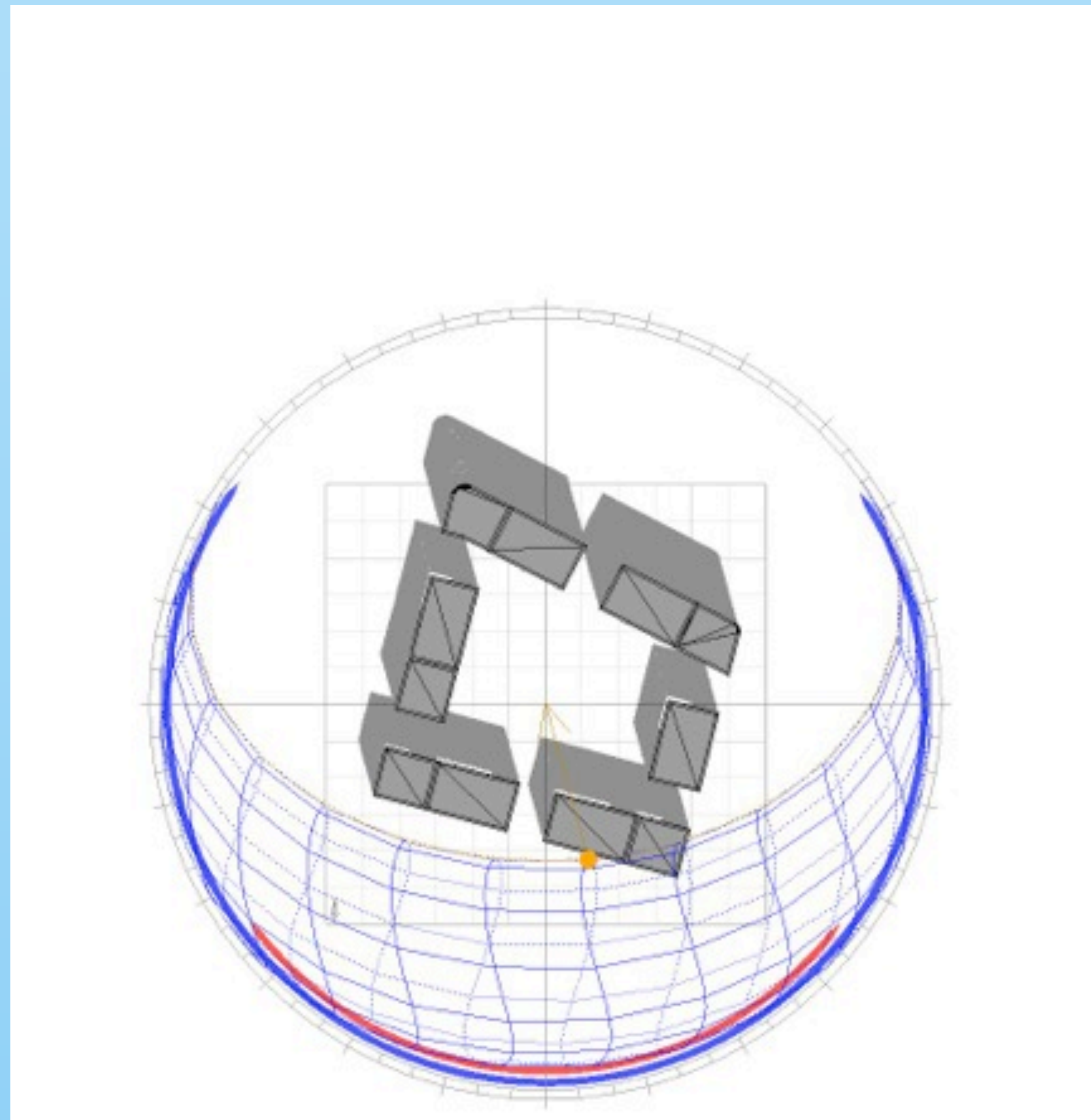
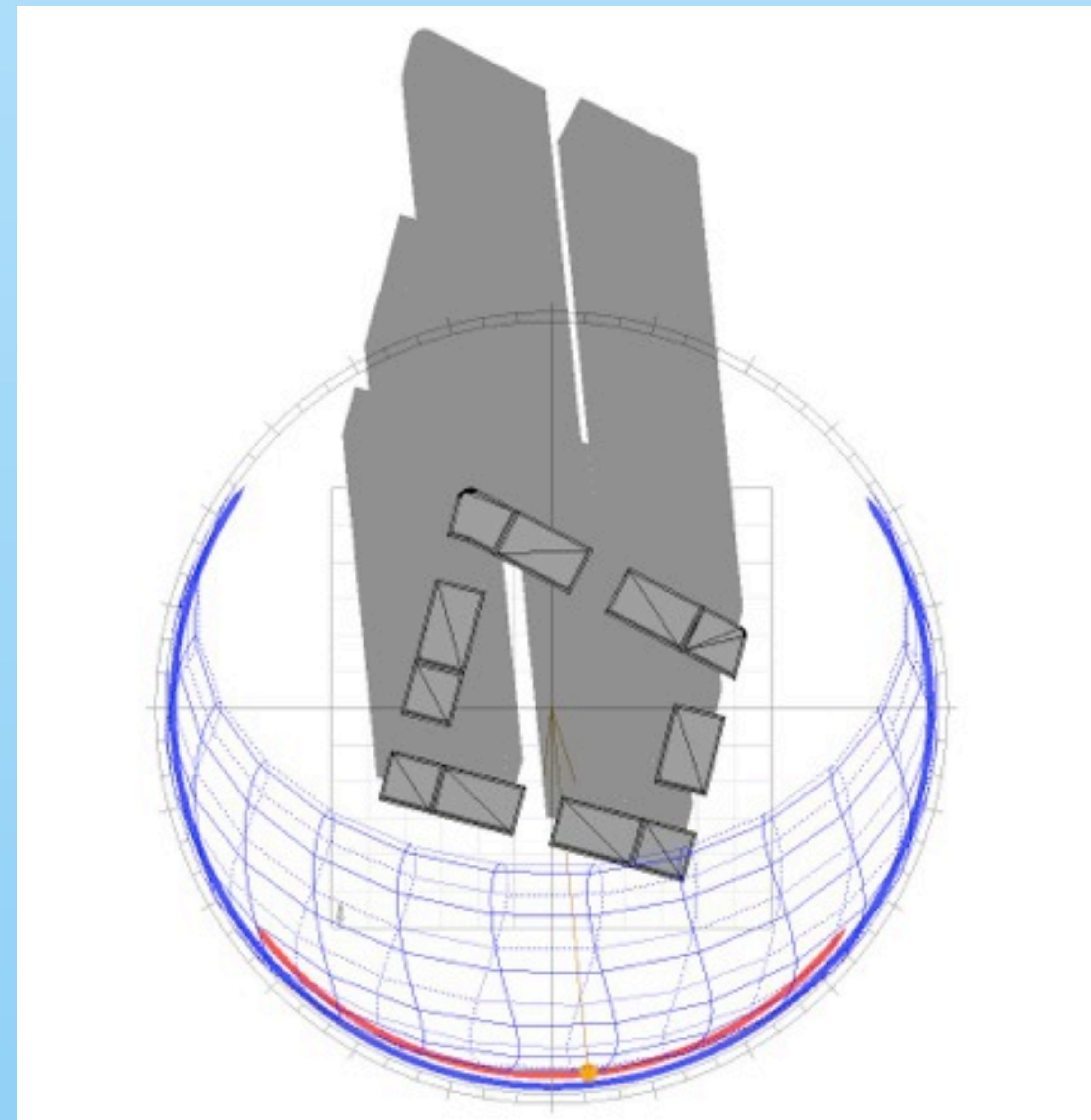
STUDENT WORK
E04 ECOTECT





Shadow images | 21.June and 21.December
Source: Student Arpad Hetey

Two shadow images (one for the 21st of June and one for the 21st of December) with the Daily Sun Path and the Annual Sun path.

