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Lecture 4 | New Methods In Urban Simulation | HS11
17-10-2011

The Art of Procedural Modelling

iA Chair for Information Architecture

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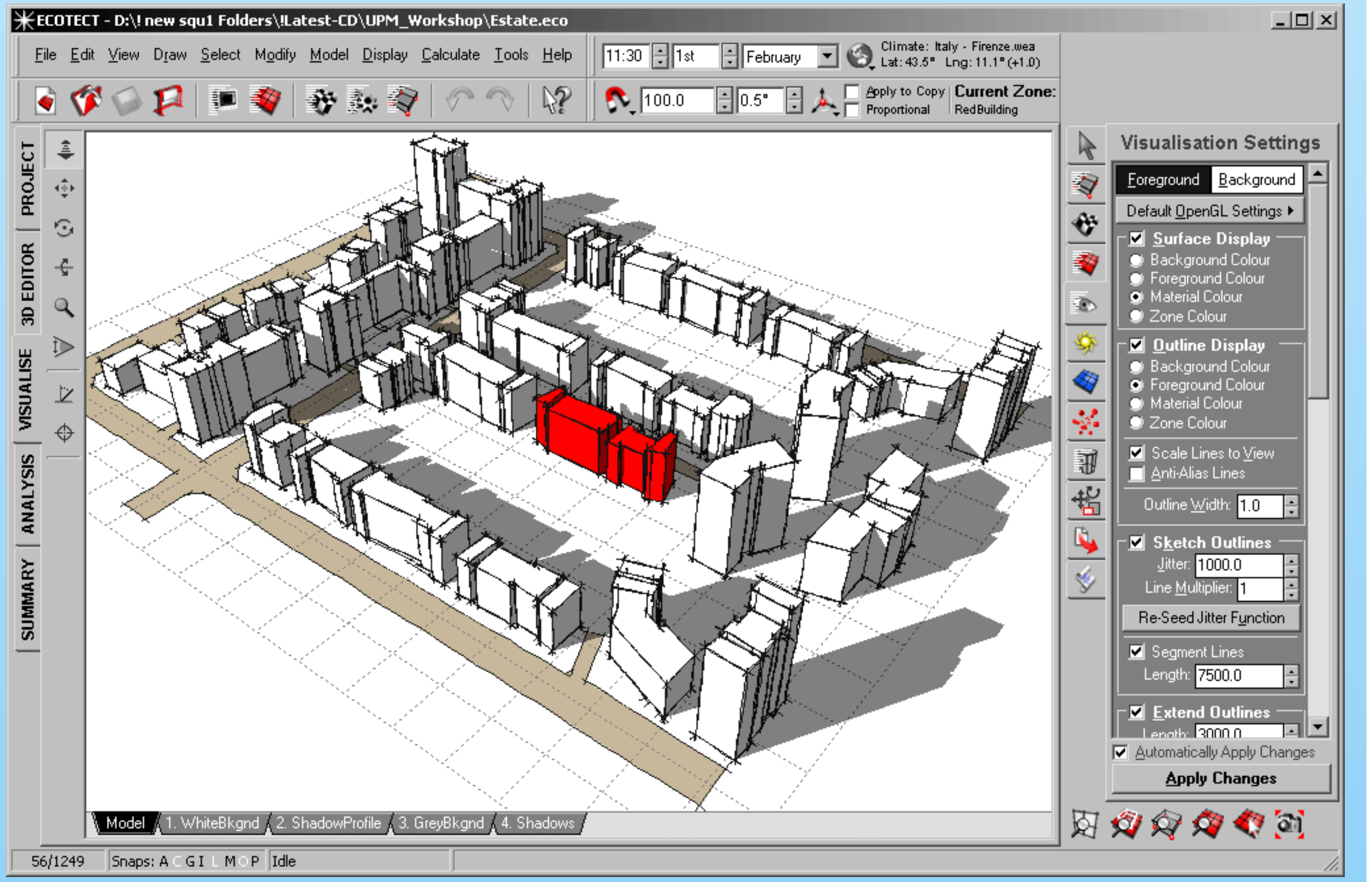
DESIGN PROCESS

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

DESIGN PROCESS



Autodesk Ecotect

Evidence based design:

- Evidence based design knowledge by planners
- Generative design by expert knowledge
- not transparent and transferable
- Application to urban blueprint plan and verification

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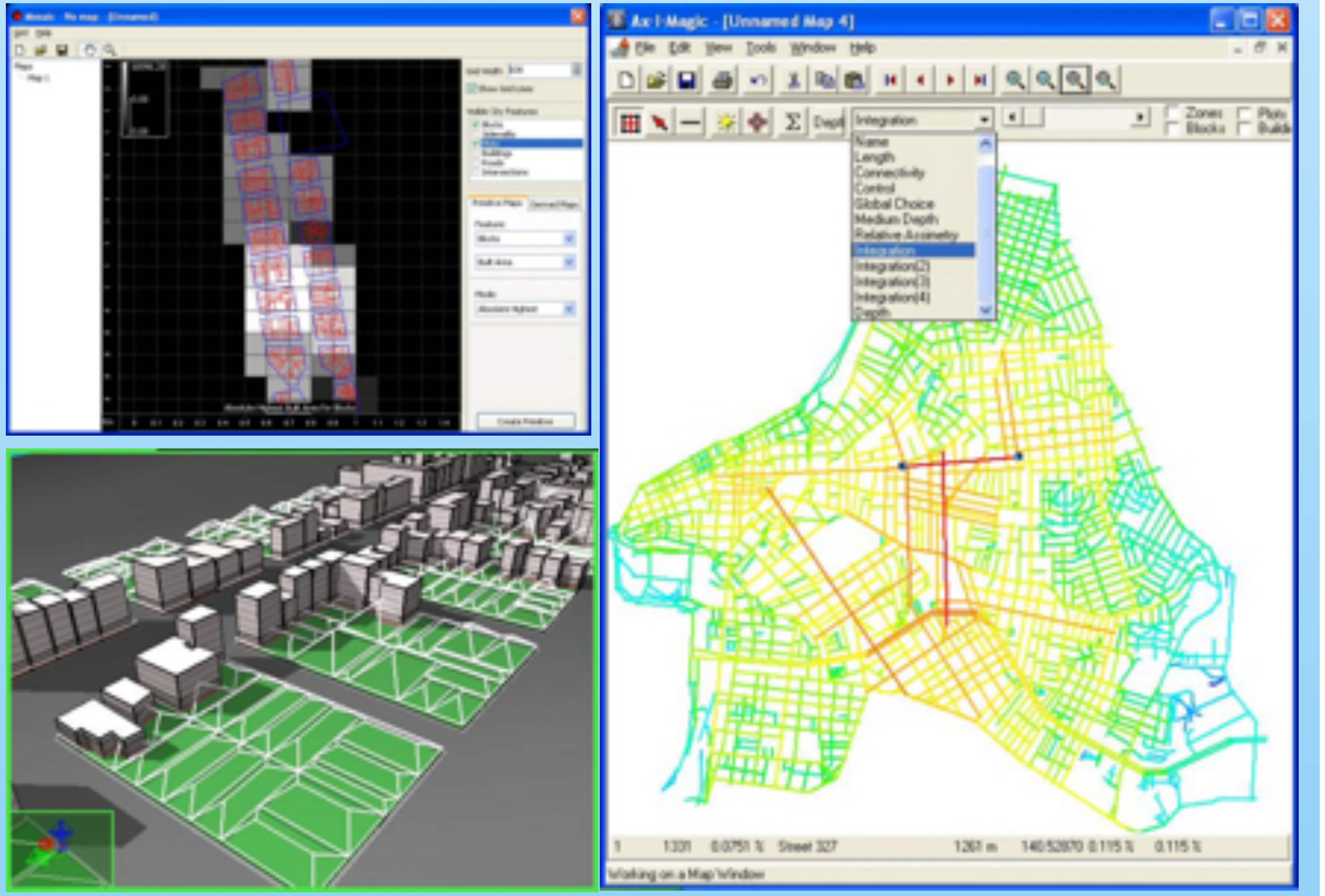


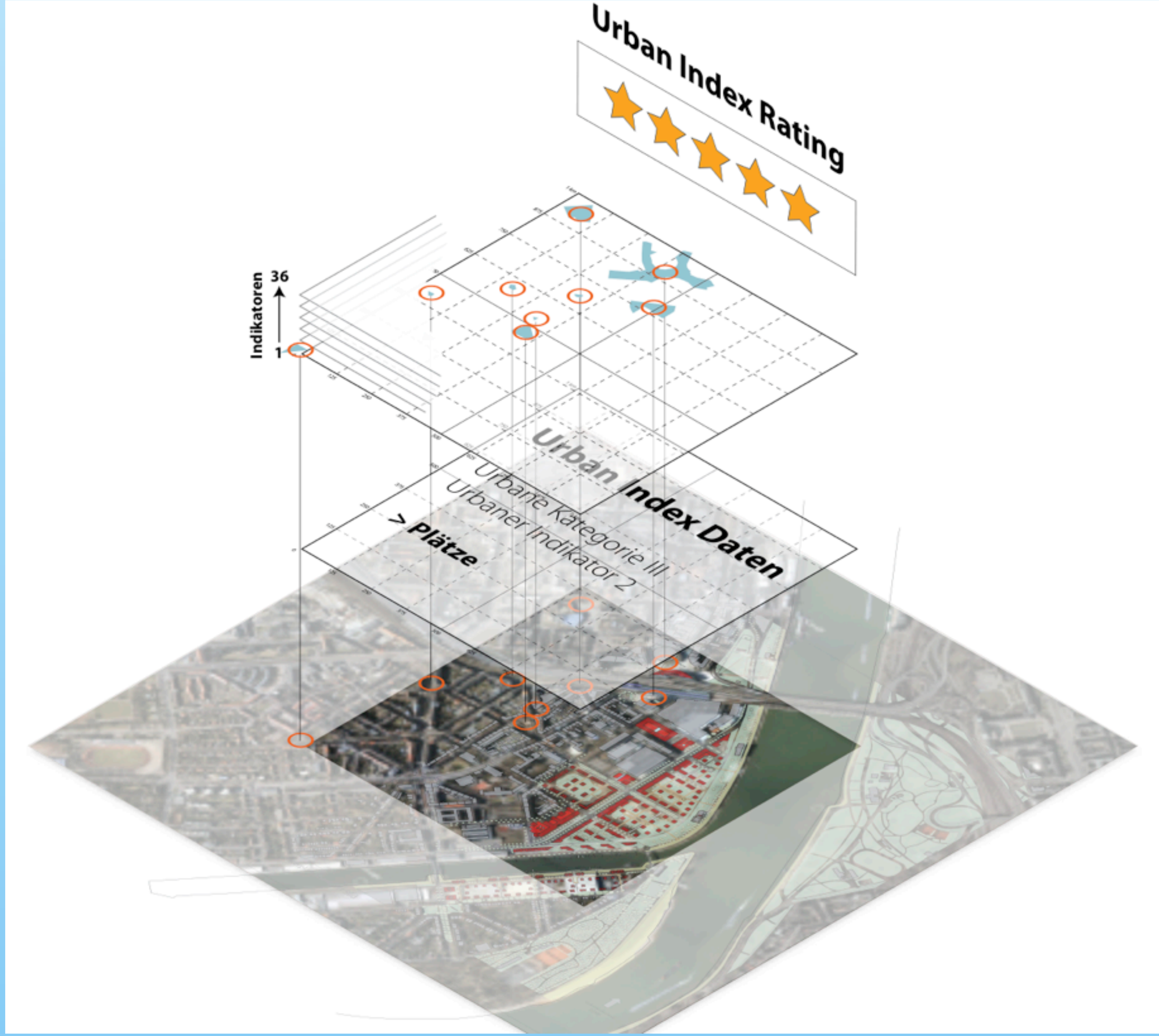
CityZoom, Benamy Turkenicz

DESIGN PROCESS

Performative urban design

- Analytical survey of planning area by experts
- On-Site collection of relevant information
- Evaluation with simulation tools
- Survey criteria serve as performance indicators
- Results are site specific

DESIGN PROCESS



Participative Design

- Workshops with stakeholders for proposal evaluation
- Design goal communication
- Design benchmark validation
- Design guidelines

General: Increase of the design acceptance

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DESIGN PROCESS

Urban Design Synthesis

Jan Halatsch, ETH Zurich

SITE ANALYSIS

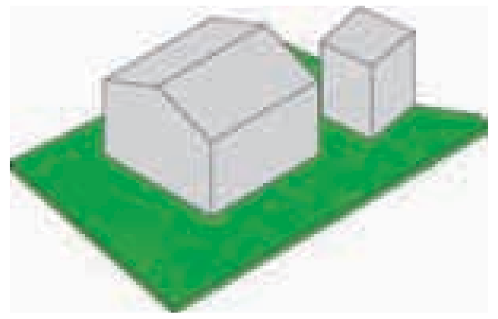
2050: Growth scenario for Porto Alegre, Brasil
Halatsch et al. (2010)

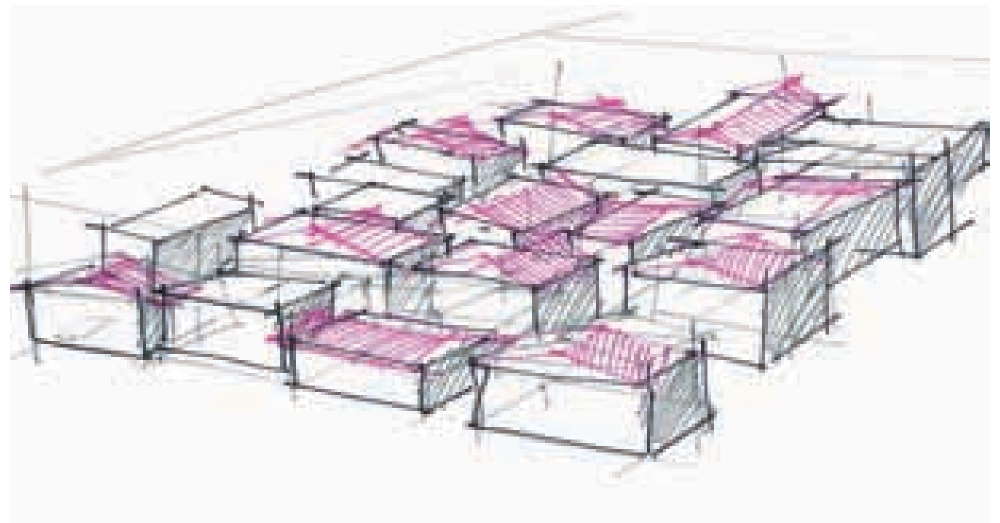
BUILDING TYPOLOGY ANALYSIS

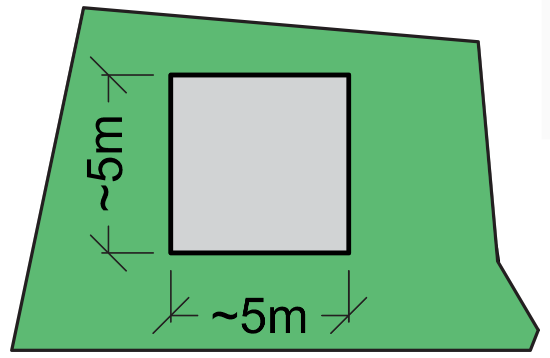
RESIDENCIAL DE BAIXA RENDA | LOW INCOME RESIDENTIAL

