Chair for Information Architecture

Jan Halatsch
iaurbansim@arch.ethz.ch

The Art of Procedural Modelling

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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iaurbansim@arch.ethz.ch

DESIGN PROCESS

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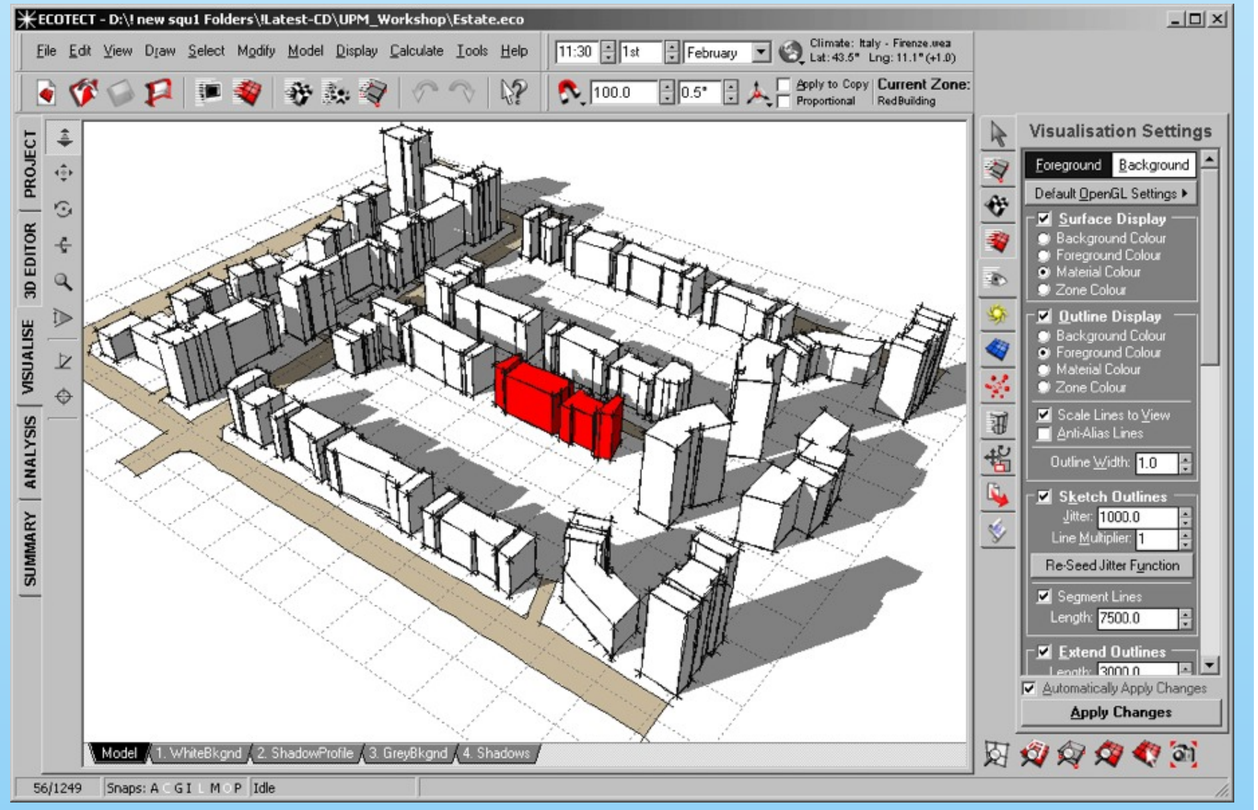
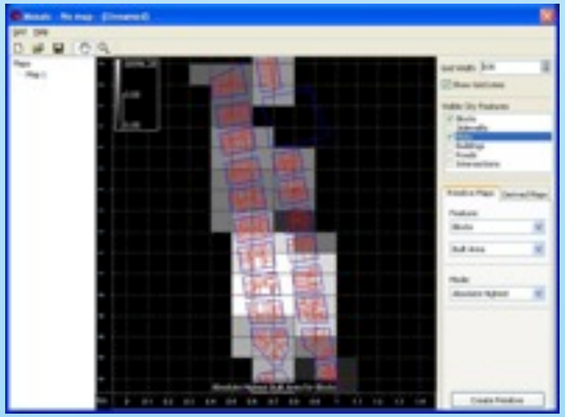