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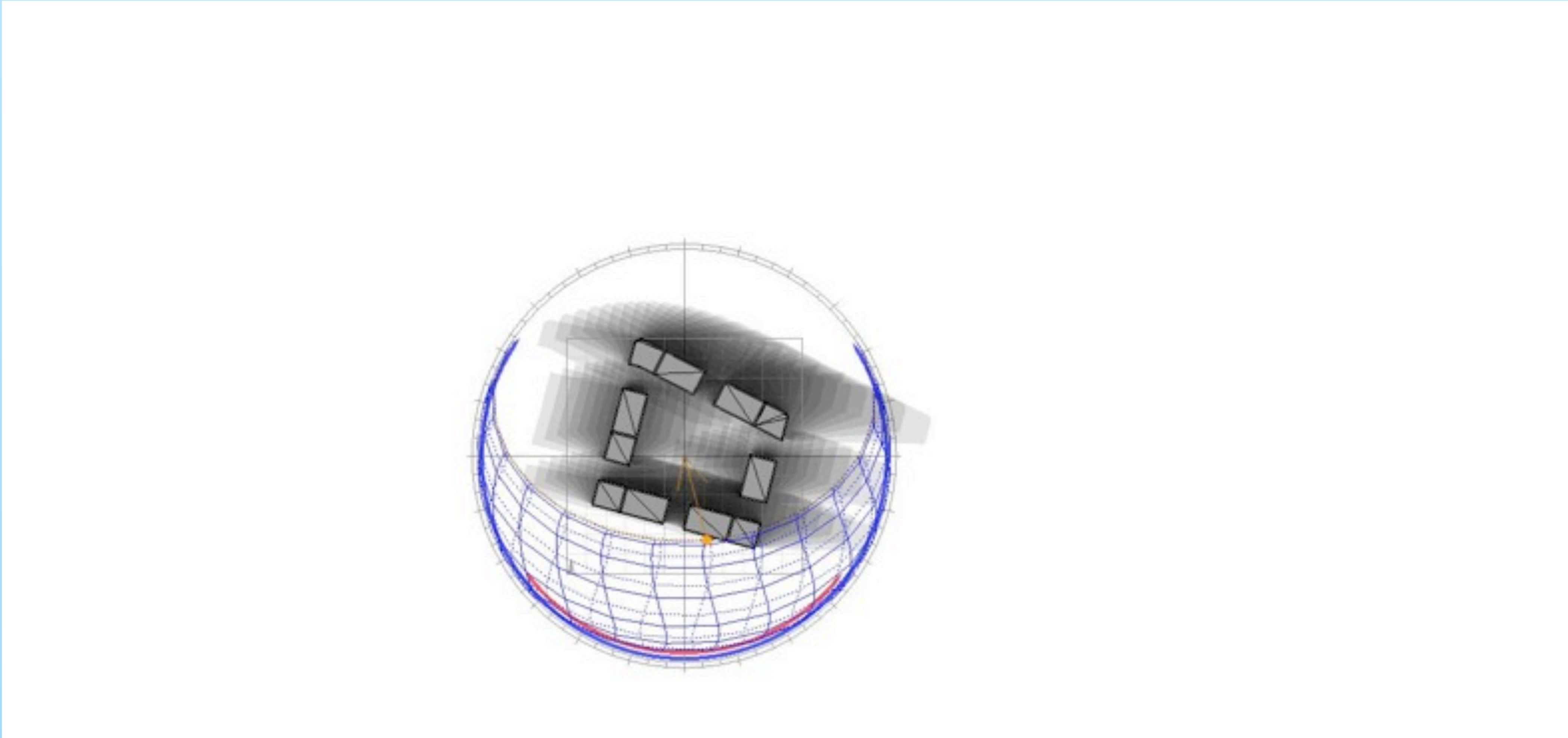
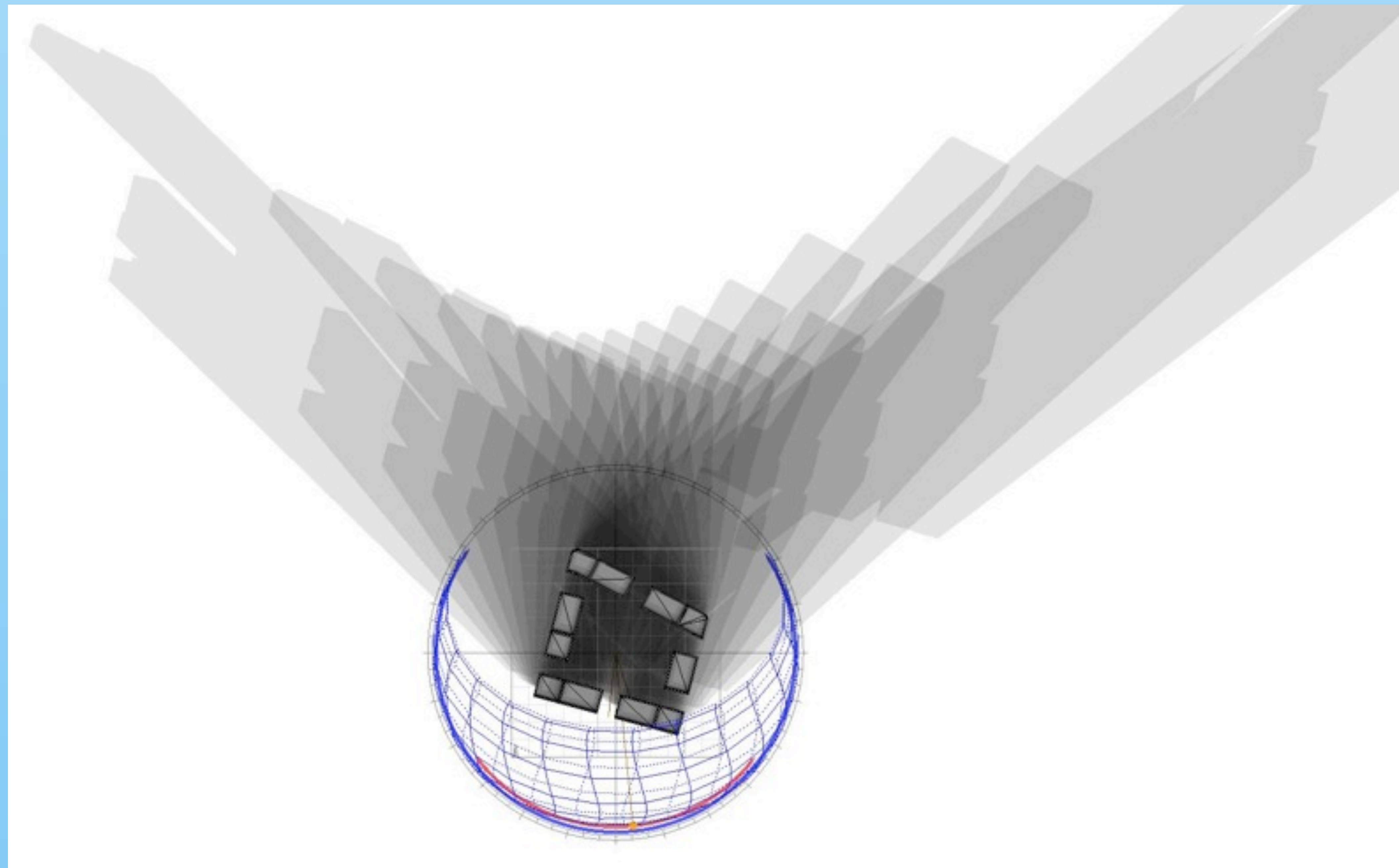
STUDENT WORK
E04 ECOTECT





Shadow range images | 21.June and 21.December
Source: Student Arpad Hetey

Two shadow range images (one for the 21st of June and one for the 21st of December). The rages have to go from 9:00 to 17:00.