VILAS
SQUATTERS

Exemplo: Vila Dique

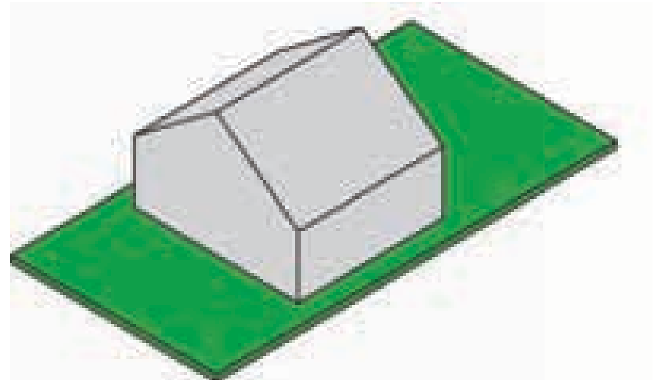


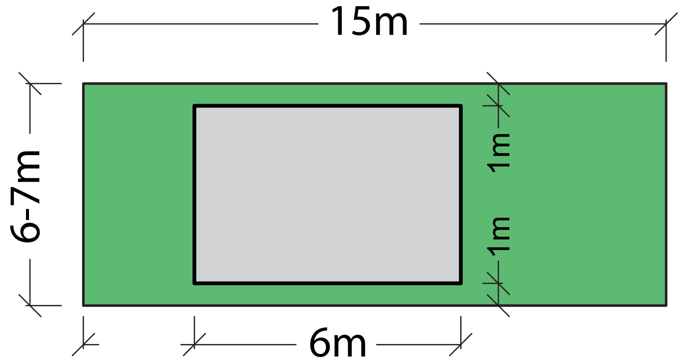




HABITAÇÃO DE INTERESSE SOCIAL
SOCIAL HOUSING

Exemplo: Vila Farrapos



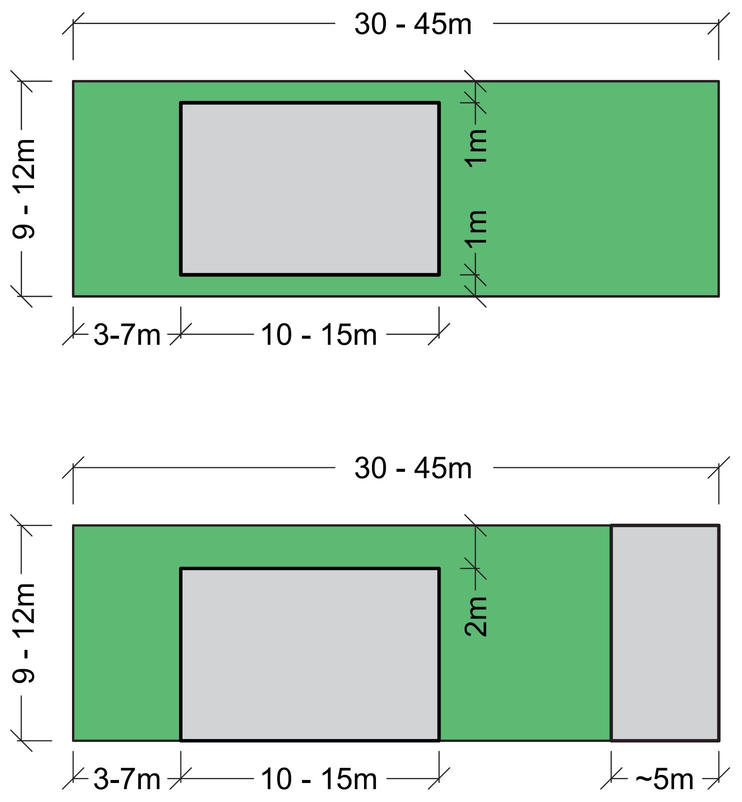


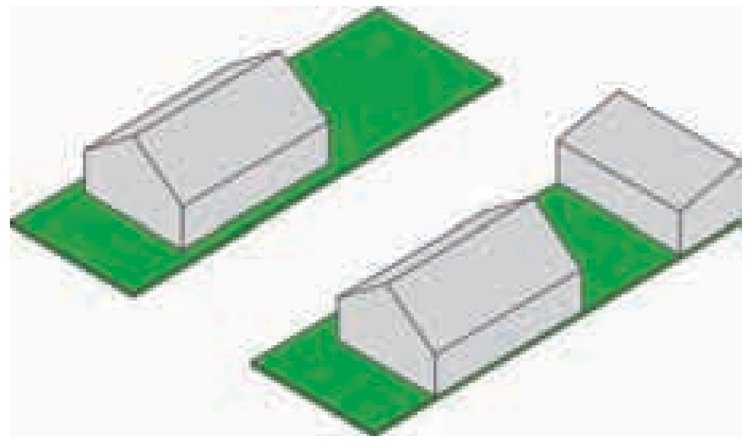
BUILDING TYPOLOGY ANALYSIS

RESIDENCIAL DE MÉDIA BAIXA RENDA | LOW MIDDLE INCOME RESIDENTIAL

CASA UNIFAMILIARES
INDIVIDUAL HOUSING

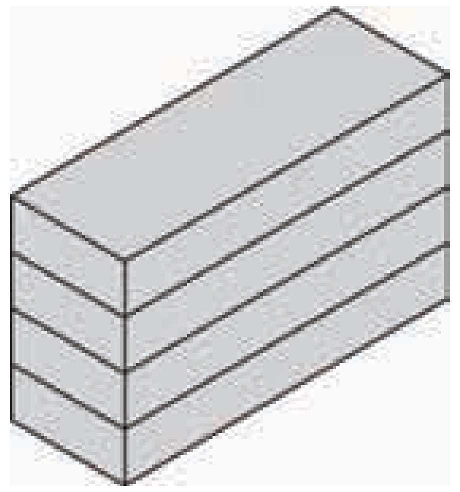
Exemplo: Bairro Jardim Itú-Sabará

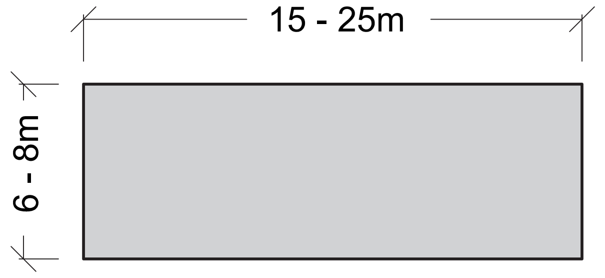




EDIFÍCIOS MULTIFAMILIARES
MULTISTOREY HOUSING

Exemplo: Rubem Berta



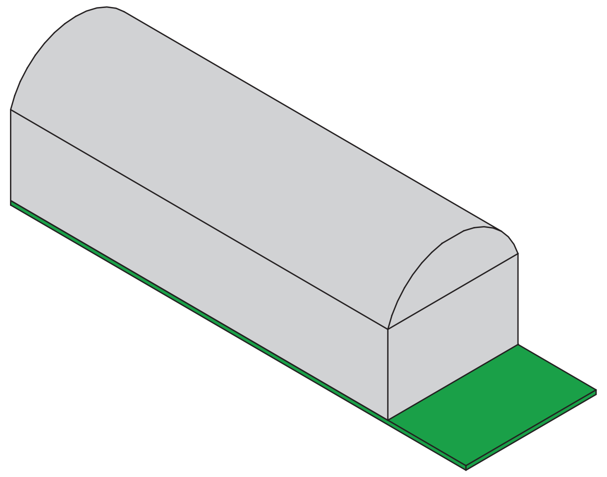


BUILDING TYPOLOGY ANALYSIS

INDÚSTRIAS | INDUSTRY

GALPÕES INDUSTRIAIS - GRANDES e PEQUENOS/MÉDIOS
INDUSTRIAL WAREHOUSES - LARGE e SMALL/MEDIUM

Exemplo: Indústria Pequena/Média Bairro São João



COMÉRCIO | RETAIL

COMÉRCIO
RETAIL

1

RUA COMERCIAL
COMMERCIAL STREET

Exemplo:
Rua dos Andradas

2

SHOPPING CENTER
SHOPPING MALL

Exemplo:
Praia de Belas

3

MERCADO DE RUA
STREET MARKET

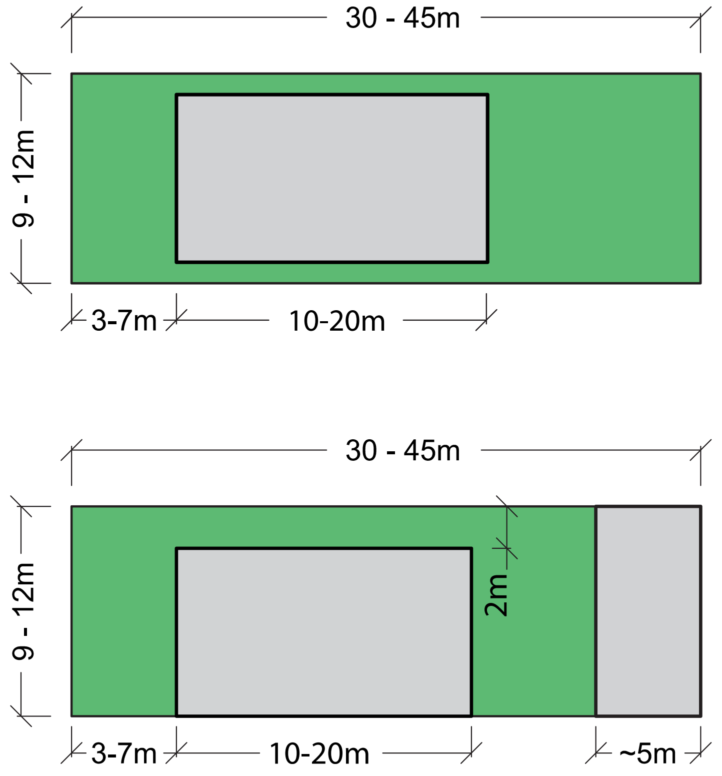
Exemplo:
Brique da Redenção

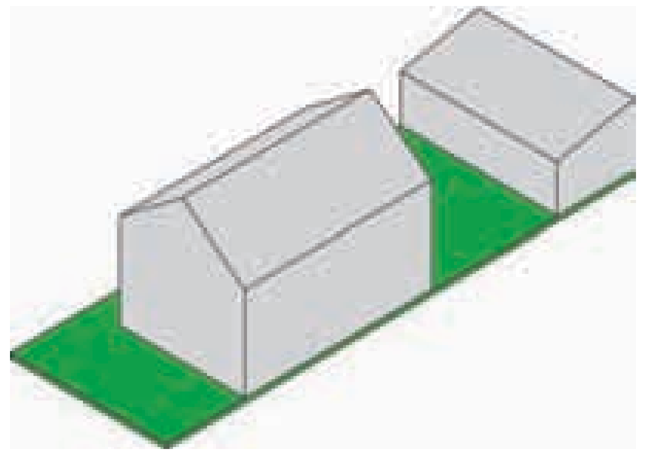
BUILDING TYPOLOGY ANALYSIS

RESIDENCIAL DE MÉDIA RENDA | MIDDLE INCOME RESIDENTIAL

CASAS UNIFAMILIARES
INDIVIDUAL HOUSING

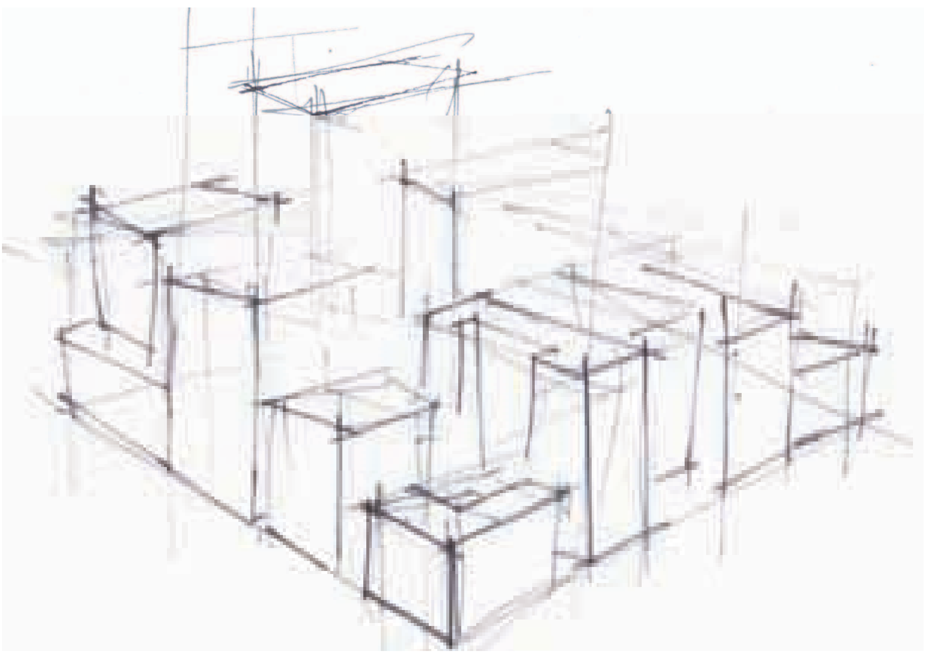
Exemplo: Bairro Bomfim

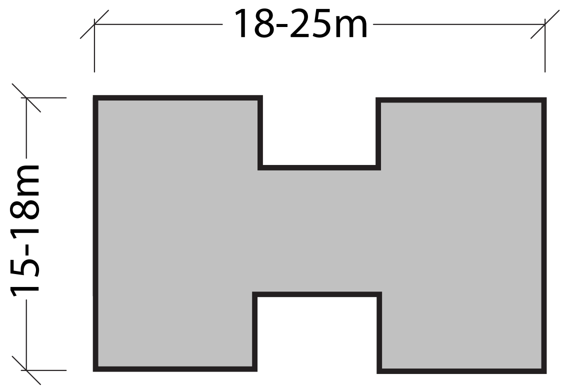




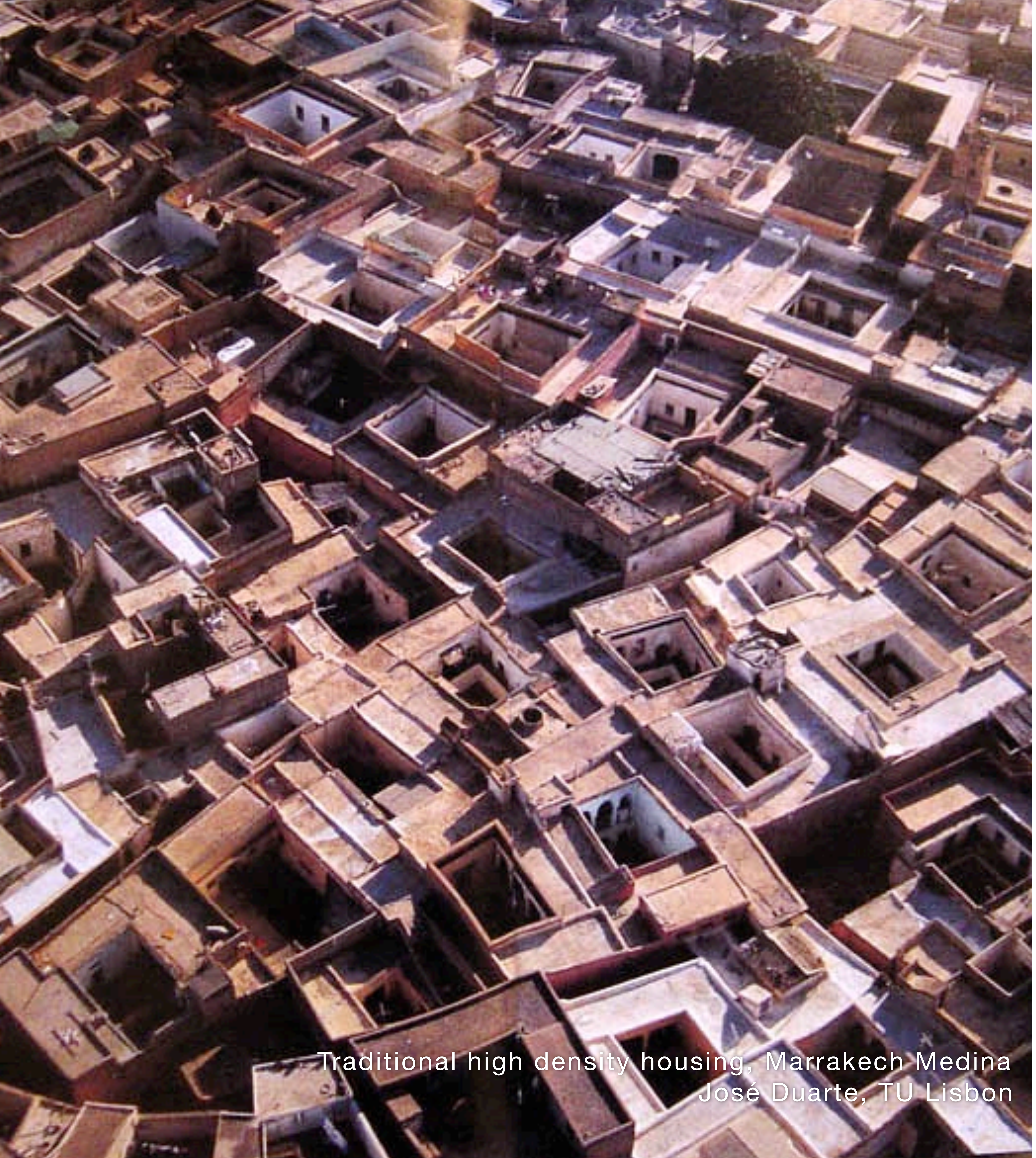
EDIFÍCIOS MULTIFAMILIARES
MULTISTOREY HOUSING

Exemplo: Bairro Jardim Itú-Sabará





DESIGN GRAMMARS



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CONCEPT OF GRAMMARS

Grammars in general are used to describe and to alter ‘strings’ in a defined manner. The results are sequences of symbols that can represent e.g. human language, compiled code ready for the interpretation by an interpreter (computer science), production of architectural shapes and their layout (shape grammars).

CONCEPT OF GRAMMARS

Due to their nature grammars can be easily adapted to store:

a) spatial configuration (geometry, network dependencies)

b) meta data (population density, value, topology)

CONCEPT OF GRAMMARS

In computer science a formal grammar consists of:

- Set of start symbols / nonterminal symbols: N
- Set of alphabet / terminal symbols: Σ (disjoint from N)
- Set of production rules for transforming strings: P
- Language, resulting set of all strings: L

CONCEPT OF GRAMMARS

Generation of a string

Begins with a single start symbol (e.g. S)

Then successive application of the rules in P

CONCEPT OF GRAMMARS

Example 1

Start symbol / Nonterminal symbol: N= { S }
Alphabet / Terminal symbols: Σ = {a, b}
Rules: P = { Rule 1, Rule 2 }

CONCEPT OF GRAMMARS

Example 1

Rule 1: S --> aSb
Rule 2: S --> ba

Possible production:
S -->1: aSb -->1: a**aSb**b -->2: aa**ba**bb.

Resulting set of all strings (language):
L(G) = {ba, abab, aababb, aaababbb, ...}

CONCEPT OF GRAMMARS

Example 2

Possible productions:

S -->

2: abc

S -->

1: **aBSc** -->

2: aB**abc**c -->

3: a**aB**bcc -->

4: aa**bb**cc

Rule 1. *S --> aBSc*
Rule 2. S --> abc
Rule 3. Ba --> aB
Rule 4. Bb --> bb

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CONCEPT OF GRAMMARS

Example 2

Resulting set of all strings (language):

$L(G) = \{a^n b^n c^n \mid n \geq 1\}$

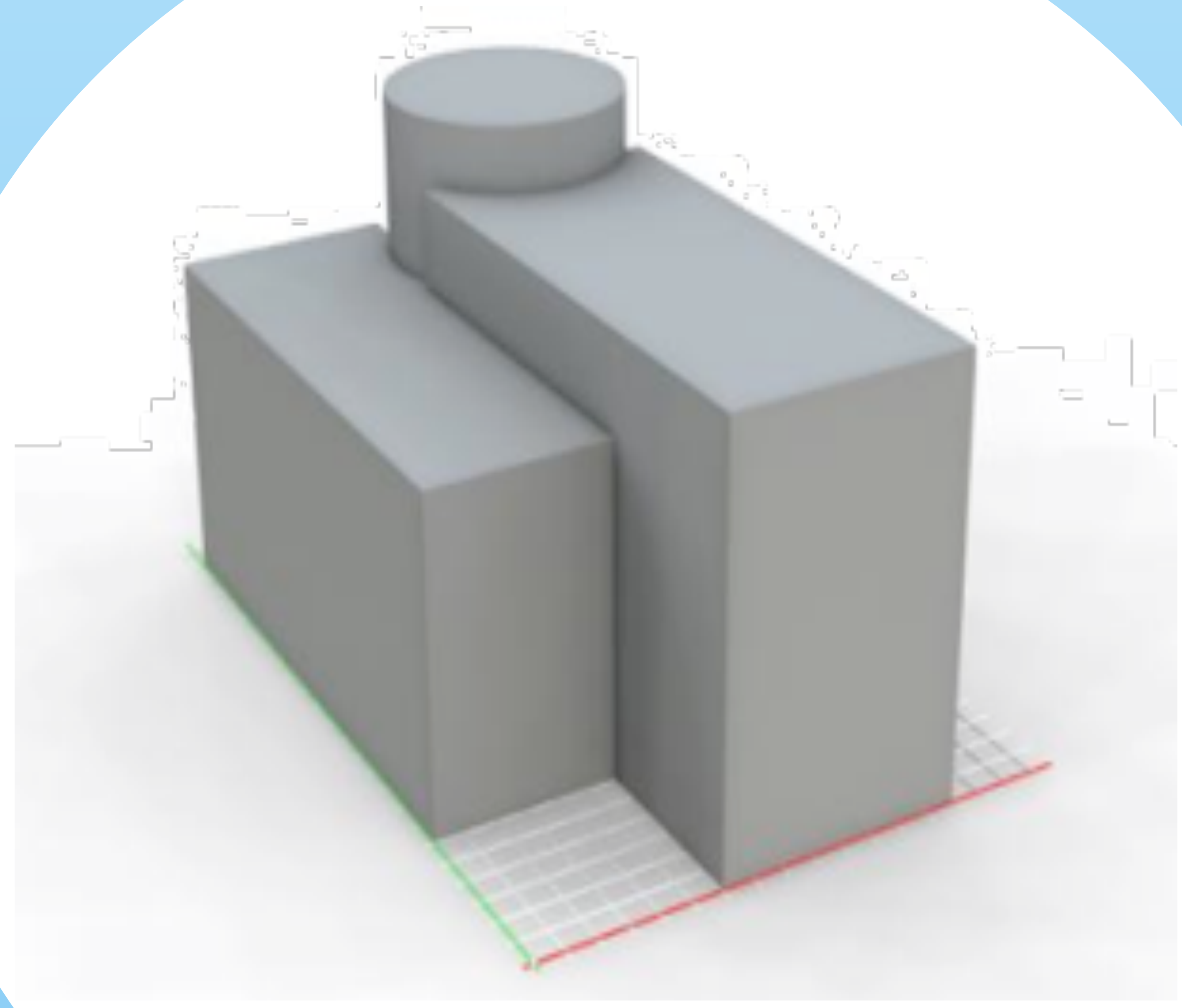
CONCEPT OF GRAMMARS

CityEngine's CGA Shape

G= { P, C, T, V, ω}

Start symbol / Axiom: **ω**= { Lot, Street, ... }
Alphabet: V = { variables, inbuilt functions, P}
Rules: P = { **C, T, V**, ω}
Constants: C = {NIL, .}
Terminals: T = {I, C}