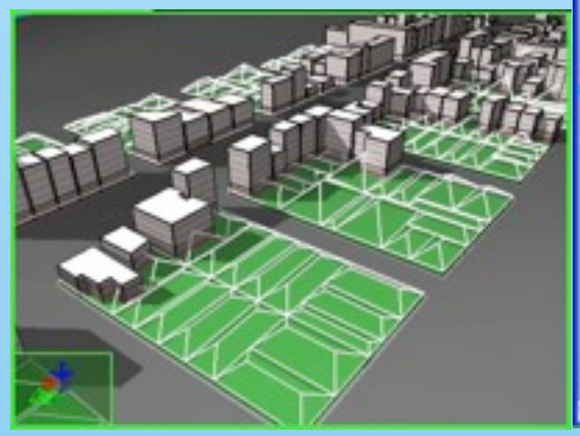
Autodesk Ecotect

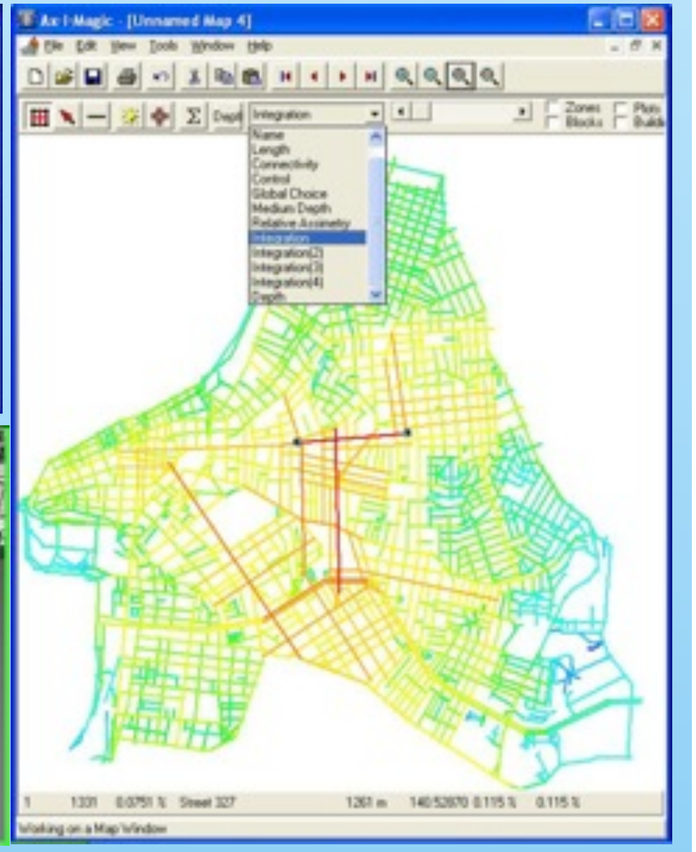
DESIGN PROCESS

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







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

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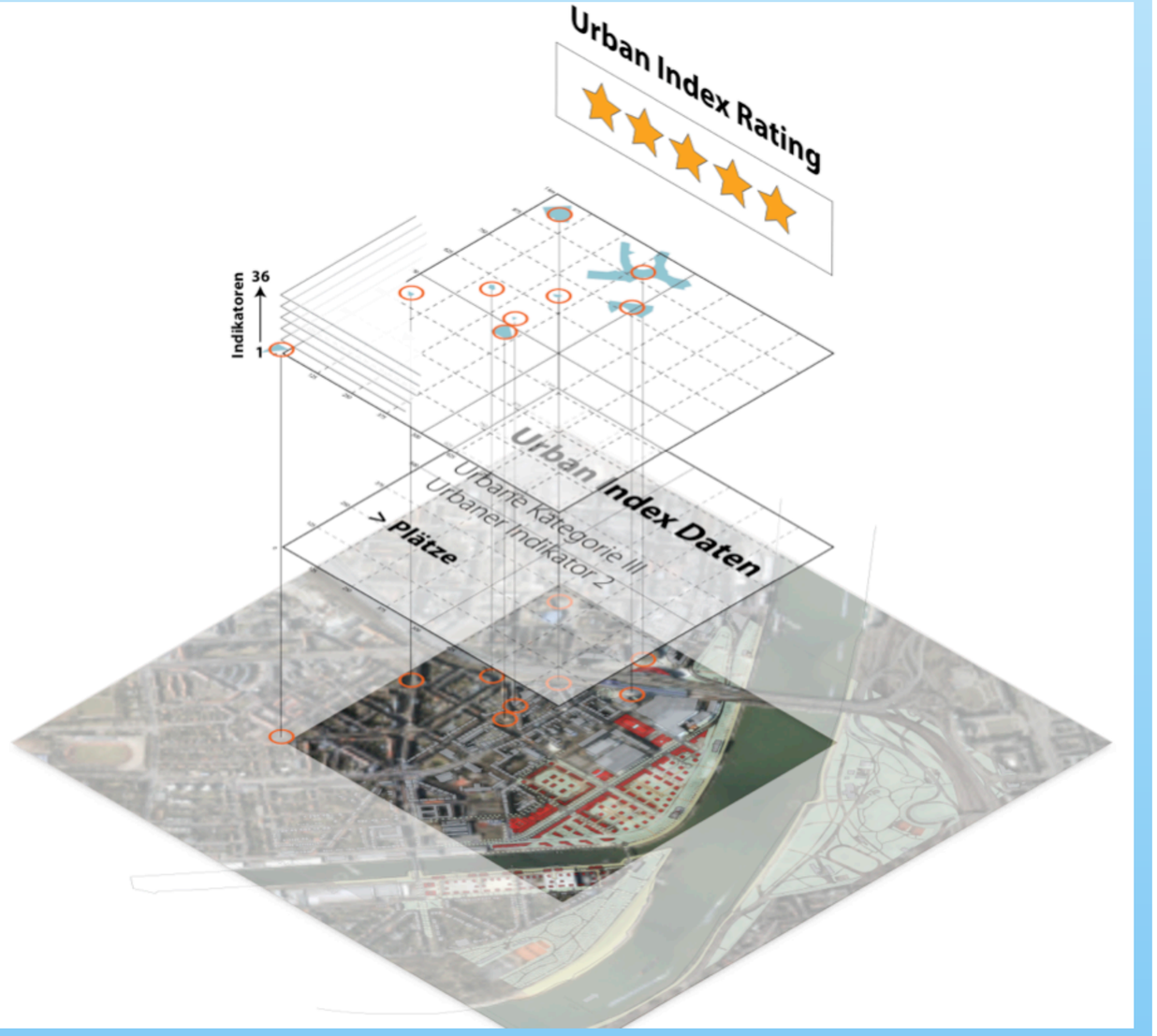