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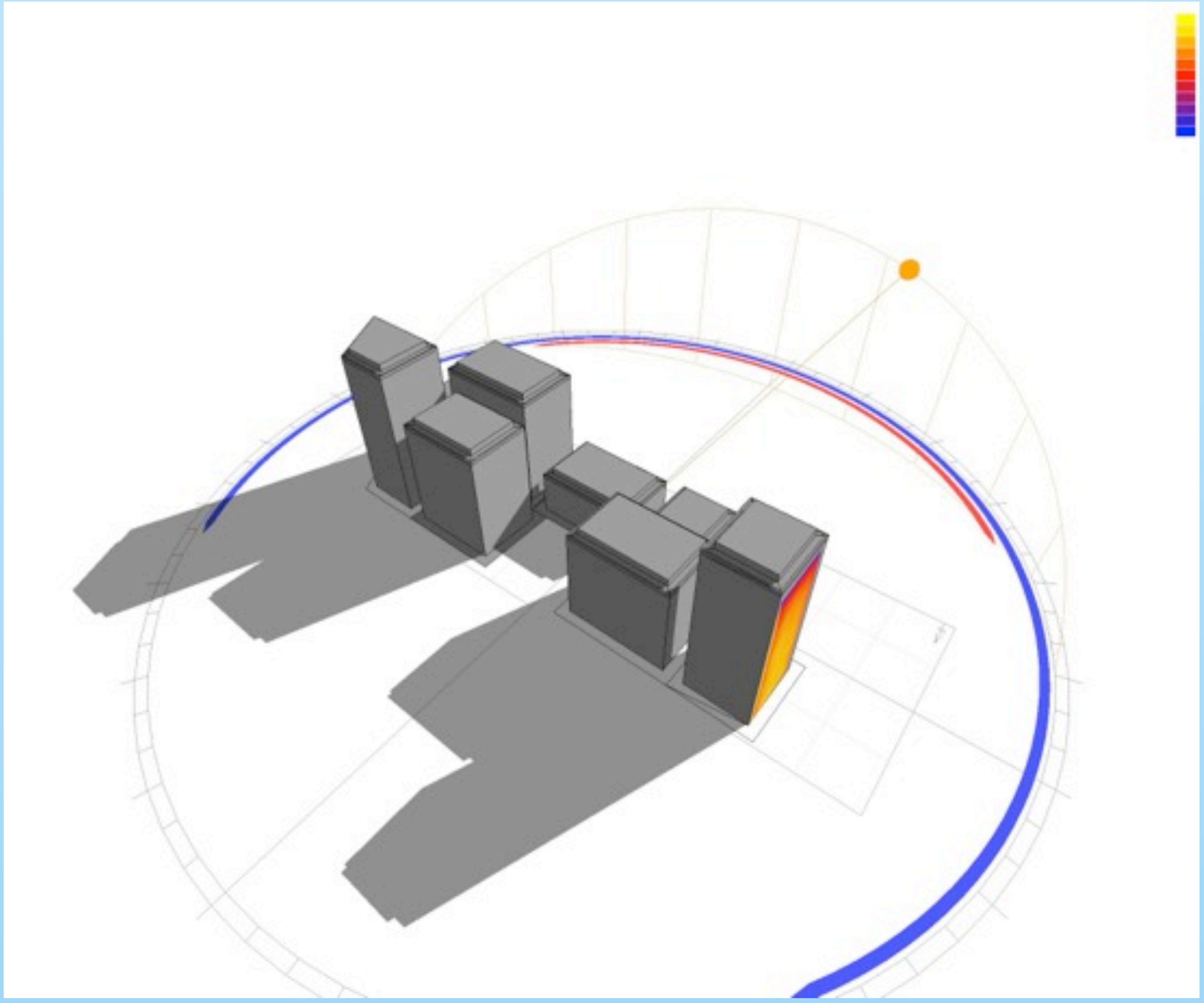
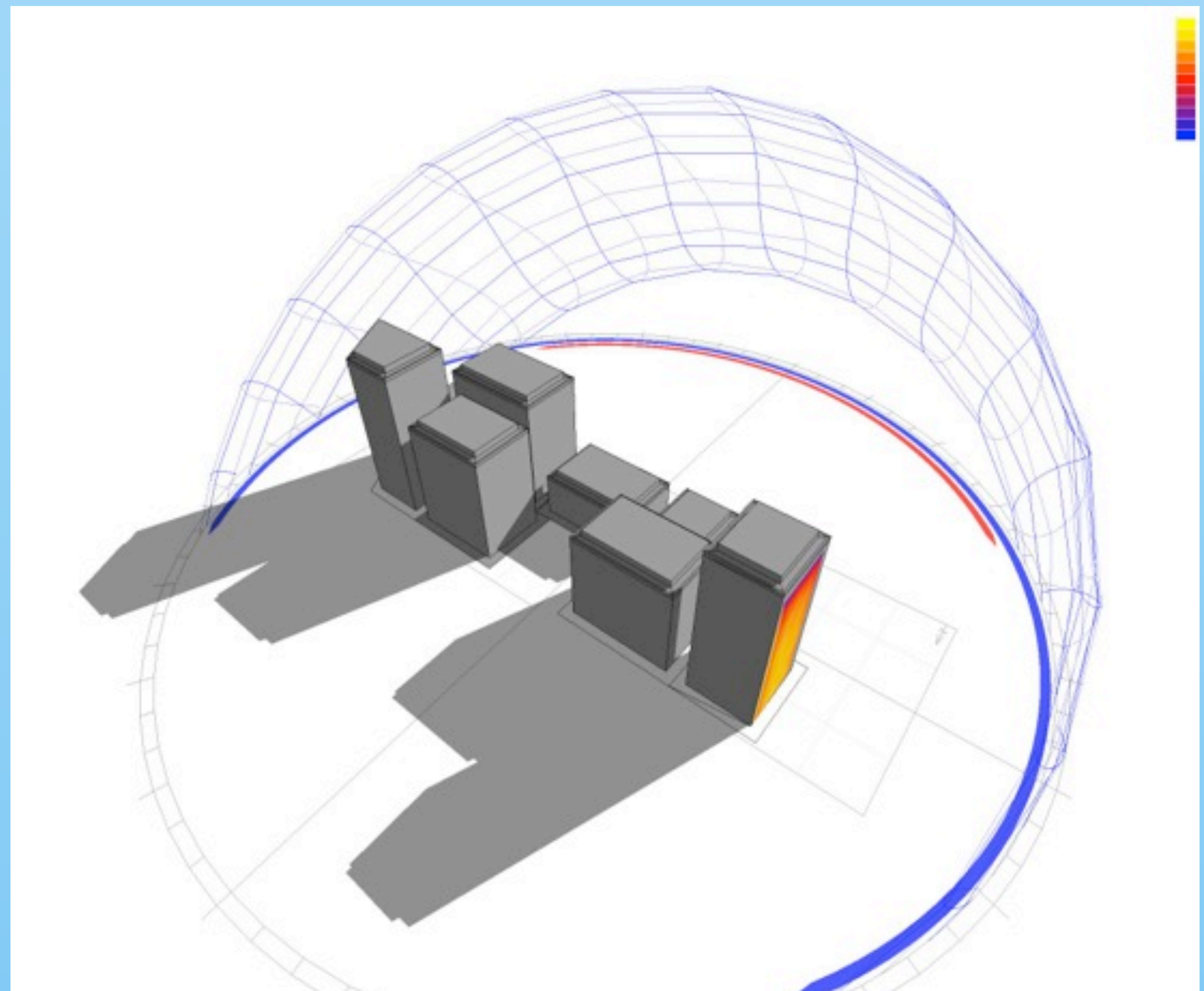
E04 ECOTECT





Shadow images | 21.October daily and 21.October annual
Source: Student Li Bo

Two shadow images (one for the 21st of June and one for the 21st of December) with the Daily Sun Path and the Annual Sun path.