CGA SHAPE: OPERATIONS



Geometry Insertion: i(objId)
Transformations: t(tx,ty,tz), s(sx,sy,sz), r(rx,ry,rz)
Branching: [...]
Simple example:

```
A  ->[ t(0,0,6) s(8,10,18) B ]
       t(6,0,0) s(7,13,18) C
       t(0,0,16) s(8,15,8) i(cylinder) D
```

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ETH Zurich

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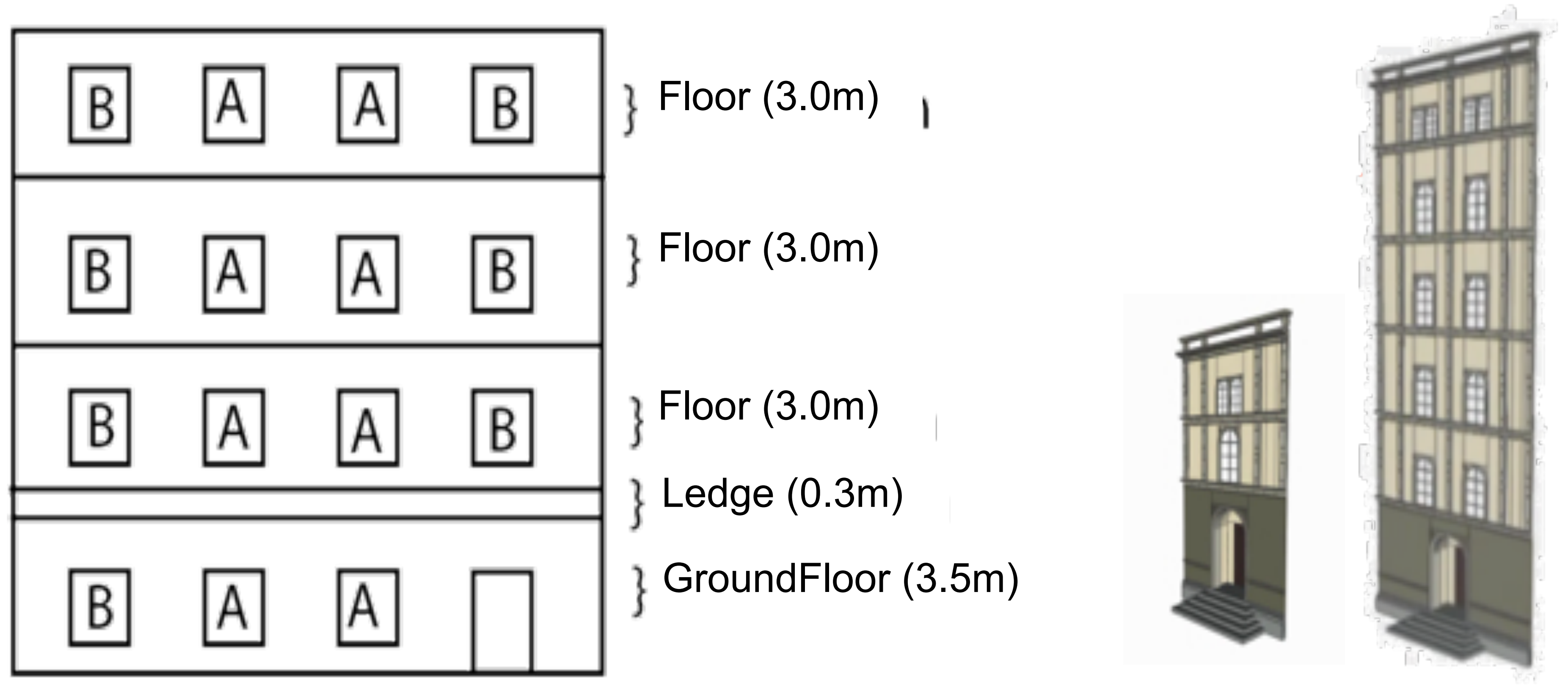
CGA SHAPE: OPERATIONS

Example

Facade -->

split(y){ 3.5: GroundFloor | 0.3: Ledge | **{** 3: Floor **}*** **}**



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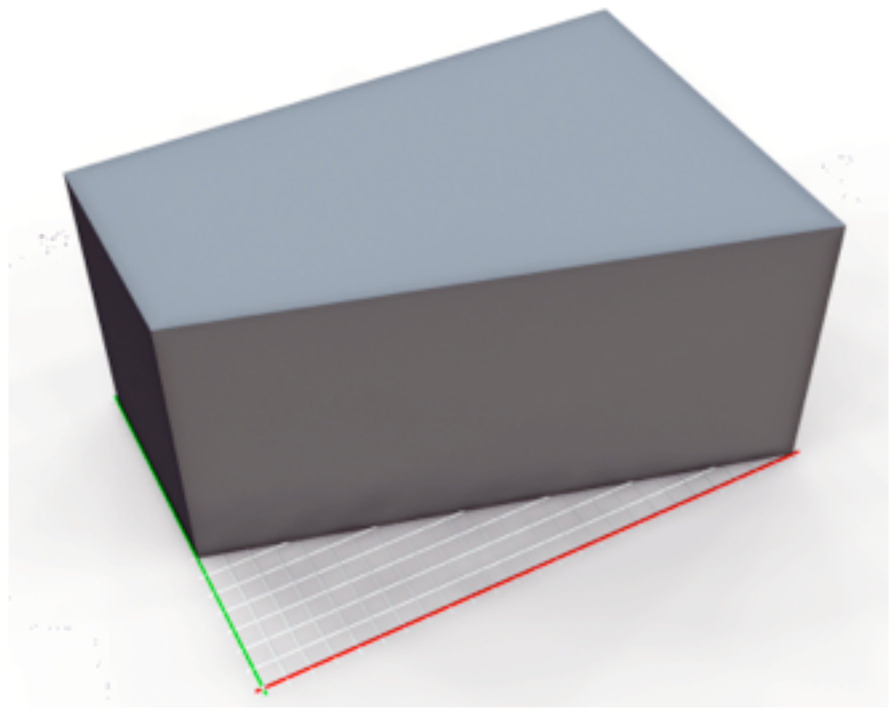
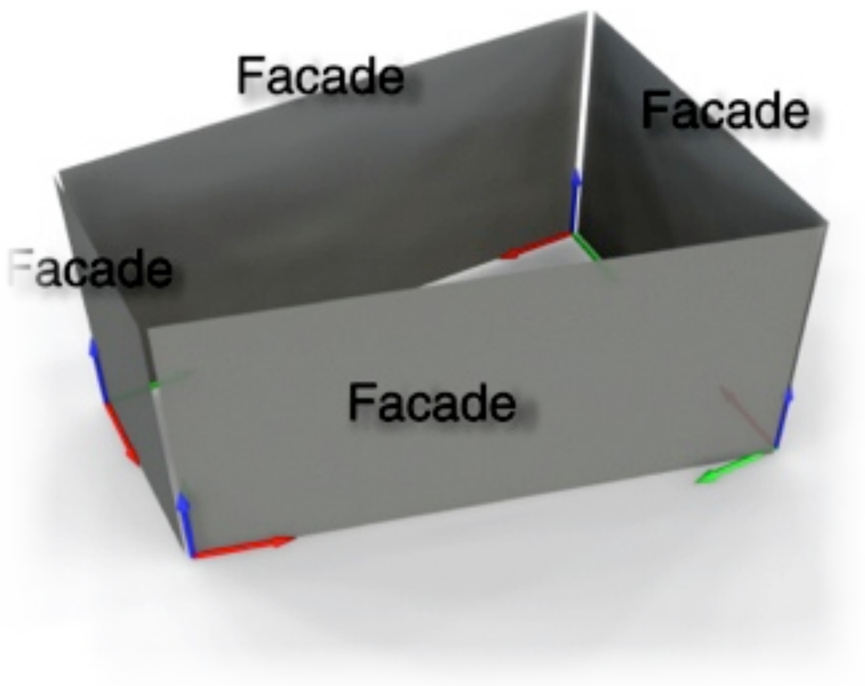
CGA SHAPE: OPERATIONS

Example

MassModel --> comp(f){ side: Facade }





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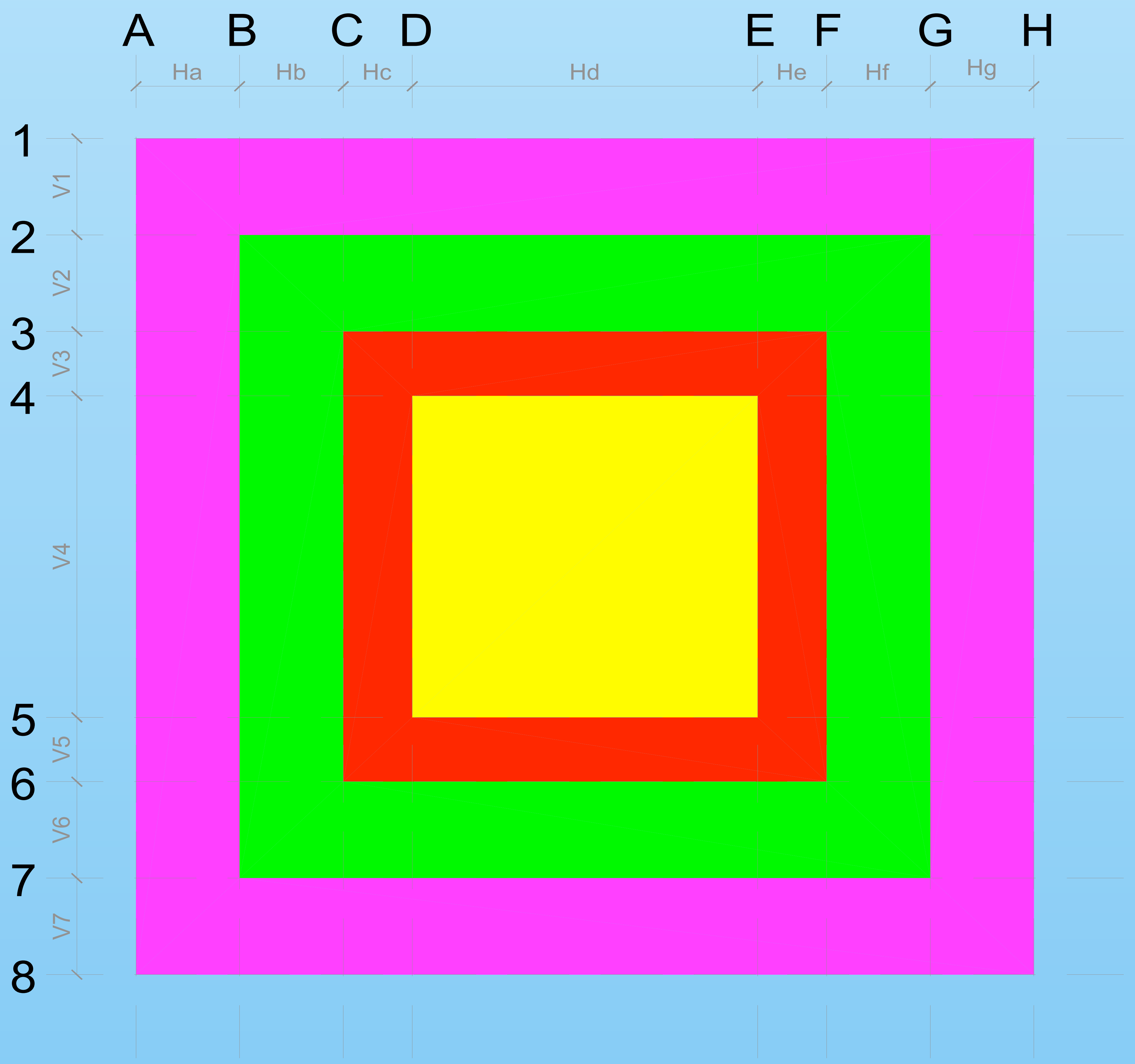
DESIGN PATTERNS

Digital Prototyping, high density housing, Marrakech Medina
José Duarte, TU Lisbon

GENERIC BUILDING BLOCK PATTERN



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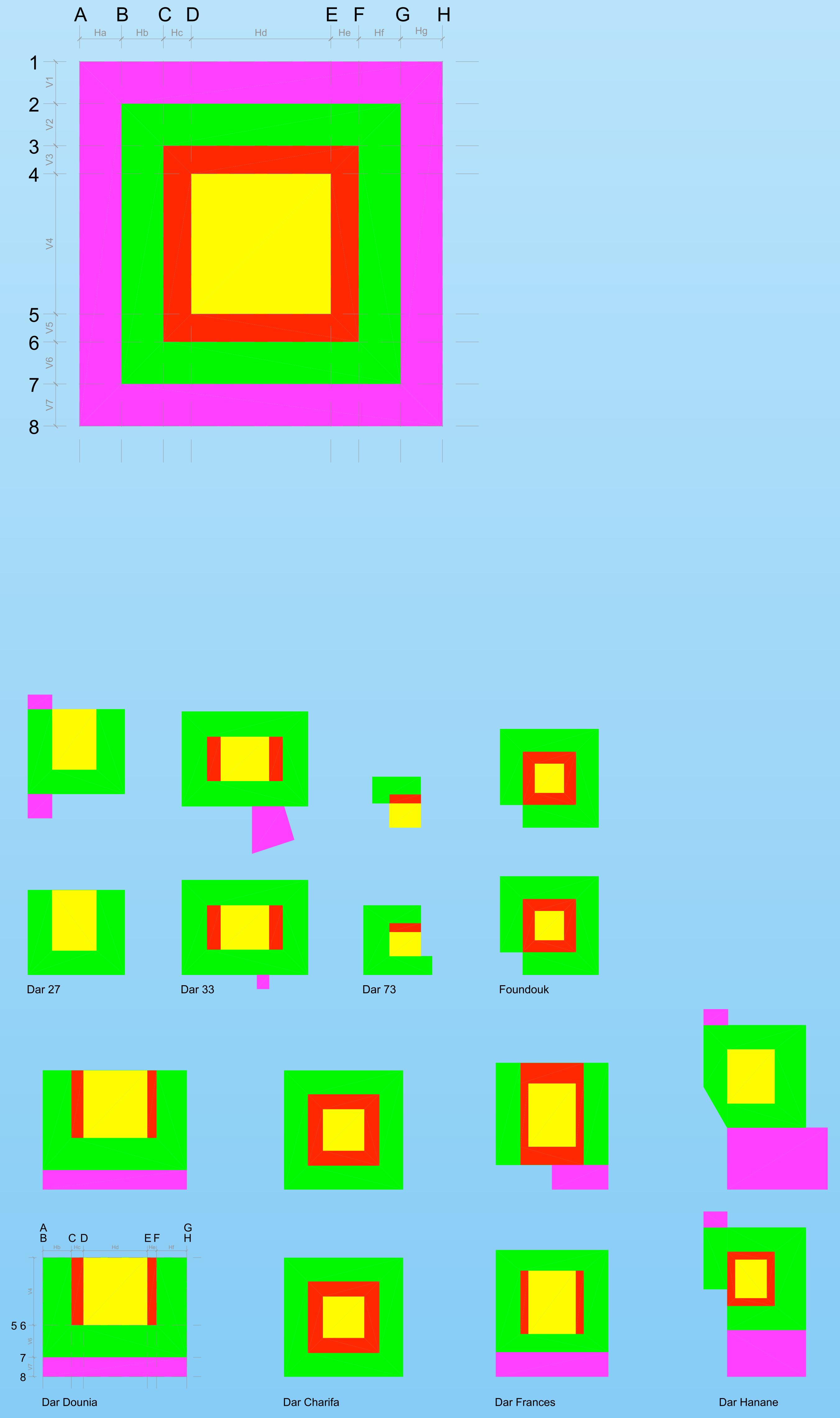
TU Lisbon

GENERIC BUILDING AND SPECIALIZATION



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DIGITAL MEDINA

José Duarte
TU Lisbon

DESIGN PATTERNS

Grammar Implementation CGA

- Simple encoding of building patterns and facades
- Split Grammar
- Context sensitive conditions

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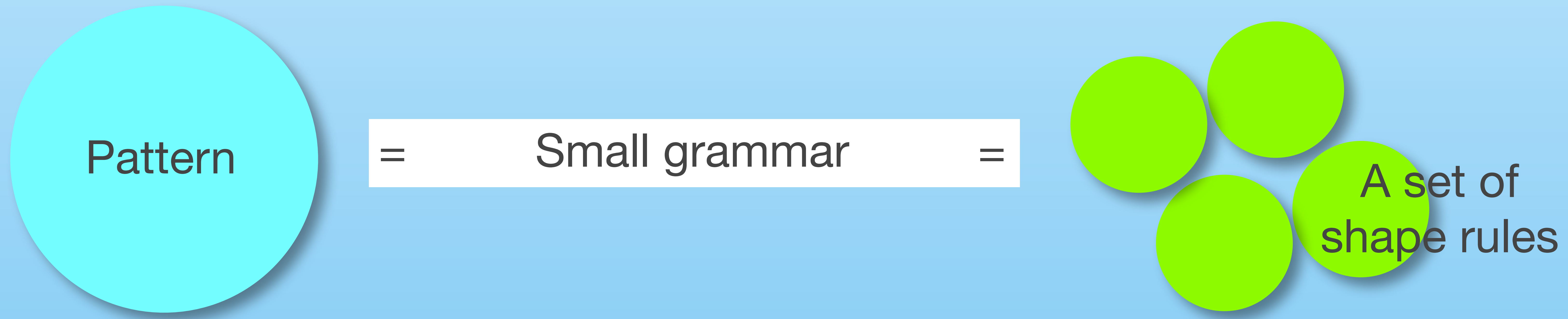
Procedural AG, ETH Zurich

PATTERN MODELLING

A pattern is a small grammar defined to produce results that satisfy the pattern's description.



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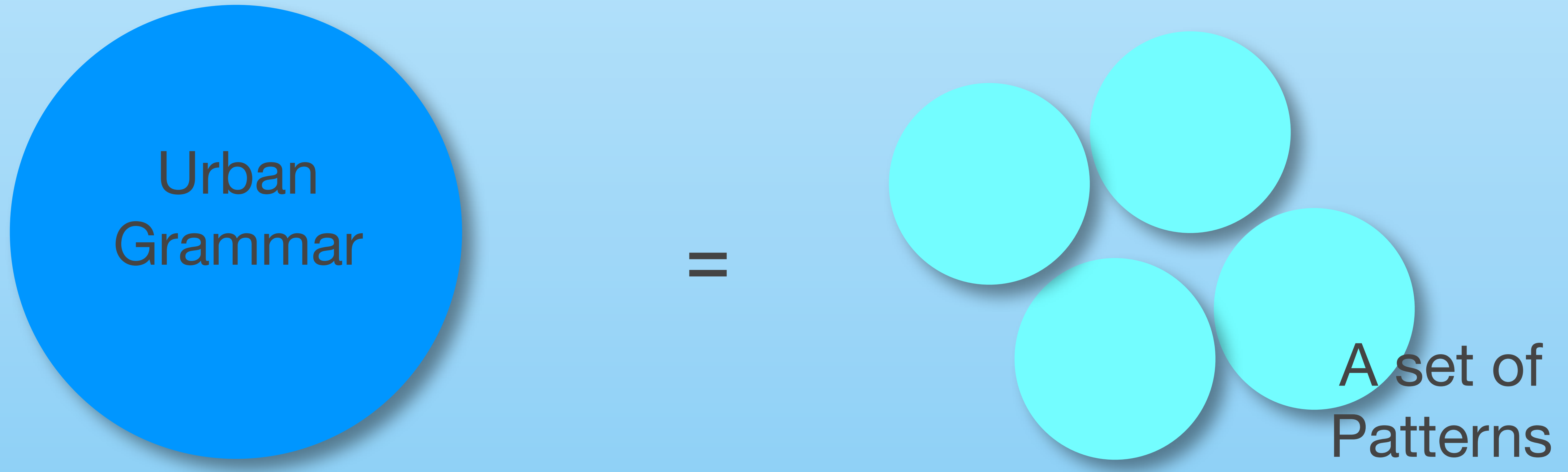
TU Delft

PATTERN MODELLING



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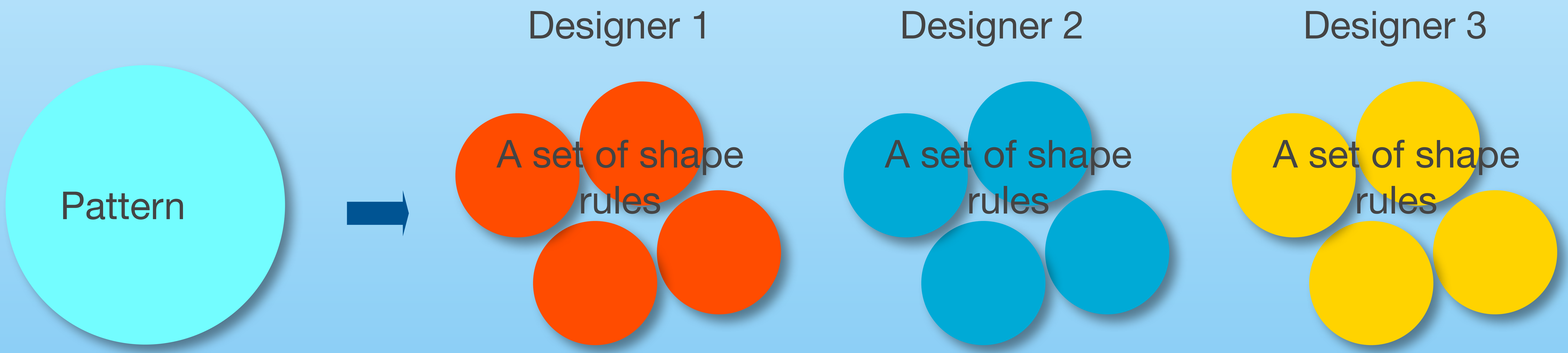
TU Delft

PATTERN MODELLING

Each designer may have a different set of shape rules for interpreting a certain pattern.



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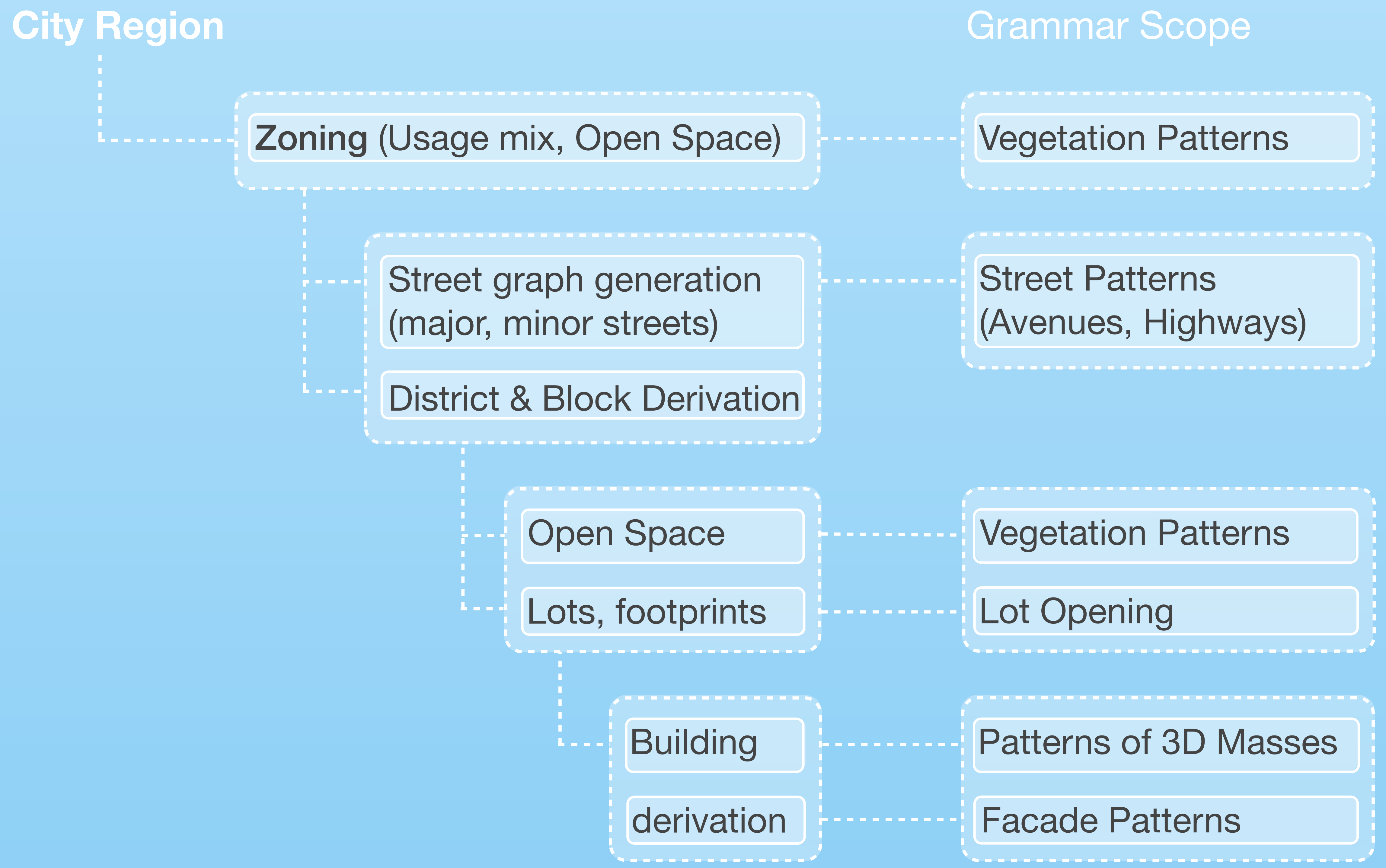
SCALE CLASSIFICATION



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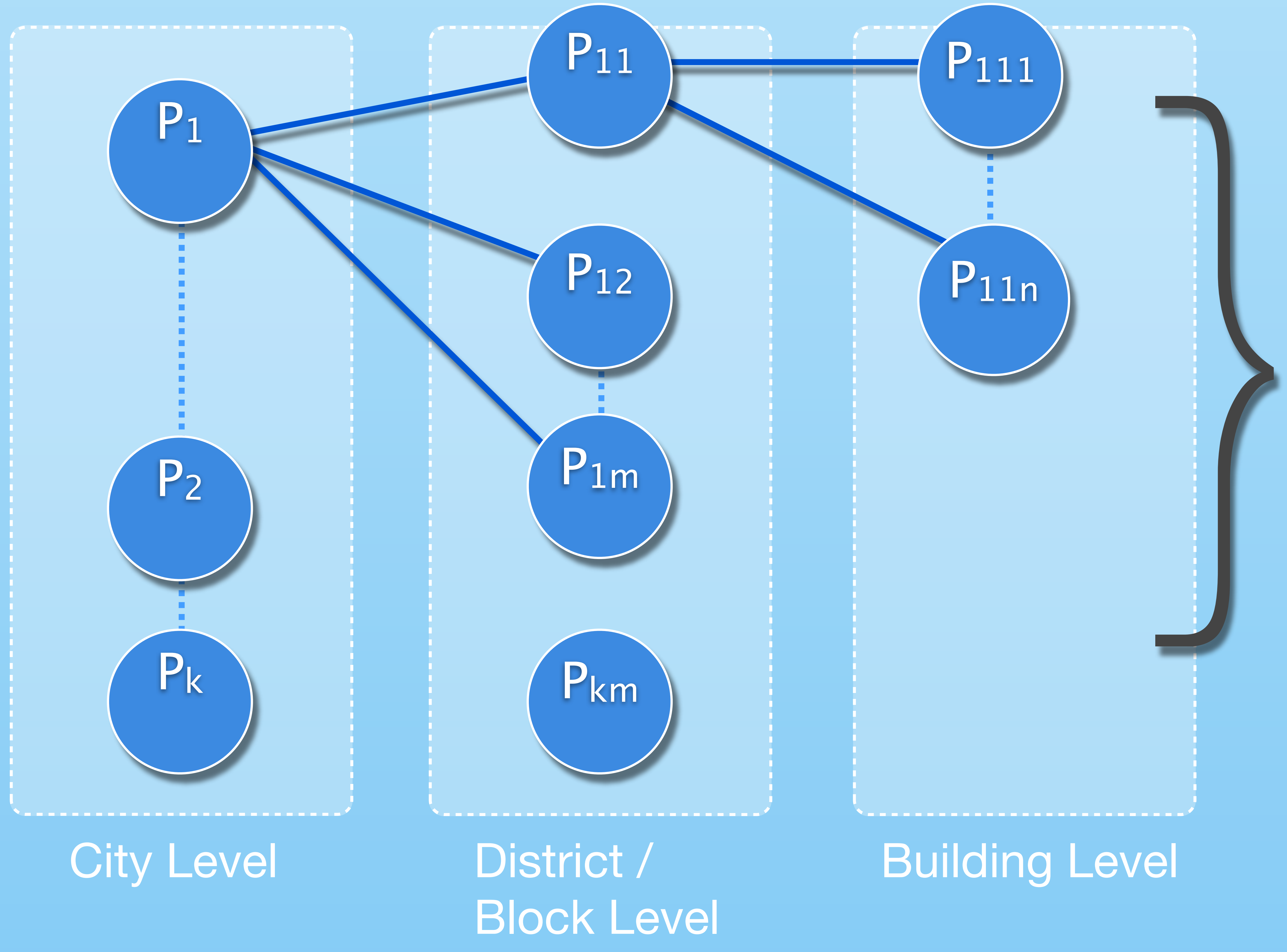
DESIGN PATTERNS



Patterns consist of 2D & 3D shape rule and offer inheritance and design variation

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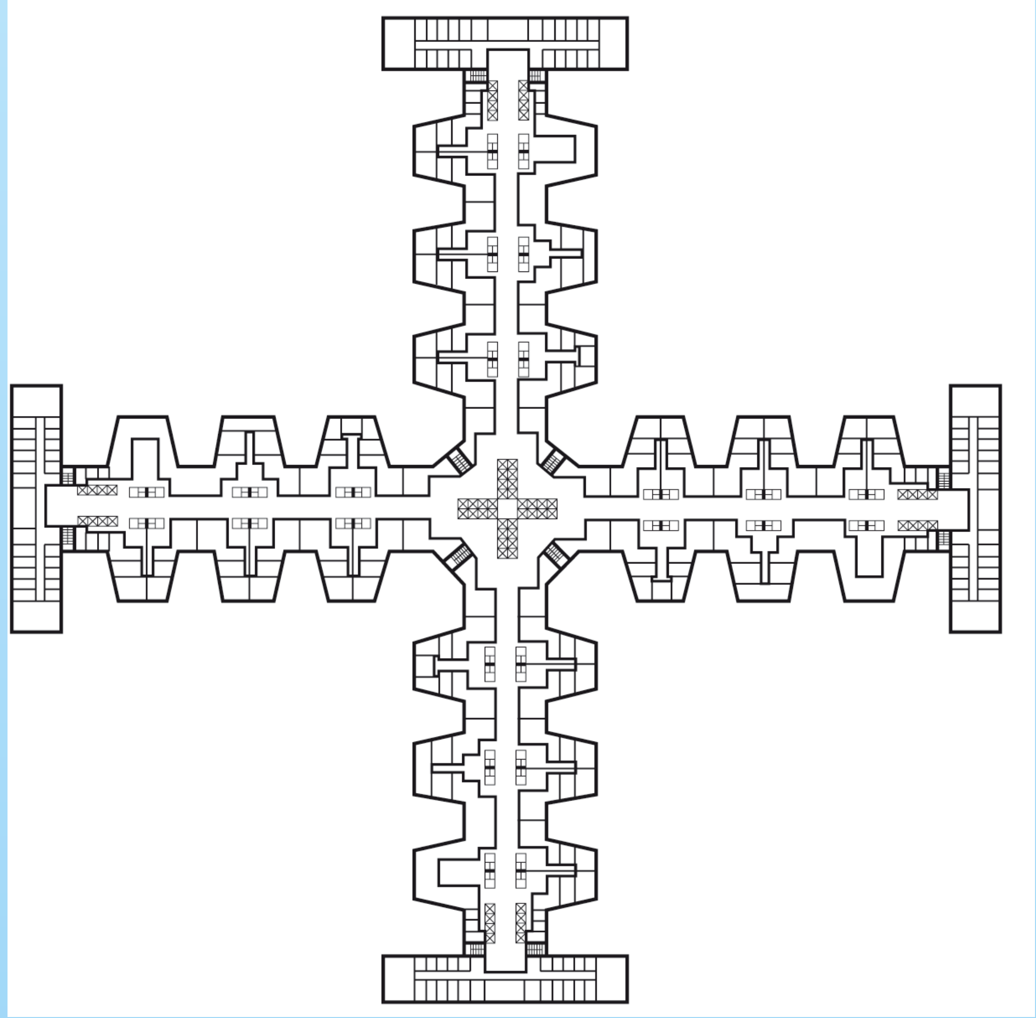
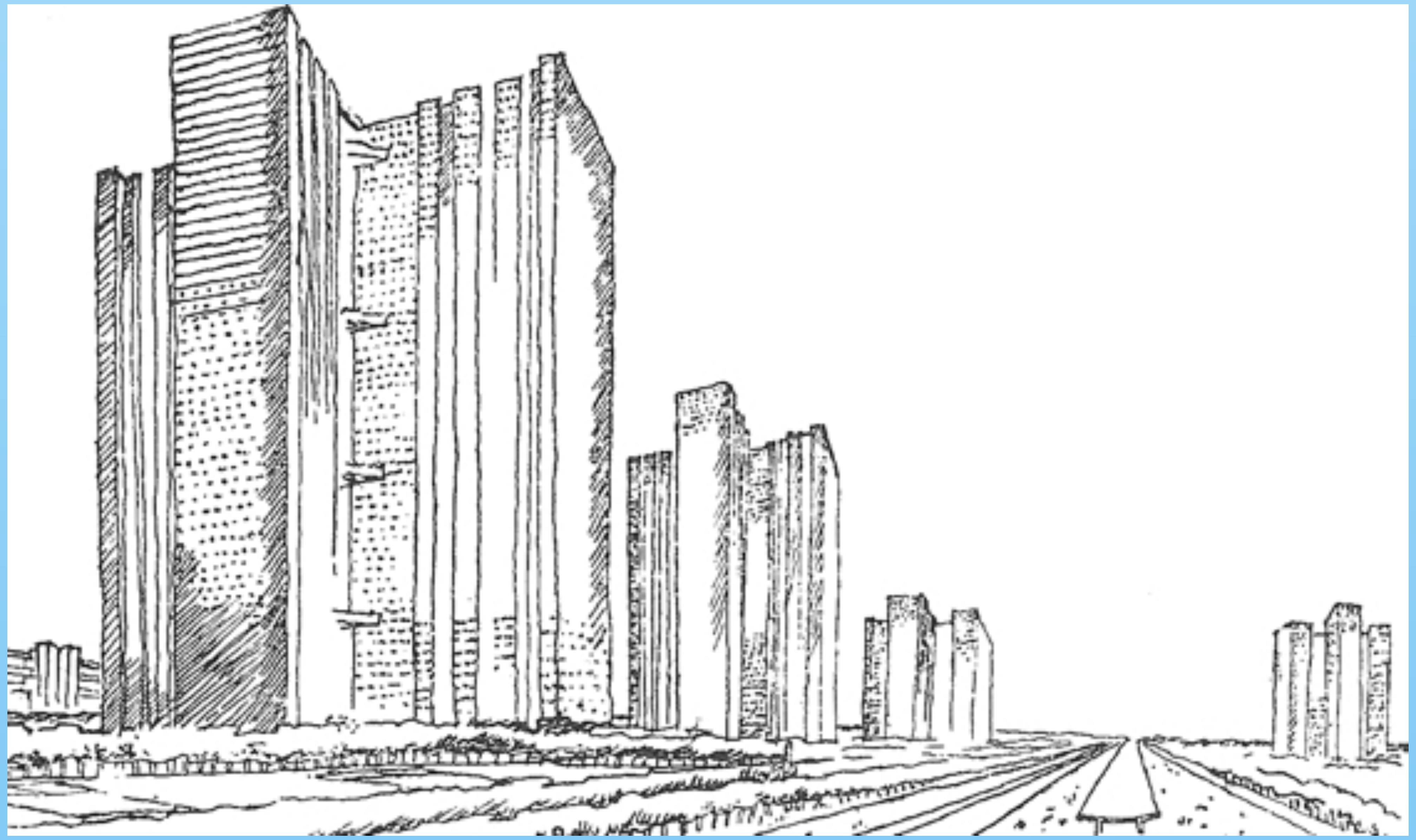
PARAMETERIZED PATTERNS