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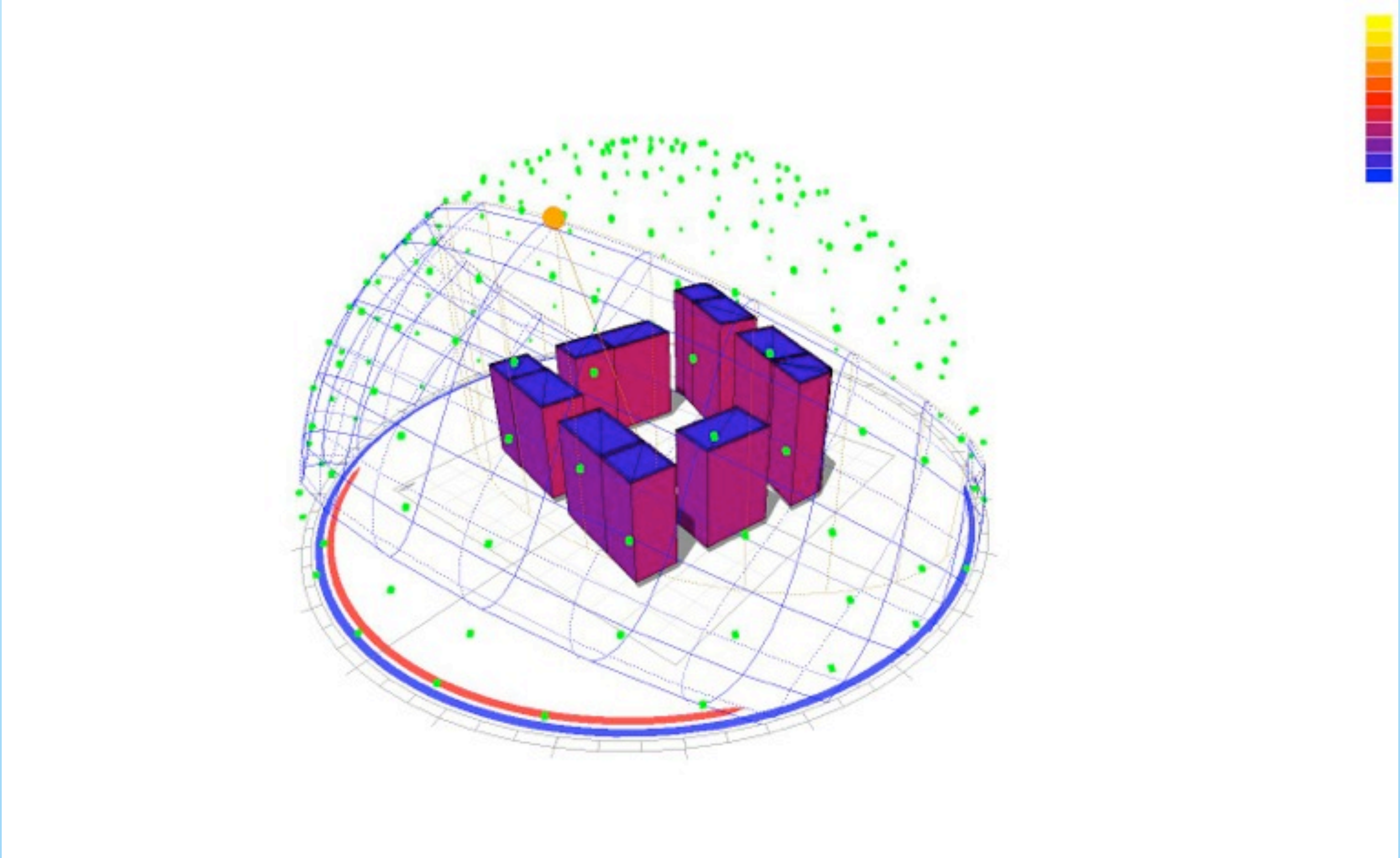

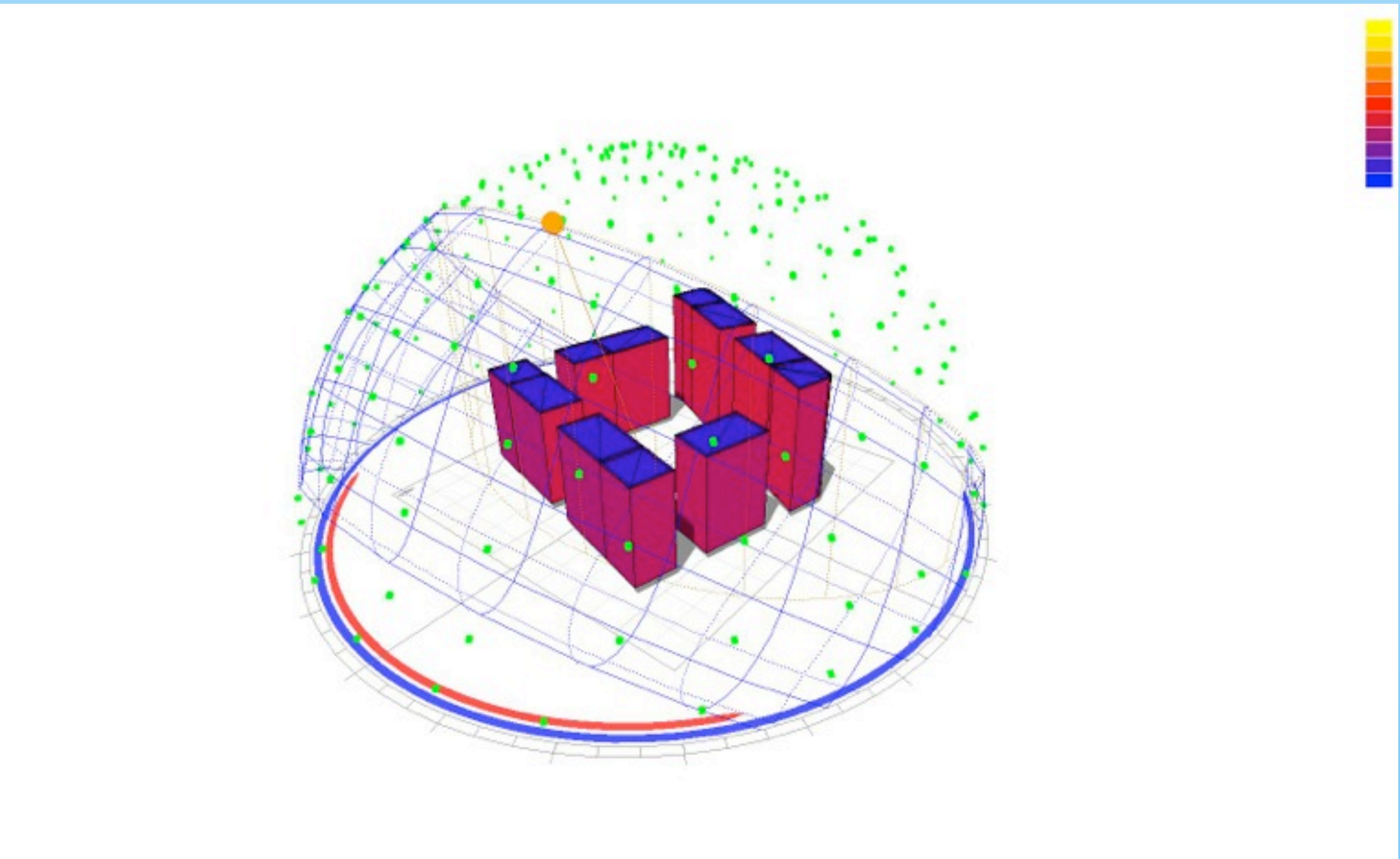

Solar Access Analysis |Summer and Winter
Source: Student Arpad Hetey

Two images for the Solar Access Analysis without setting the grid (one for summer and one for winter).