Example





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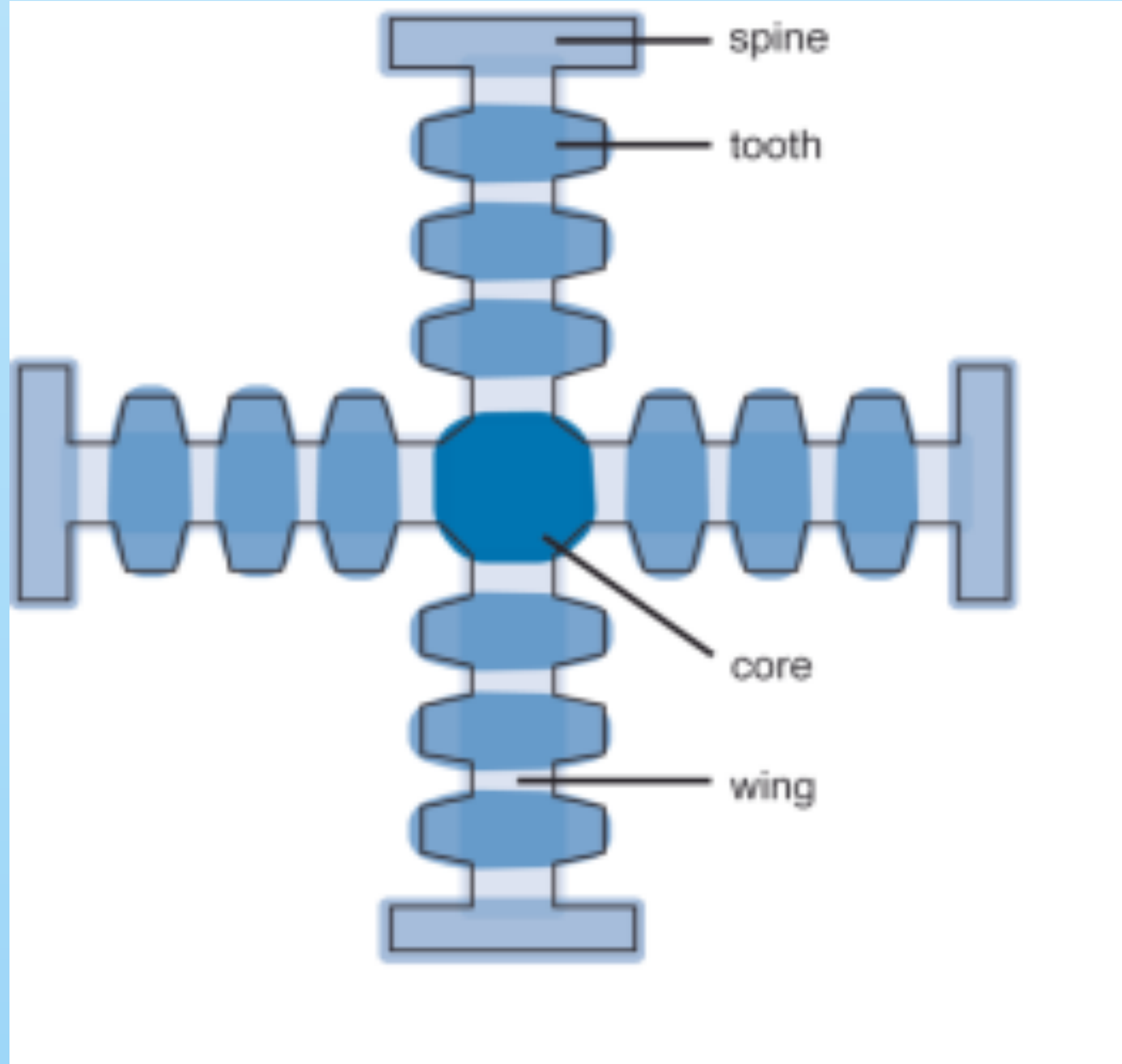
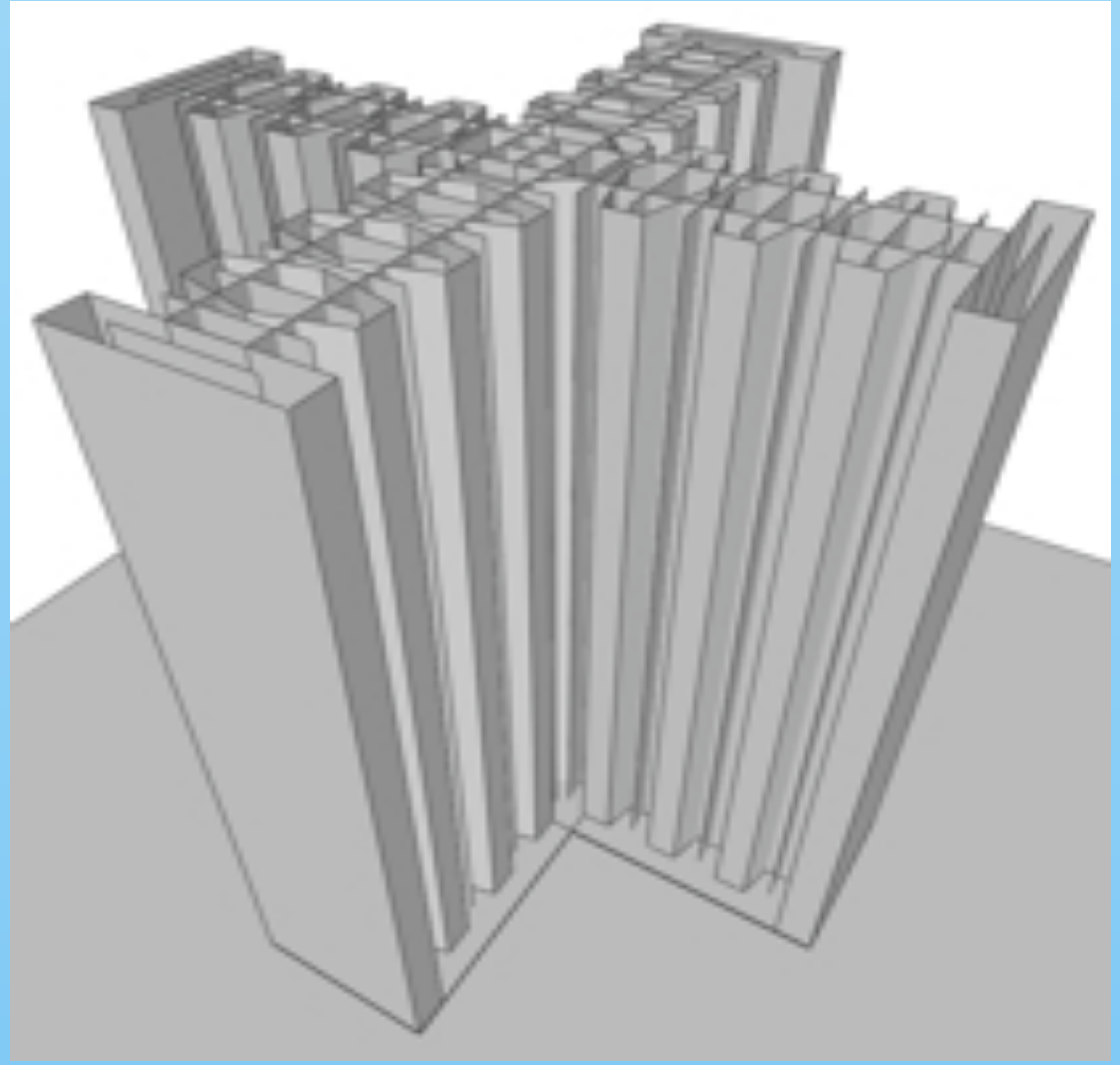
CONTROL ATTRIBUTES FOR VOLUME





BUILDING_H = 220
BUILDING_W = 100
GROUNDFLOOR_H = 6
WING_W = 16
SPINE_W = 50
TEETH_PROJ = 10
TEETH_DIST = 12

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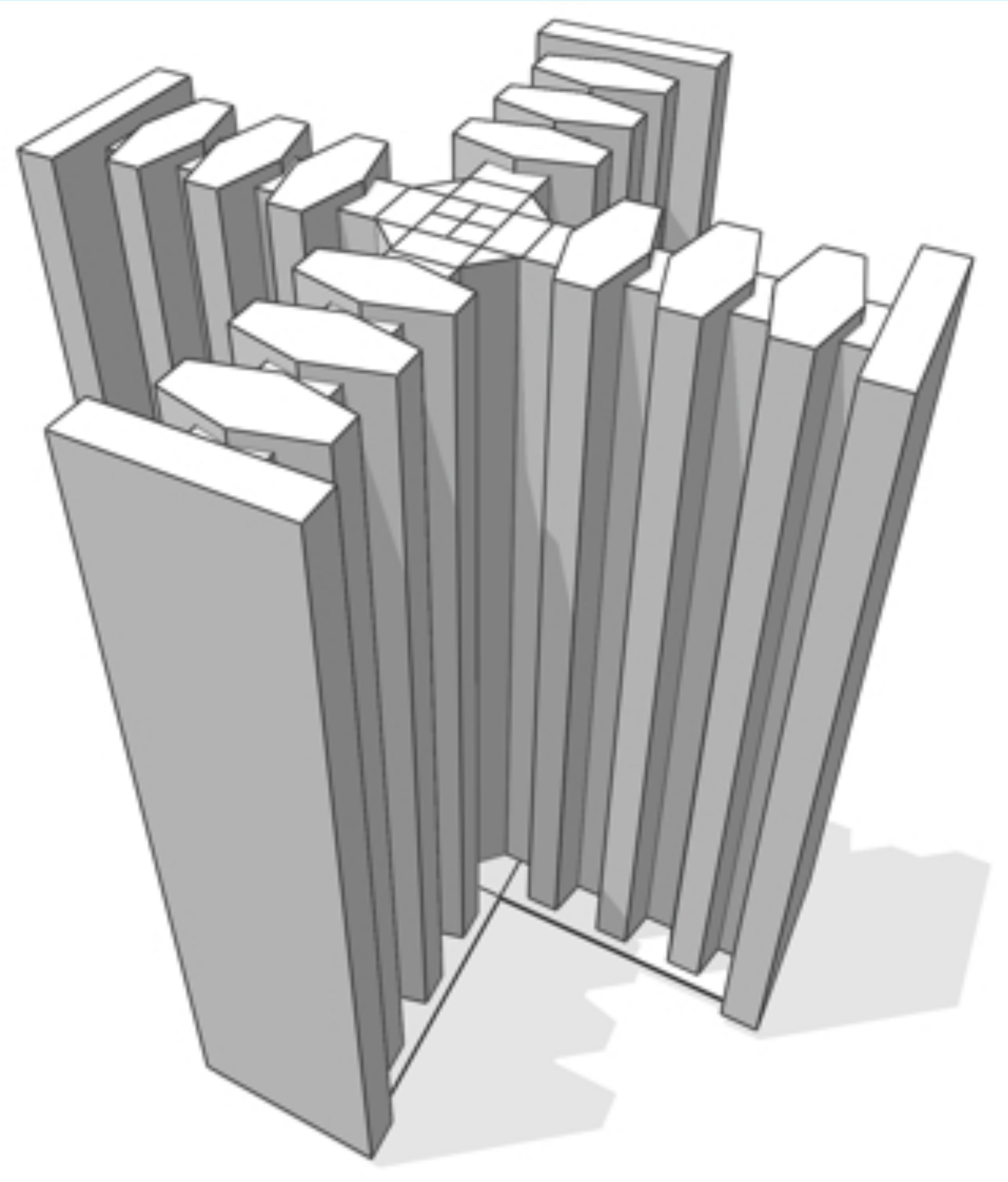
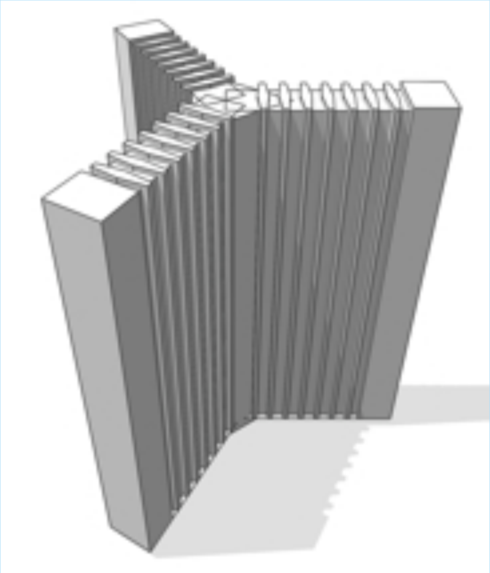
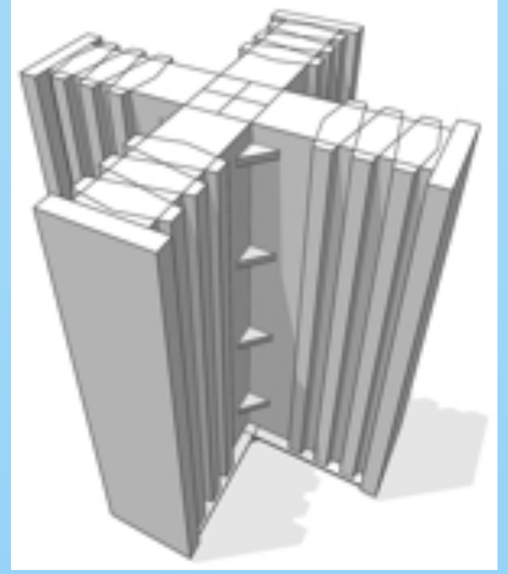
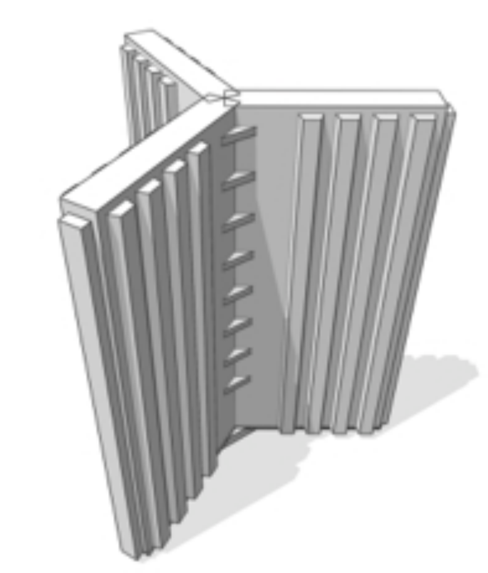
PARAMETERIZED PATTERNS

Example









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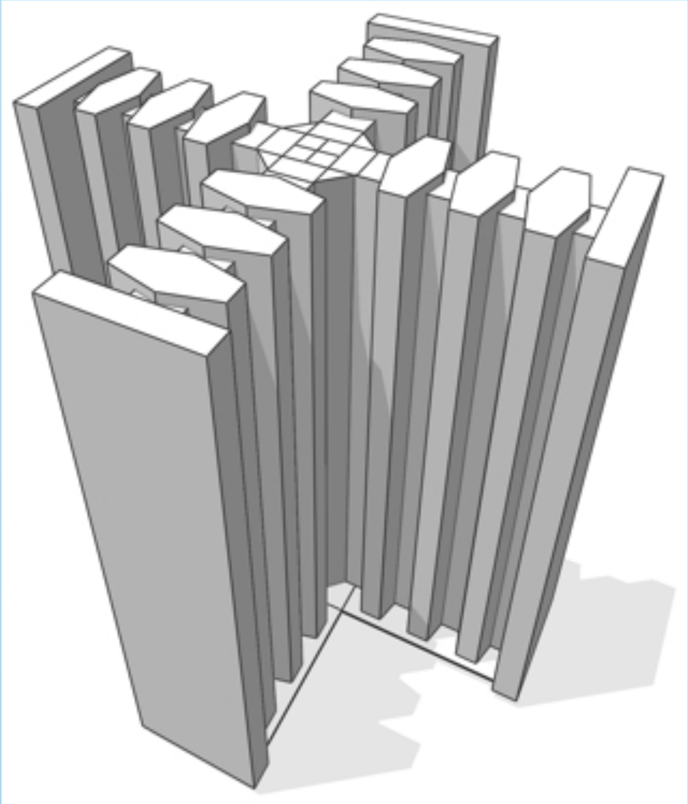
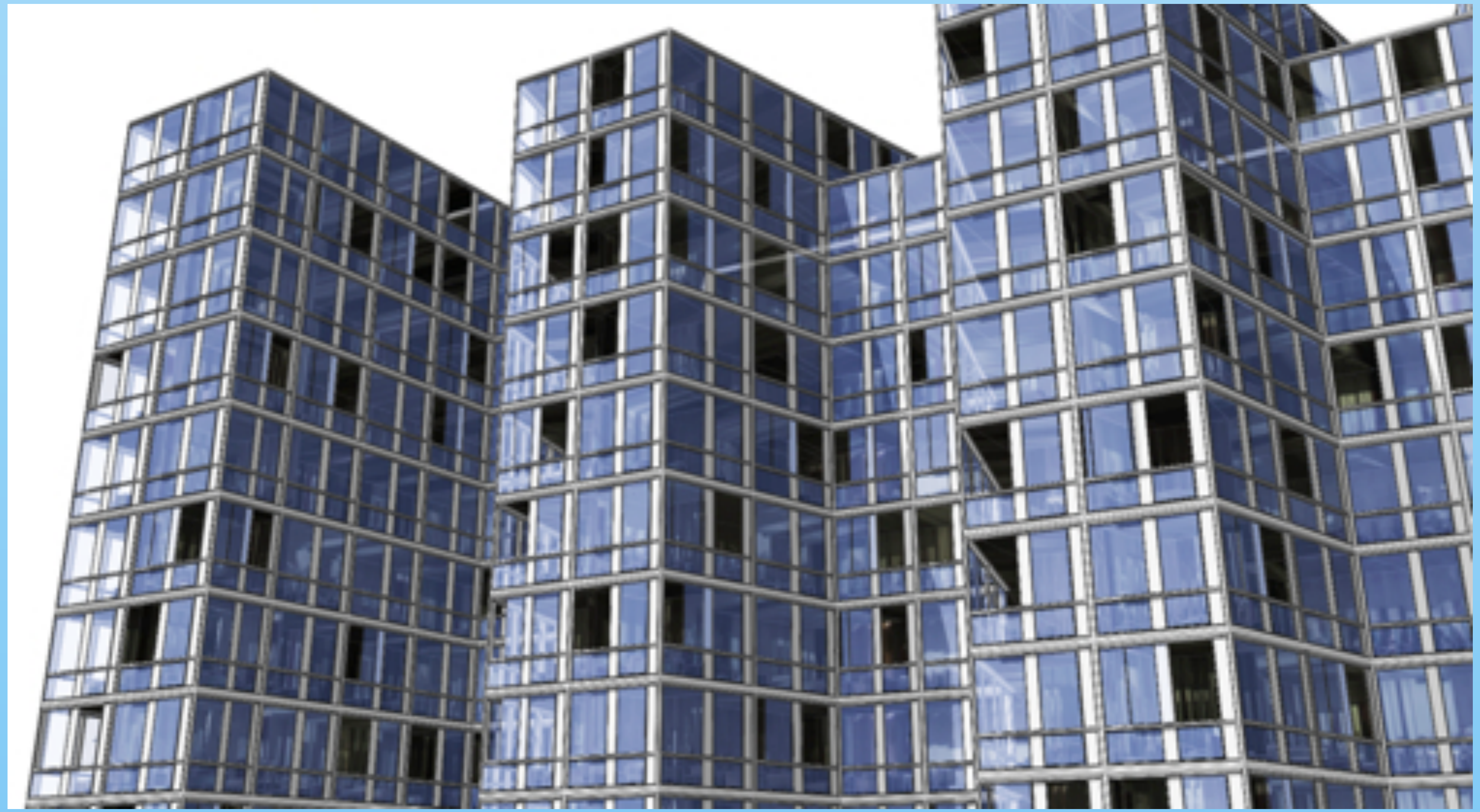
PARAMETERIZED PATTERNS

Example





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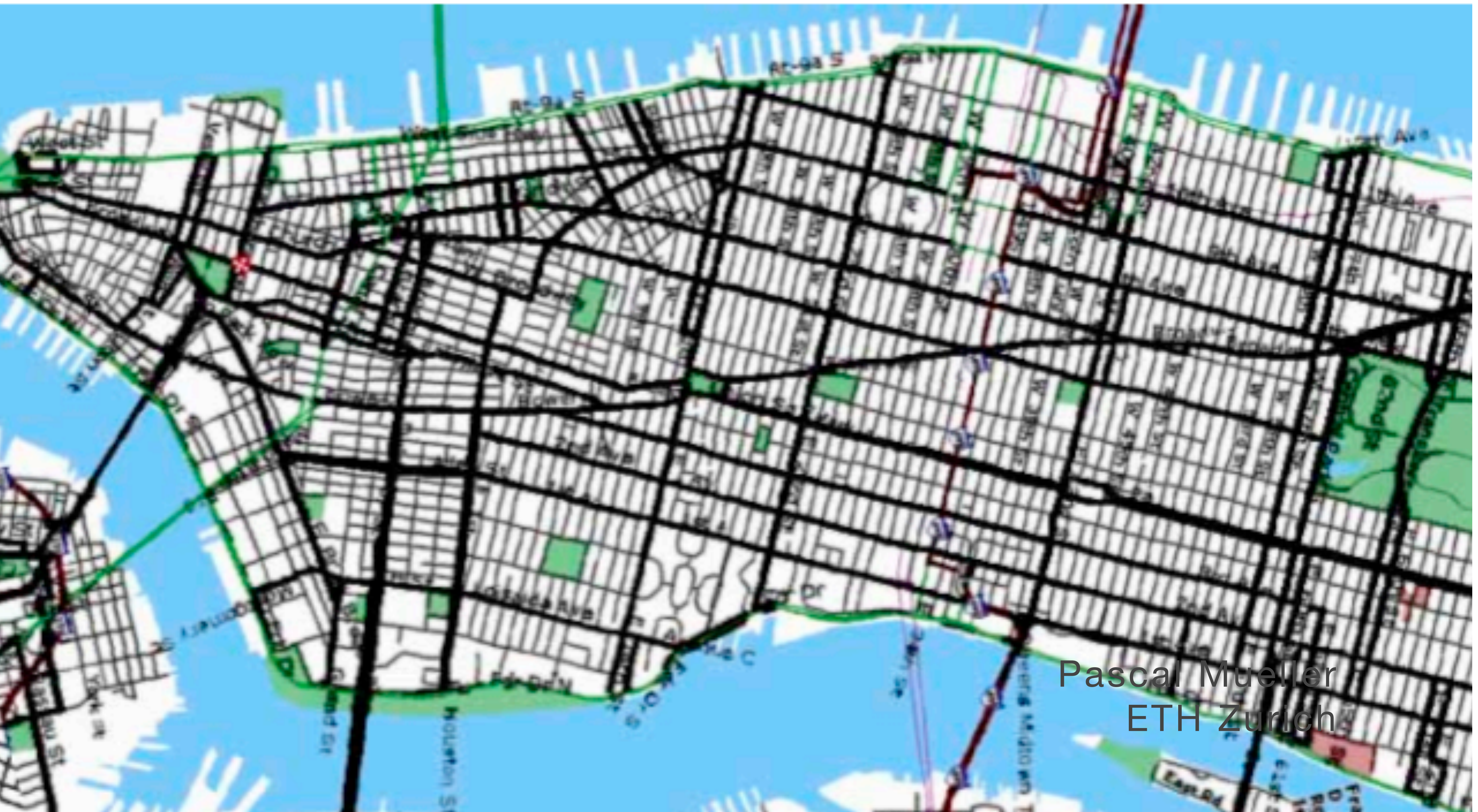
MERGING TECHNIQUES

Synthetic street growth



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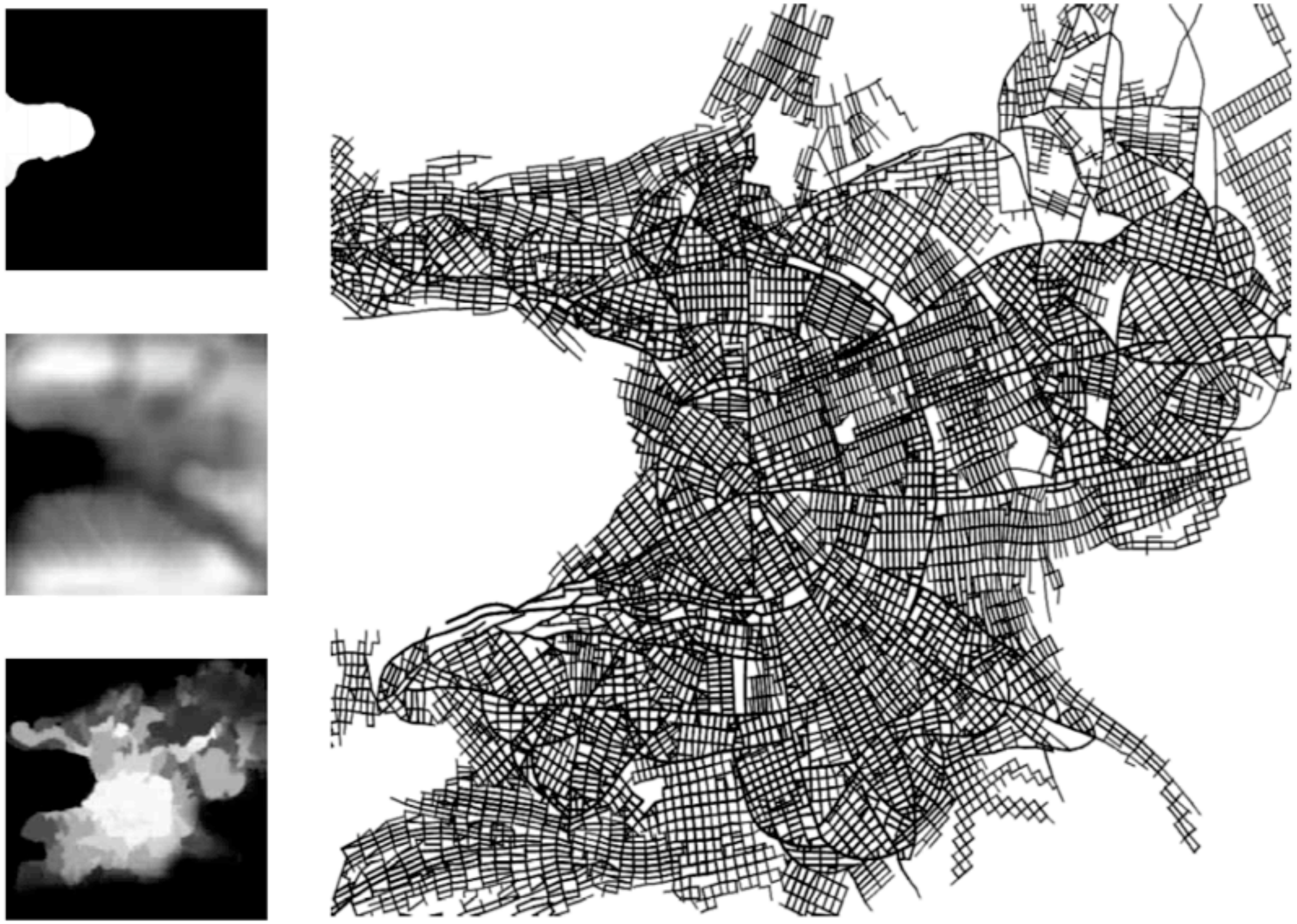
LINDENMEYER SYSTEMS FOR VIRTUAL STREETS



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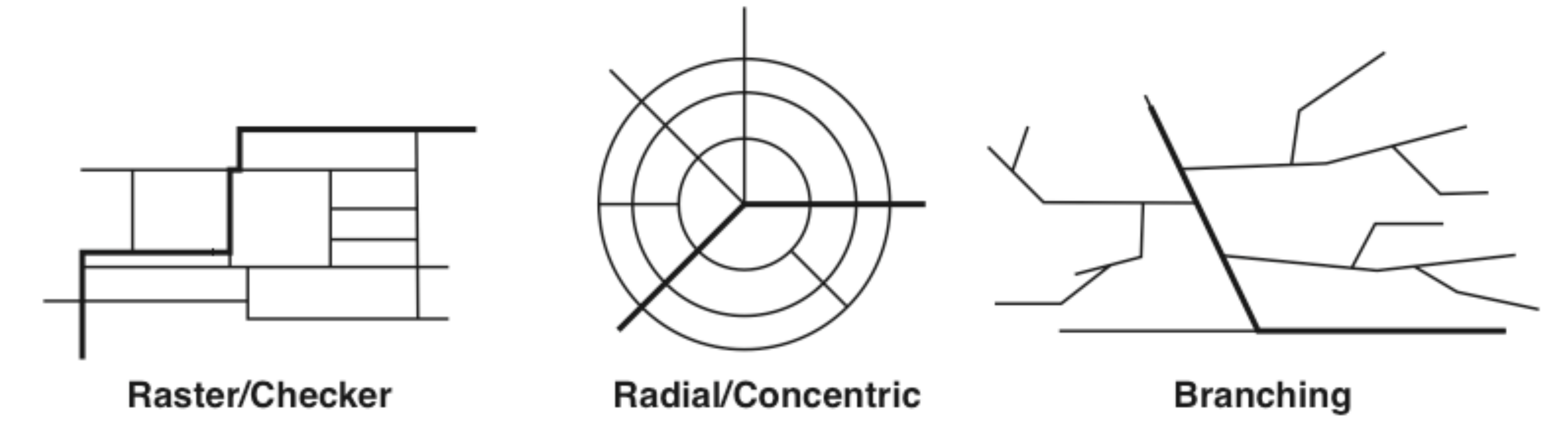
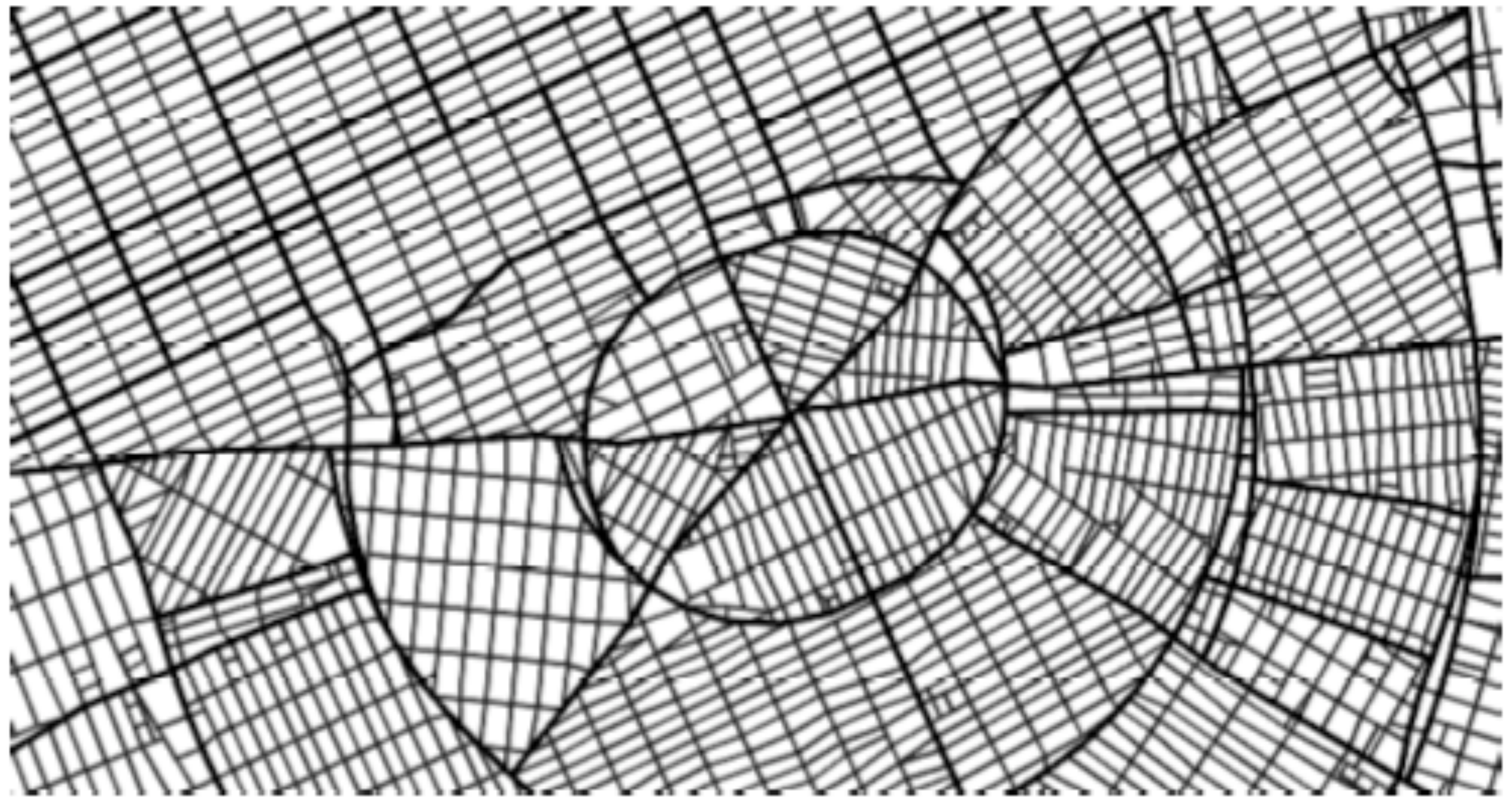
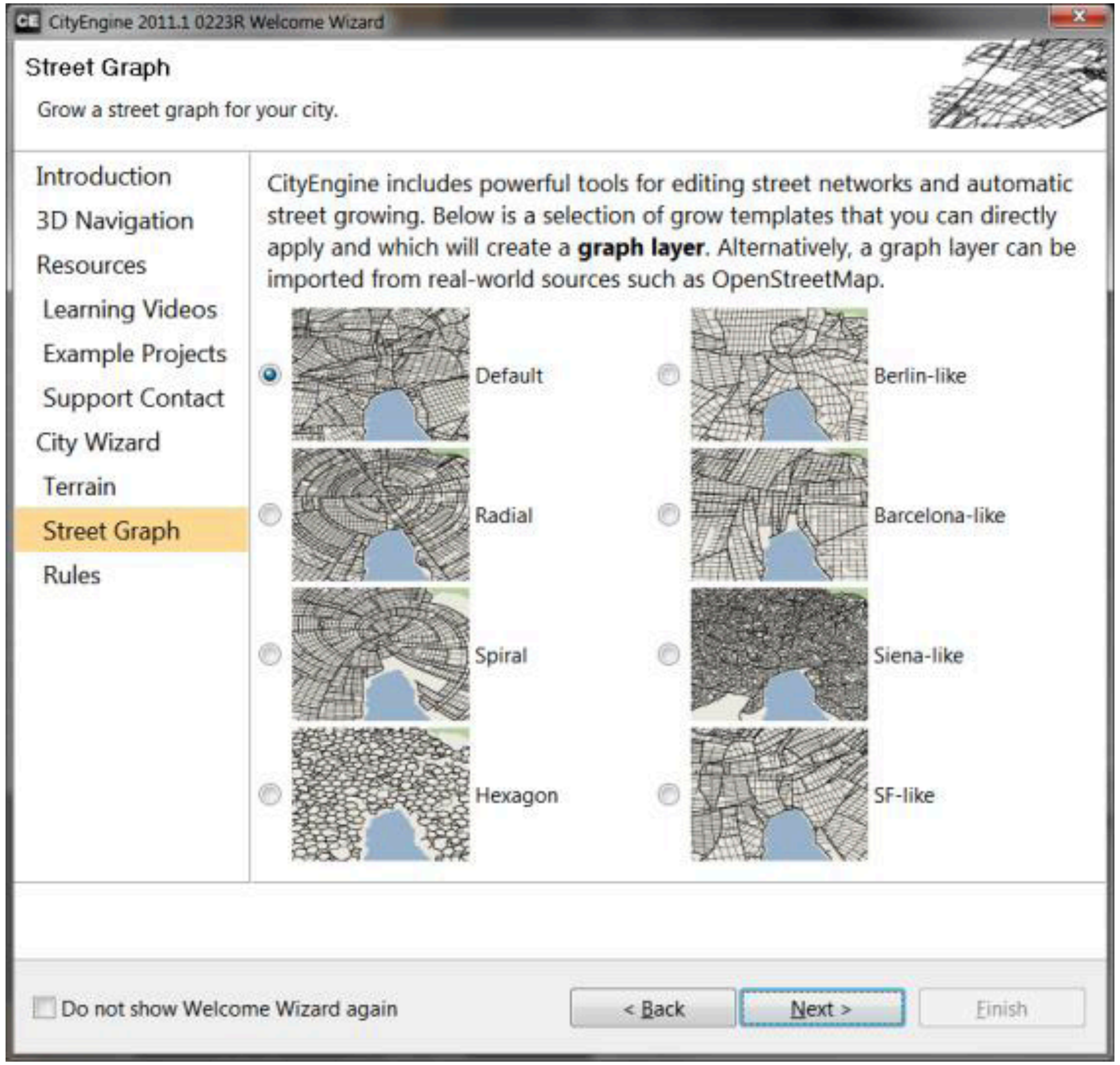
LINDENMEYER SYSTEMS FOR VIRTUAL STREETS







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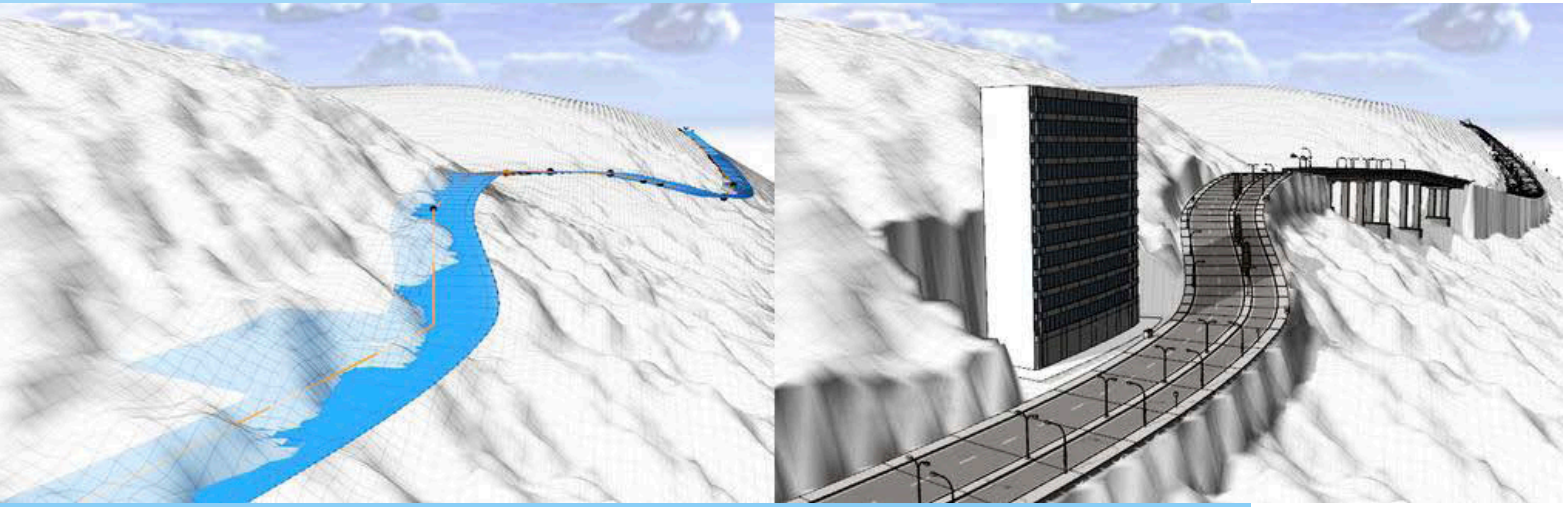
LINDENMEYER SYSTEMS FOR VIRTUAL STREETS