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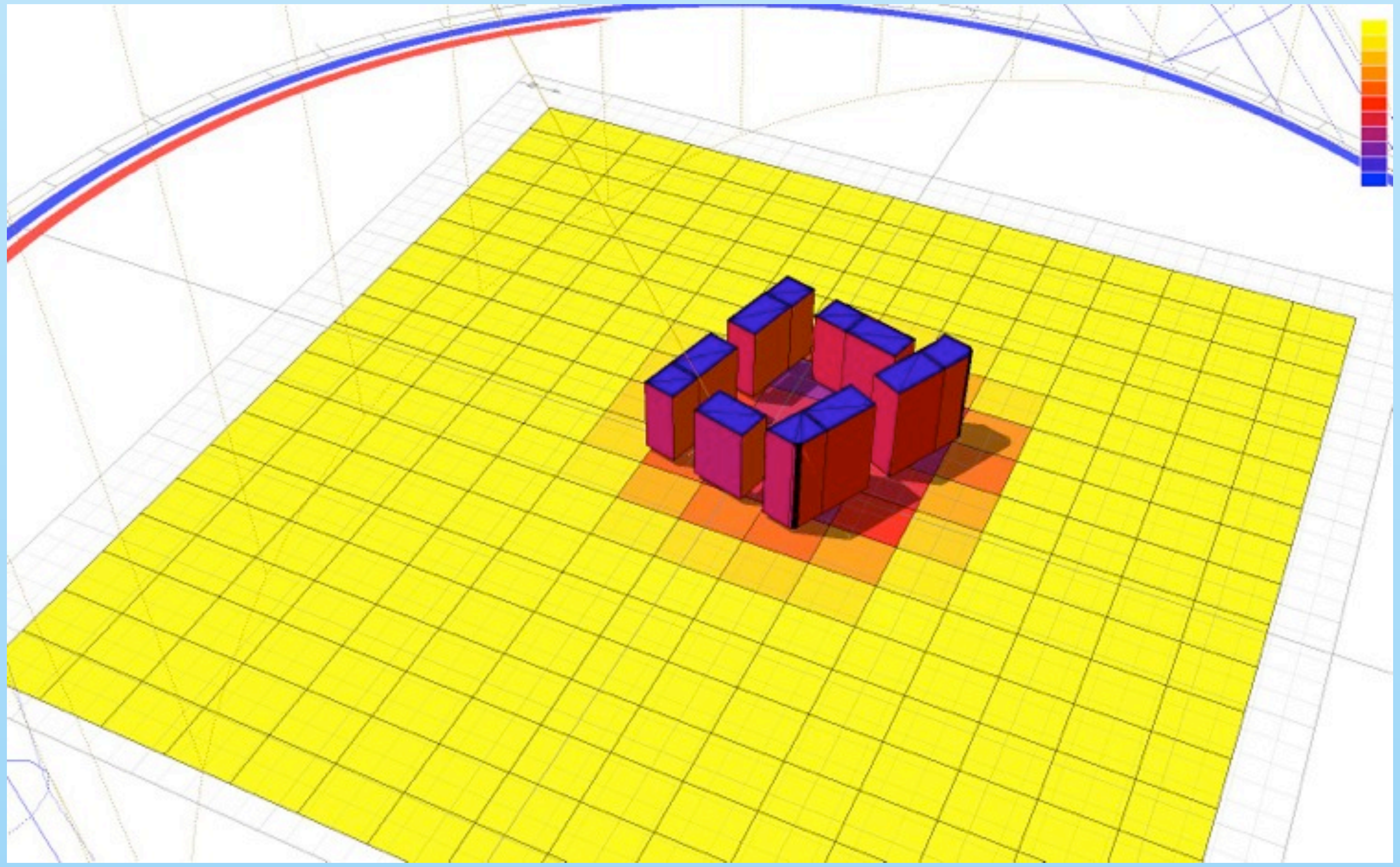

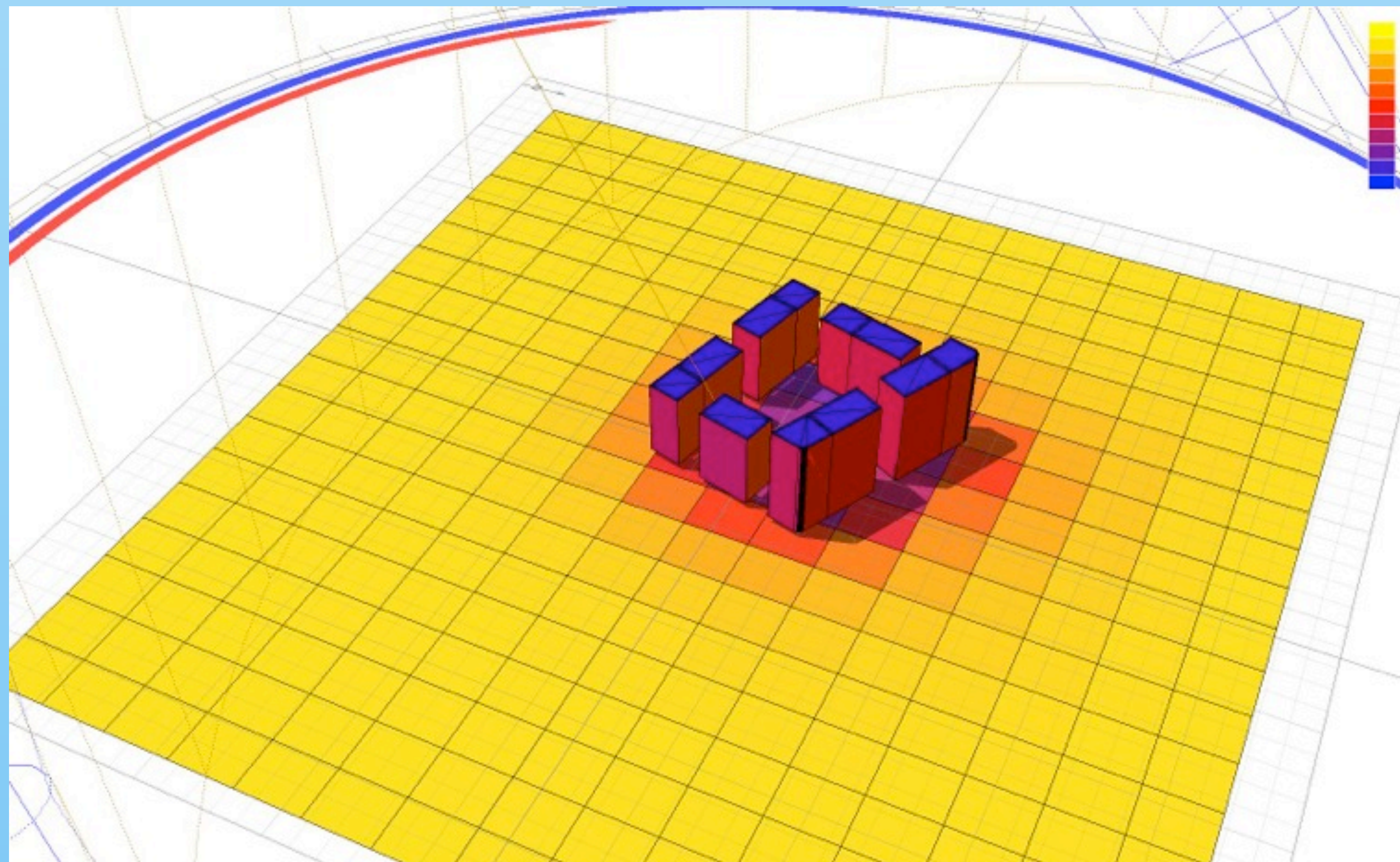

Solar Access Analysis |Summer and Winter
Source: Student Arpad Hetey

Two images for the Solar Access Analysis with the grid on the xy plane base (one for summer and one for winter).