- Promising quantitative results
- Still needed: hand-made modifications

STREET MODELLING

- Terrain and slope modeling



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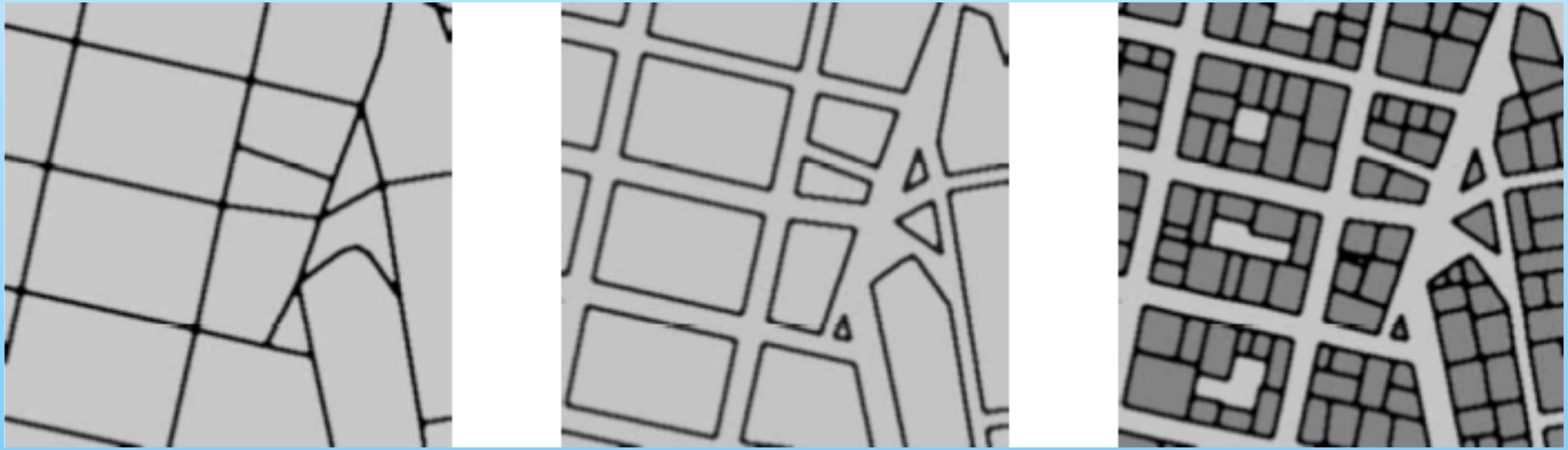
AUTOMATIC BLOCK DERIVATION

- Street networks includes street width
- Major blocks
- Controlled parcel subdivision



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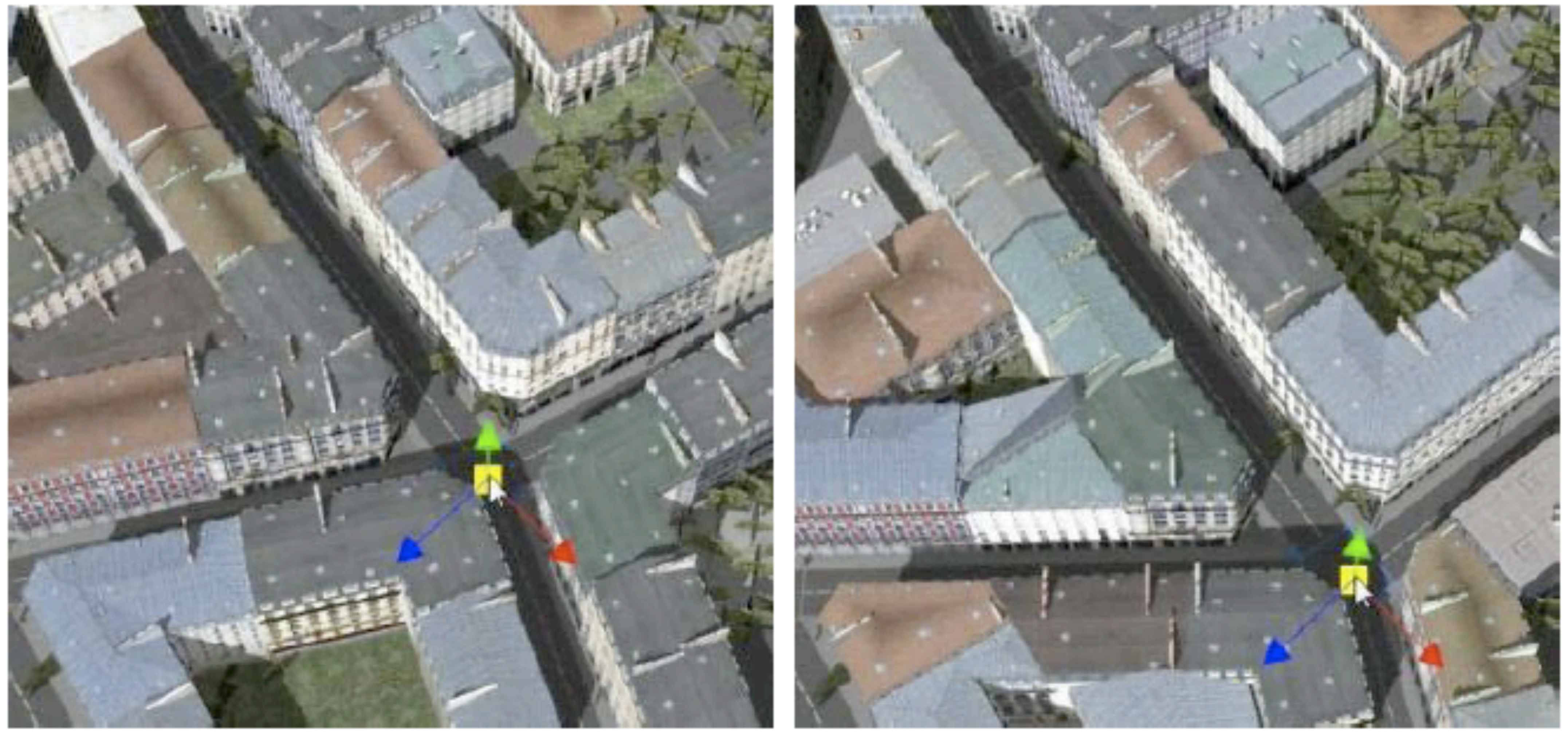
PARAMETRIC BLOCKS AND STREETS

Consistent block and street modifications

- Blocks can be interactively modified
- New streets can be inserted
- Blocks stay consistent (e.g., orientation)



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VISUALIZATION PIPELINE

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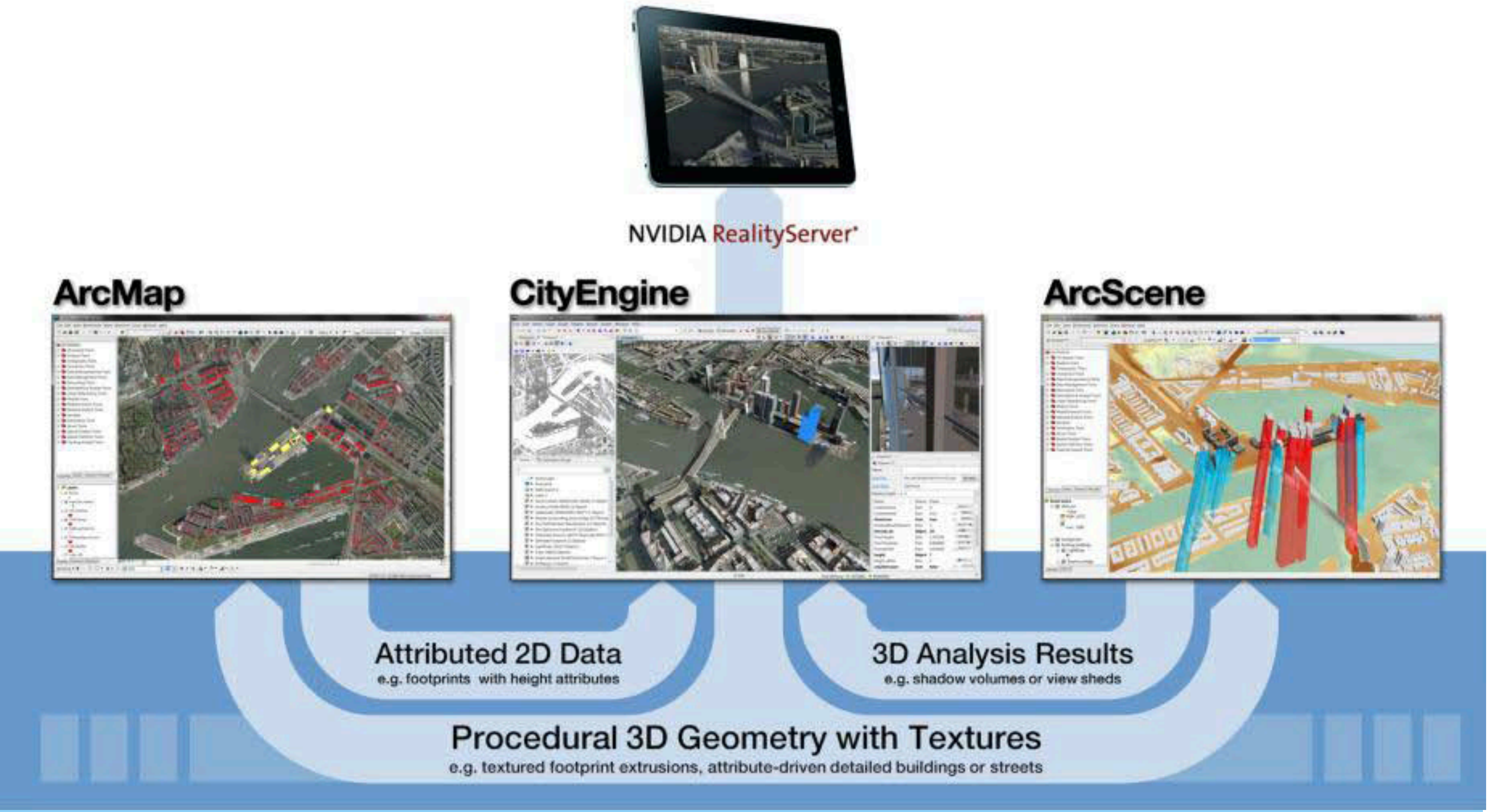
CLOUD-BASED RENDERING OF LARGE SCALE MODELS



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City Models are hard to visualize

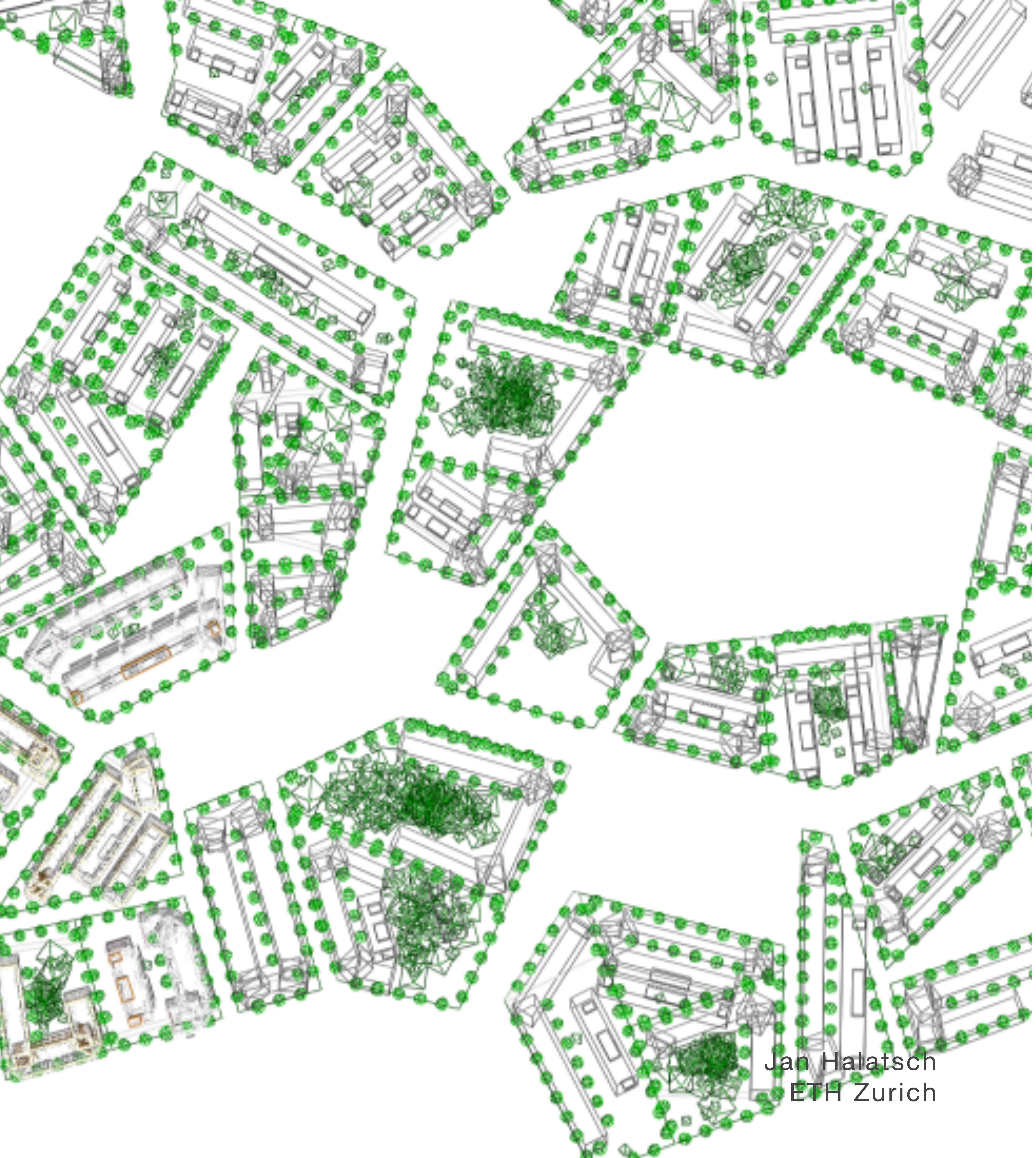
(a) powerful computers for visualization
(b) distributed computing ressources that feed information through web browsers

GIS based visualization

(a) Geo information system with urban design and site data
(b) CE for authoring design patterns
(c) Spatial Analyst or Ecotect for evaluation
(d) Cloud based renderer composites output

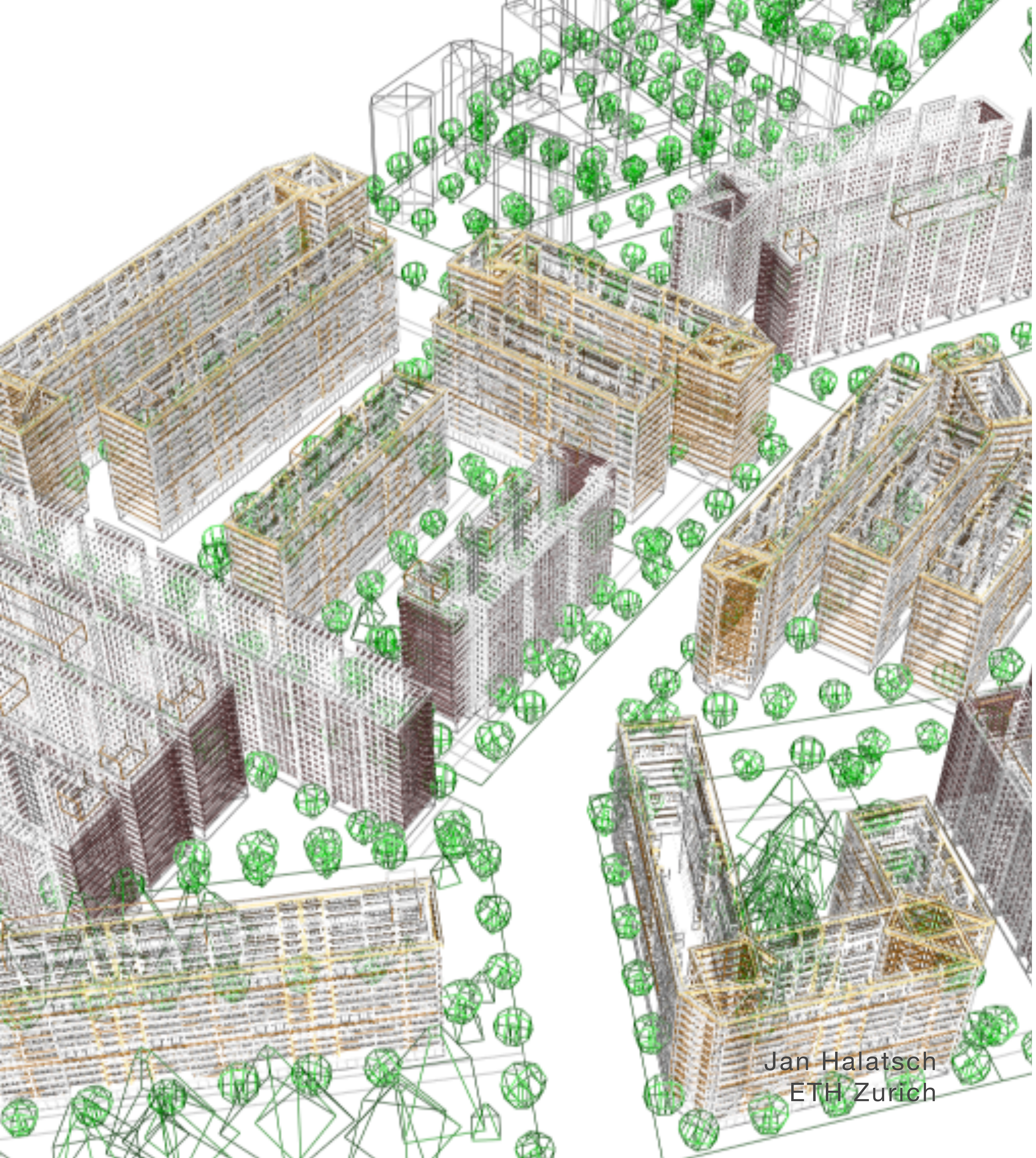
URBAN PATTERN EXAMPLE

Open Space Generation



URBAN PATTERN EXAMPLE

Open Space Generation



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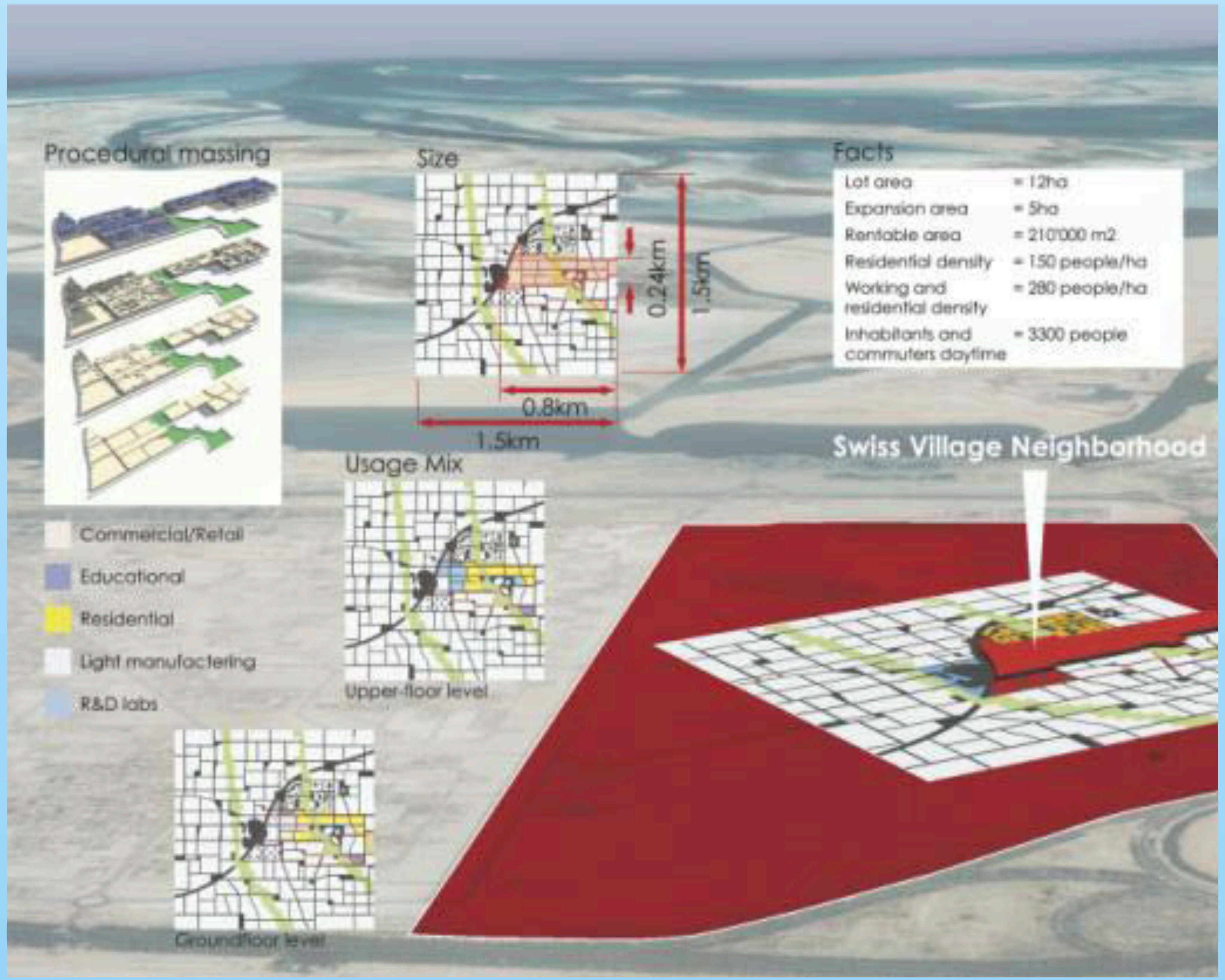
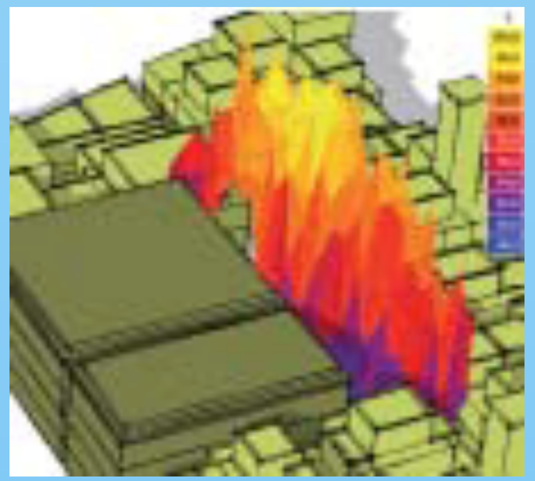
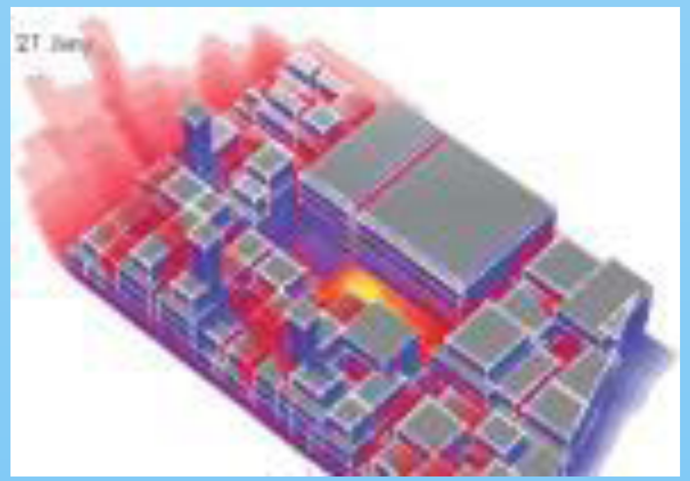
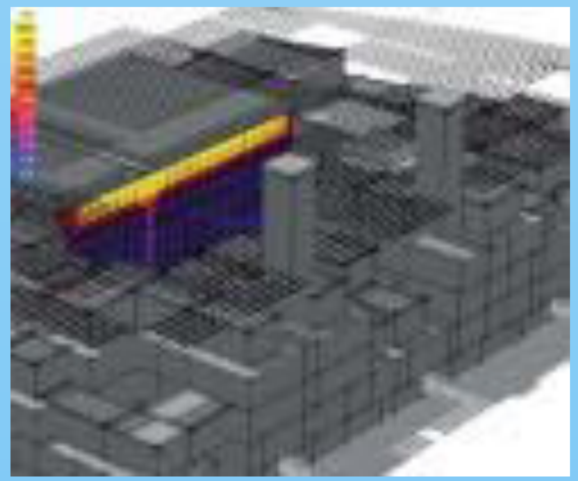
URBAN PLANNING EXAMPLES

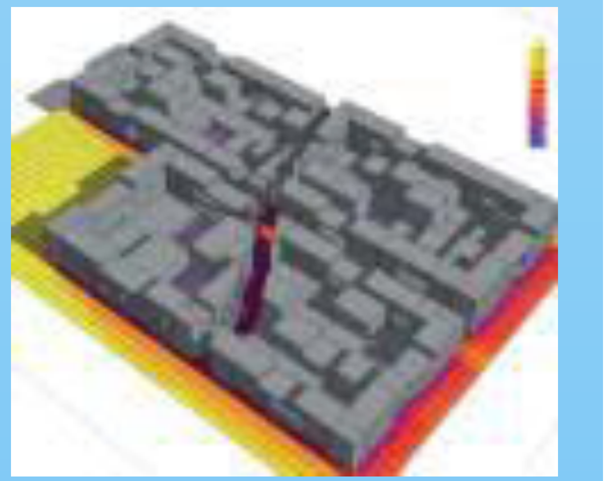
Masdar City, UAE











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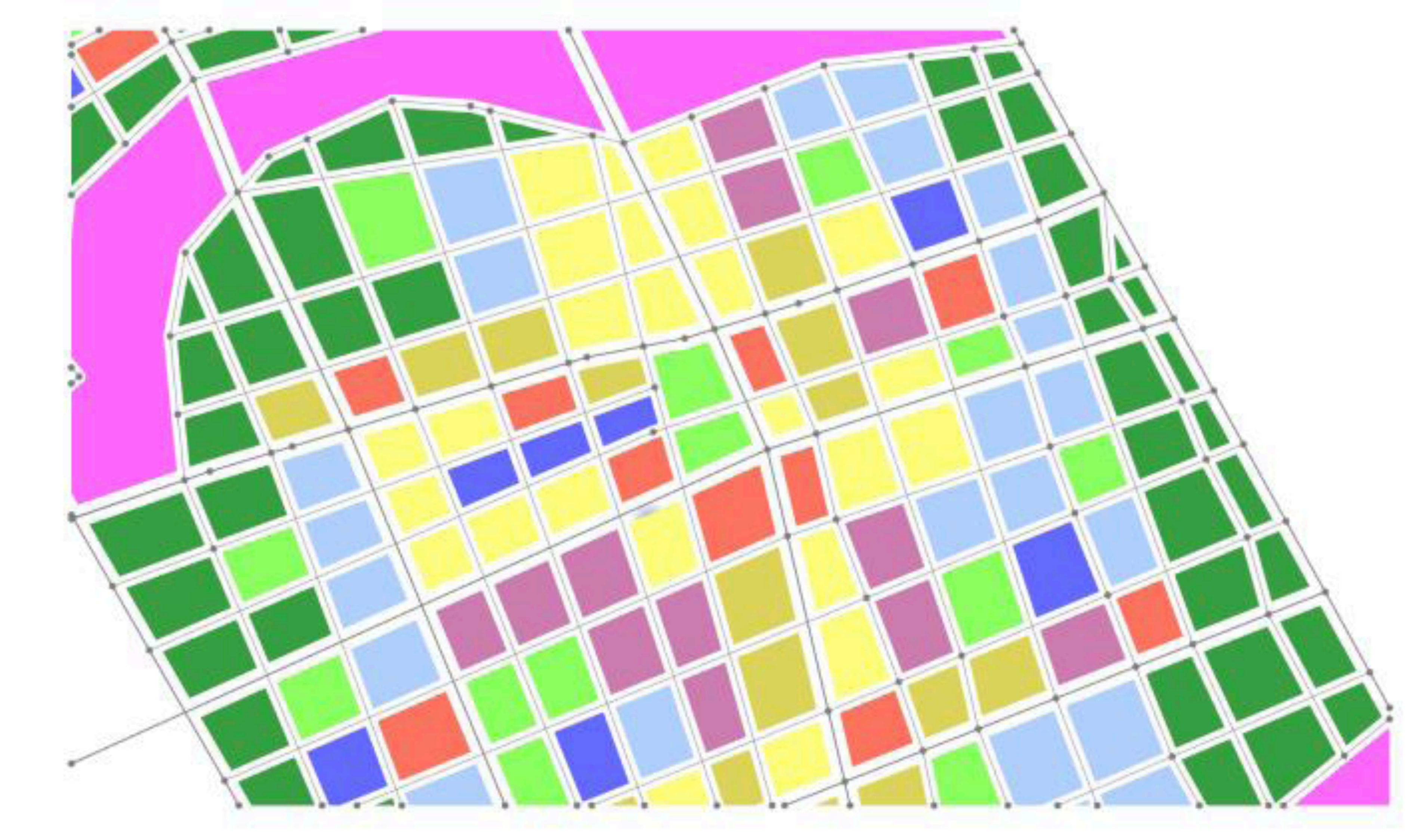

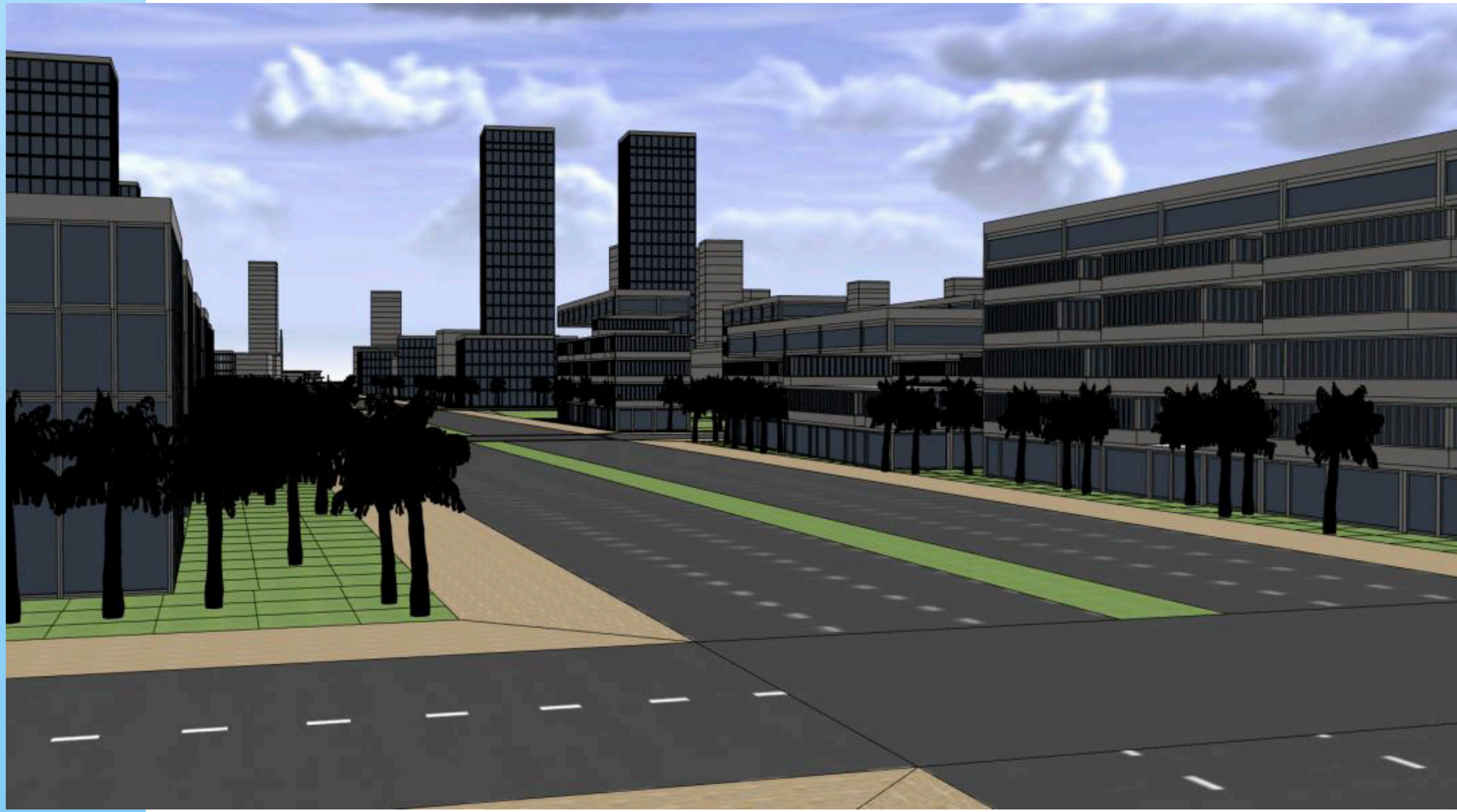

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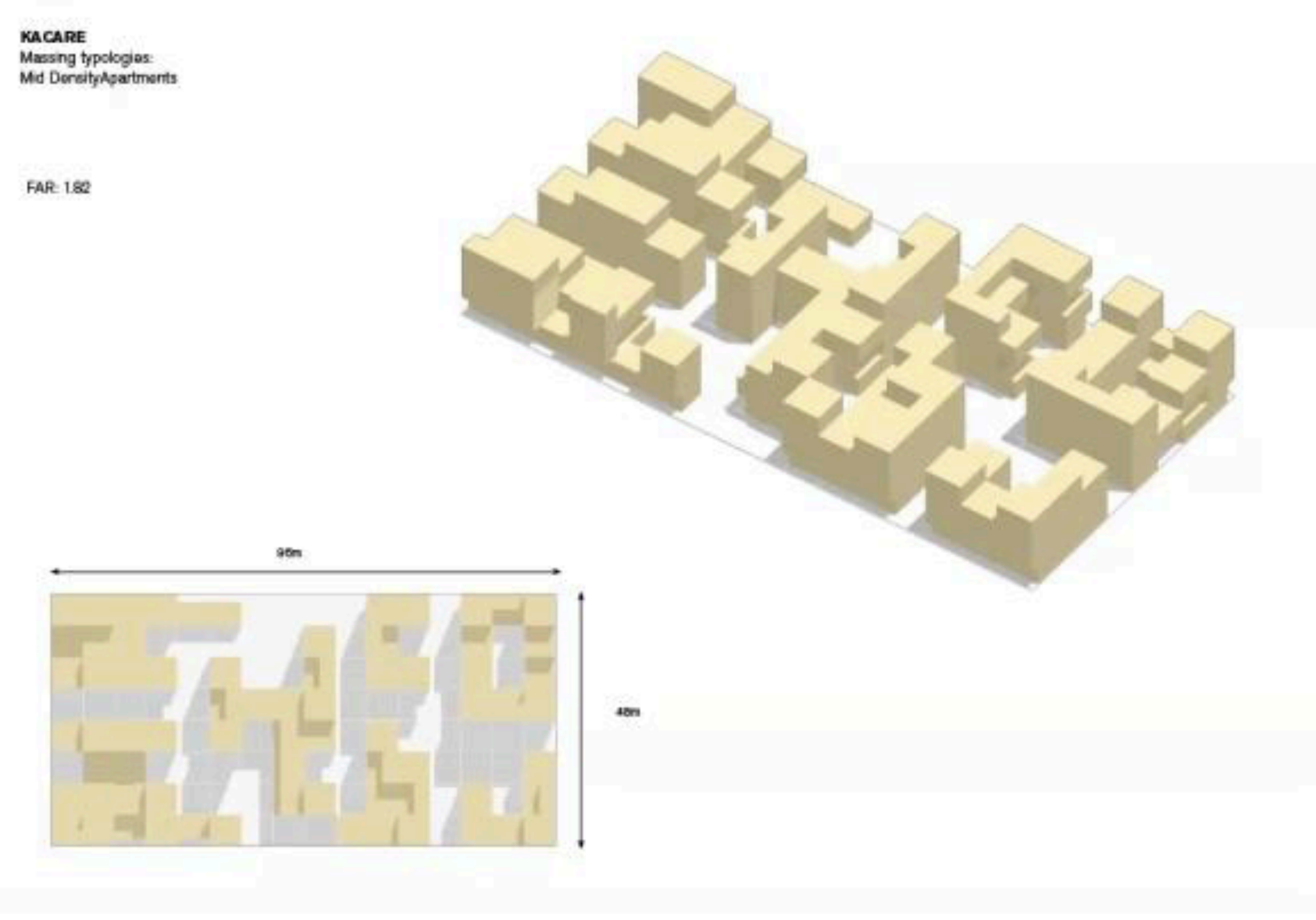

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THANK YOU!

Following slides from 2011 Siggraph Course

Modeling 3D Urban Spaces Using Procedural and Simulation-Based Techniques

http://www.cs.purdue.edu/cgvlab/urban/sg_2011_course/contents.html

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