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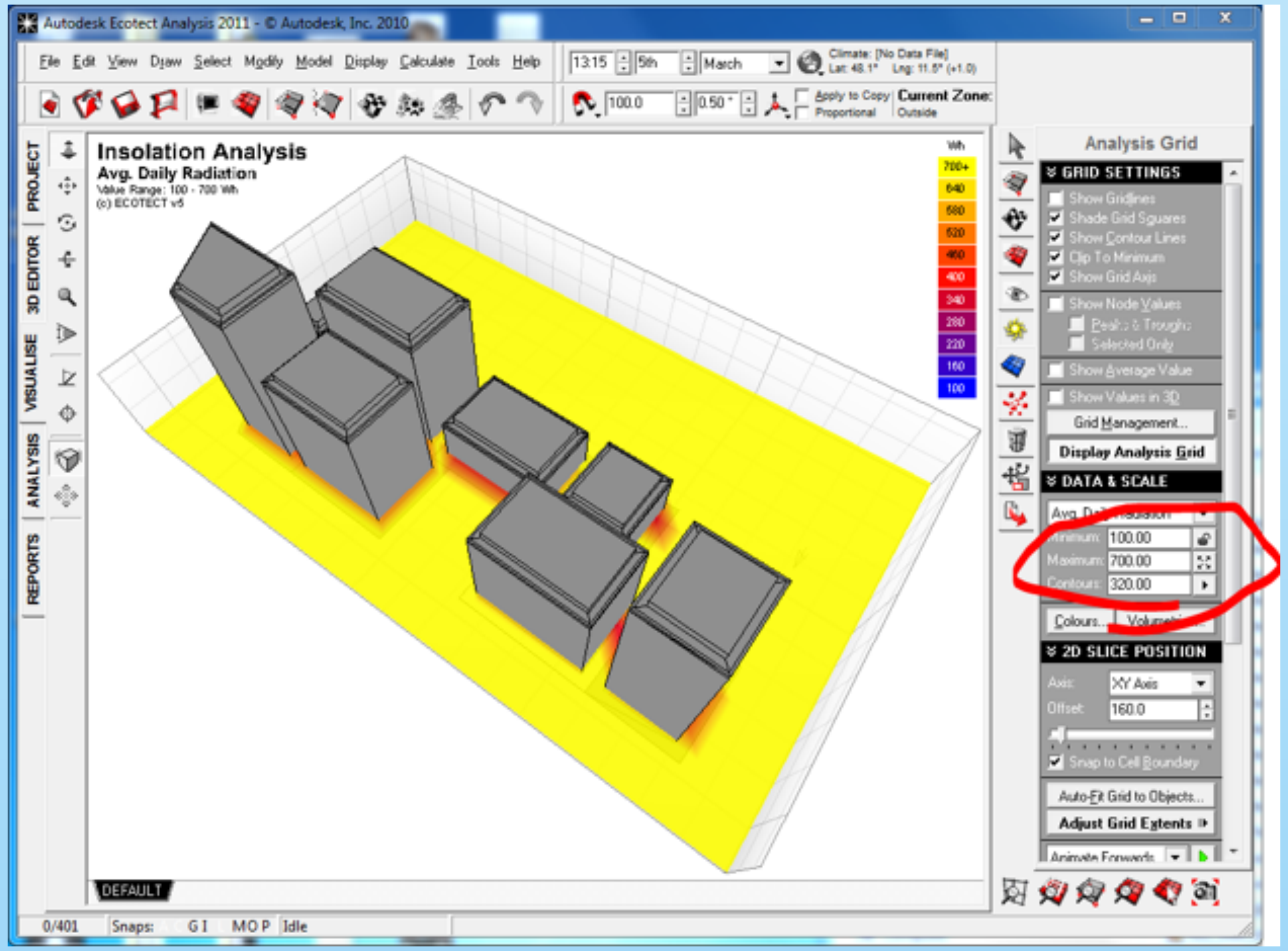
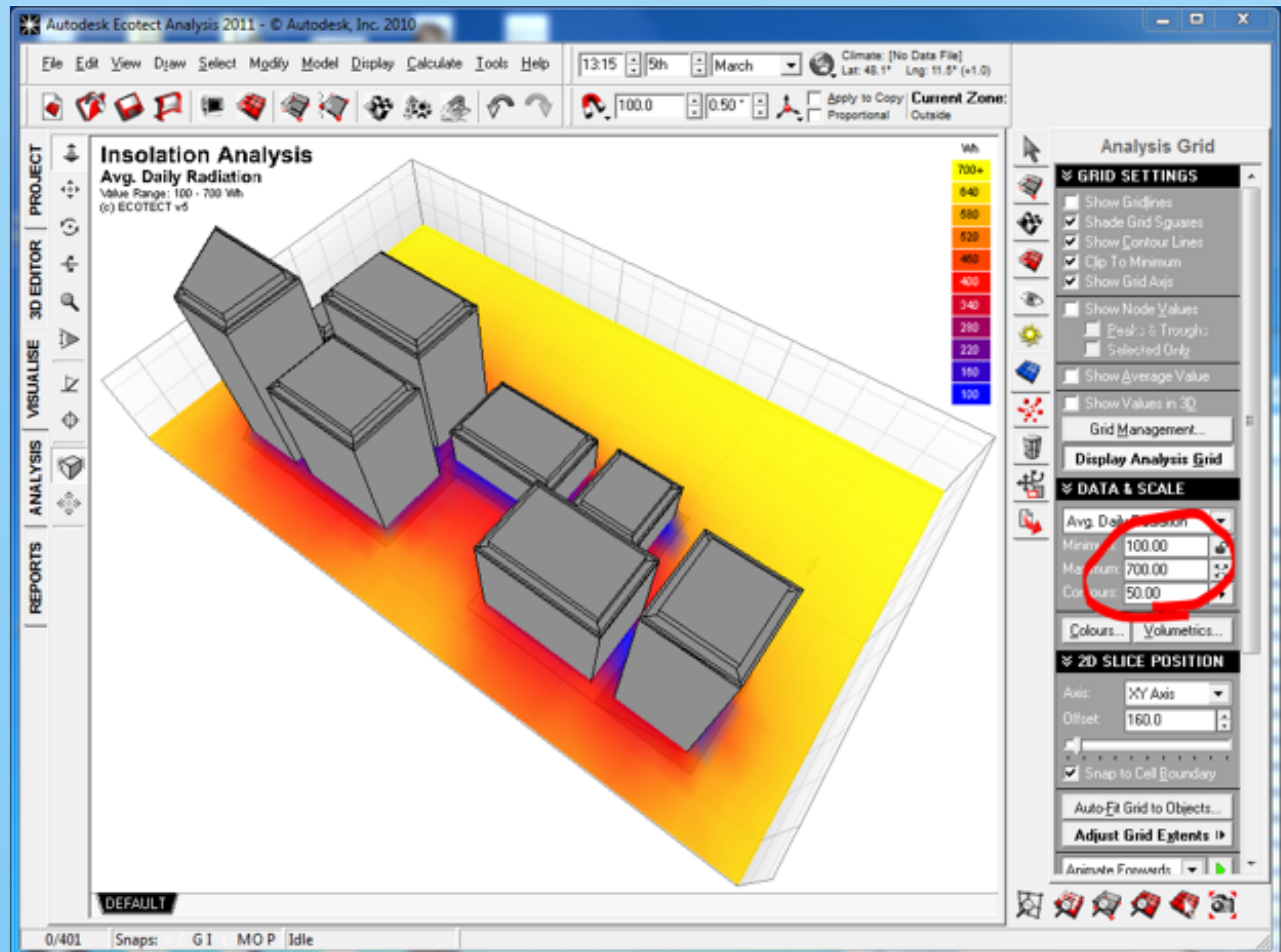
STUDENT WORK
E04 ECOTECT





Solar Access Analysis |Summer and Winter
Source: Student Li Bo

Two images for the Solar Access Analysis with the grid on the xy plane base (one for summer and one for winter).

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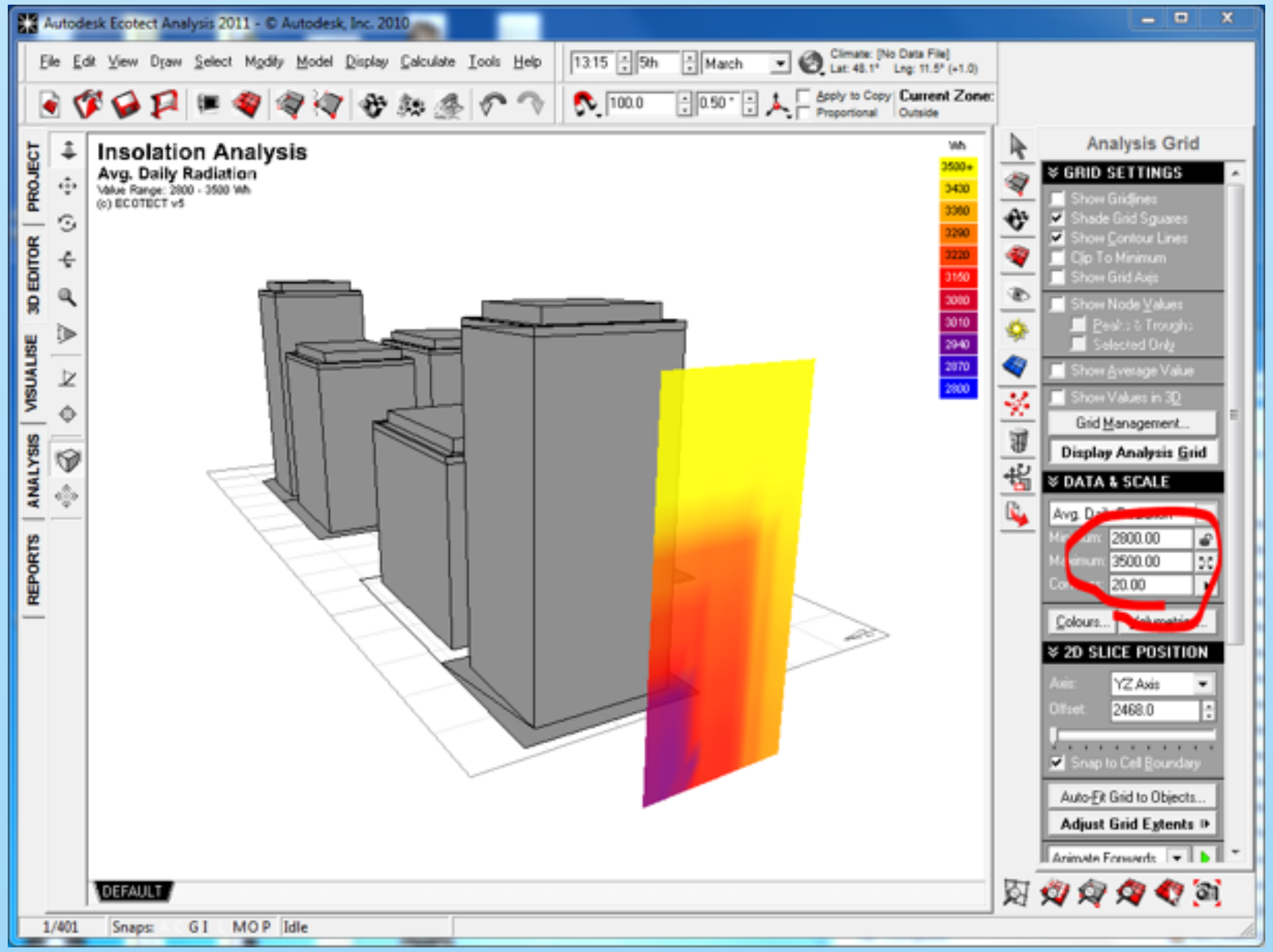

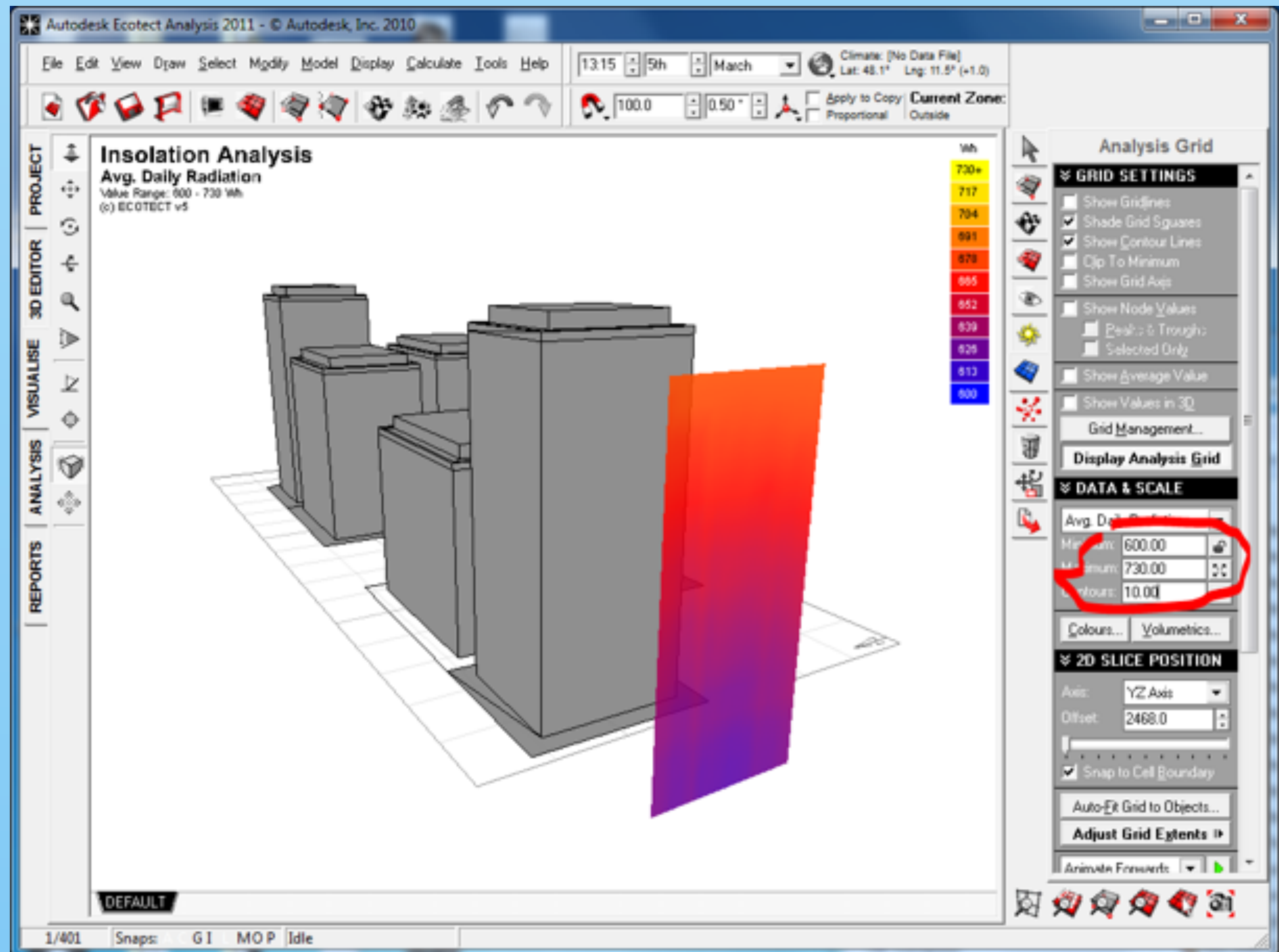

Insolation Analysis |Spring
Source: Student Li Bo

Two images for the Solar Access Analysis with the grid on a facade (one for summer and one for winter).

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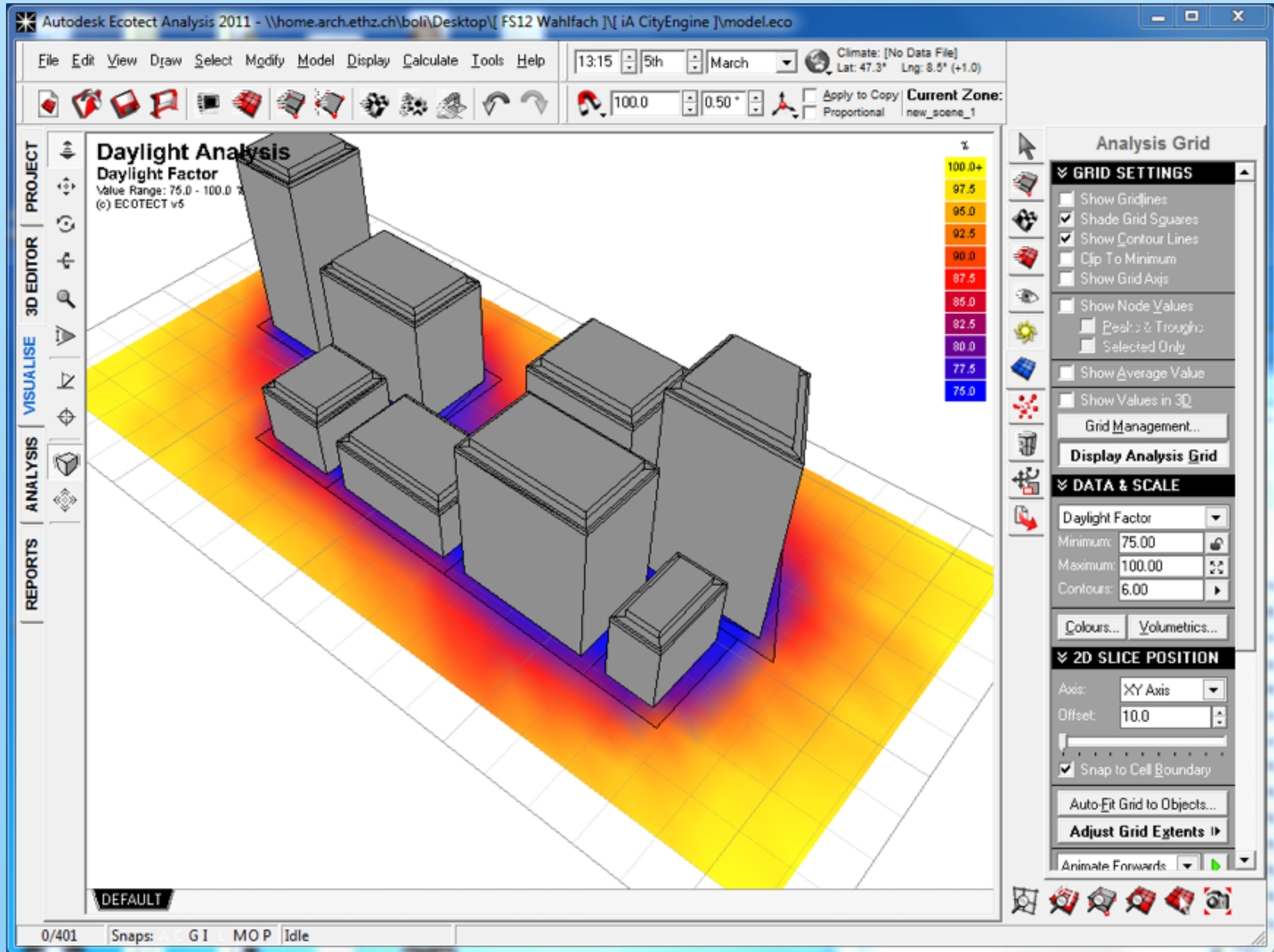
E04 ECOTECT



Daylight Analysis |Spring
Source: Student Li Bo

An image of the Daylight factor analysis on the xy plane base.

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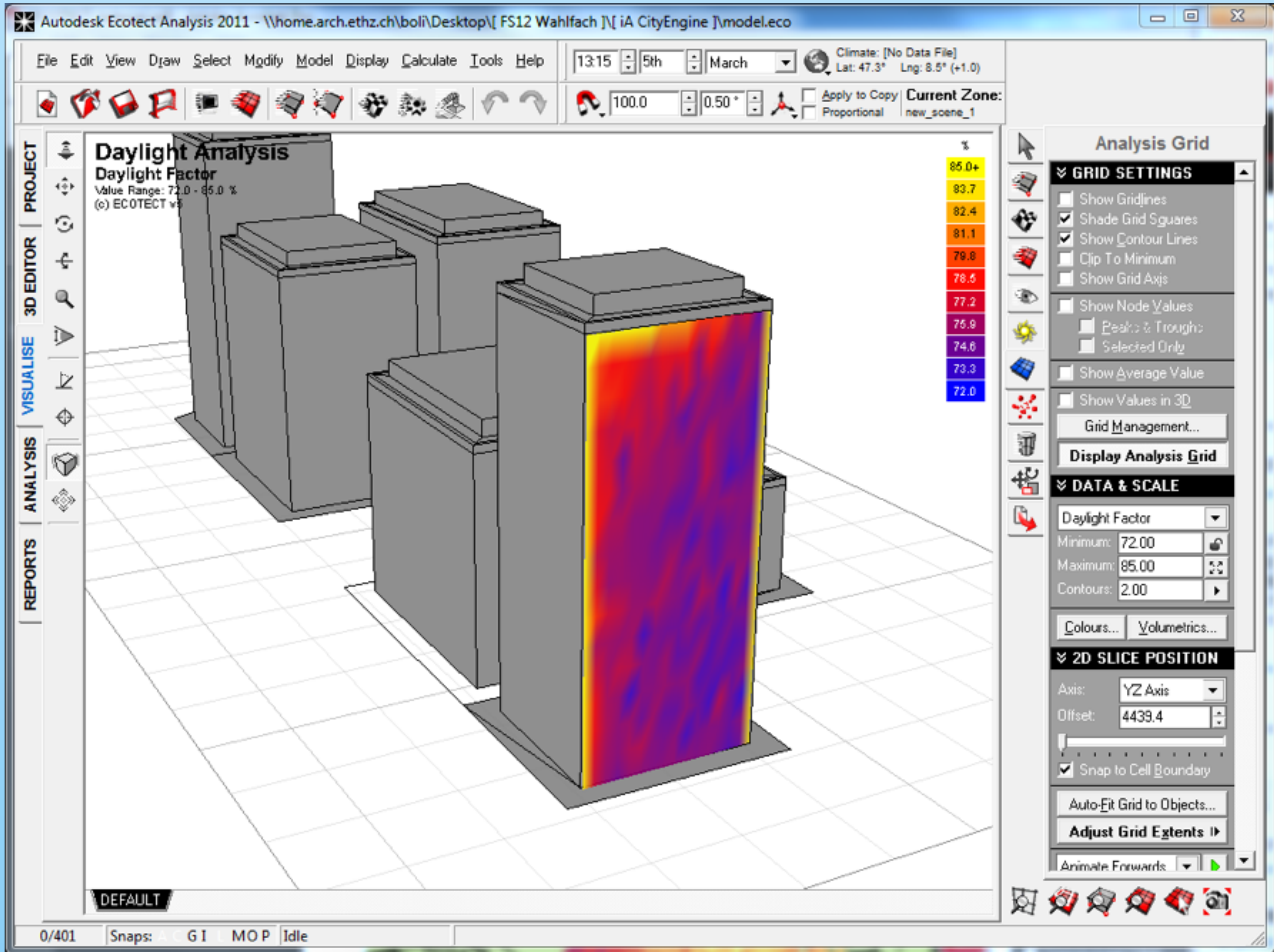
E04 ECOTECT



Daylight Analysis |Spring
Source: Student Li Bo

An image of the Daylight factor analysis on a facade.

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THANK YOU!

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