DESIGN PROCESS

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)

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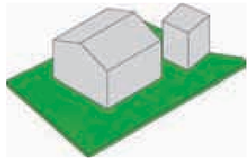
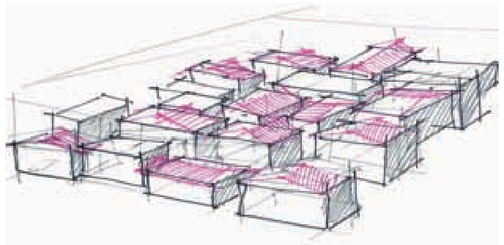
BUILDING TYPOLOGY ANALYSIS

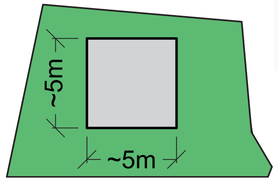
RESIDENCIAL DE BAIXA RENDA | LOW INCOME RESIDENTIAL

VILAS
SQUATTERS

Exemplo: Vila Dique

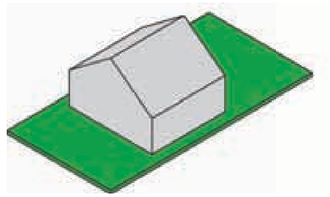


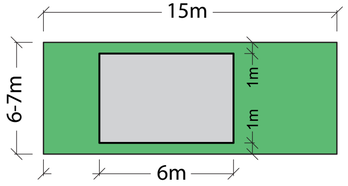




HABITAÇÃO DE INTERESSE SOCIAL
SOCIAL HOUSING

Exemplo: Vila Farrapos



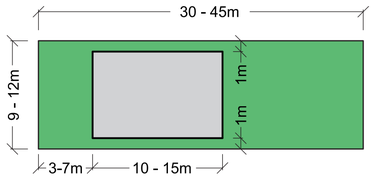


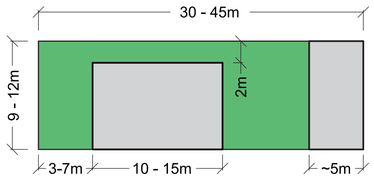
BUILDING TYPOLOGY ANALYSIS

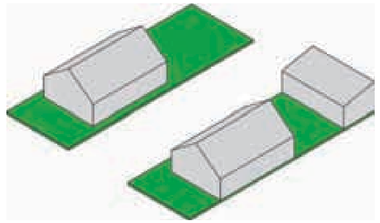
RESIDENCIAL DE MÉDIA BAIXA RENDA | LOW MIDDLE INCOME RESIDENTIAL

CASA UNIFAMILIARES
INDIVIDUAL HOUSING

Exemplo: Bairro Jardim Itú-Sabará

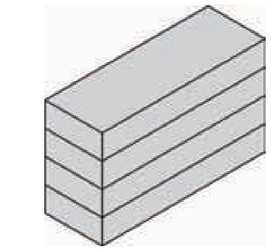


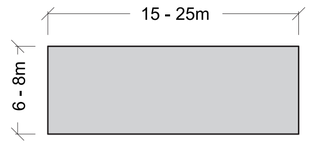




EDIFÍCIOS MULTIFAMILIARES
MULTISTOREY HOUSING

Exemplo: Rubem Berta



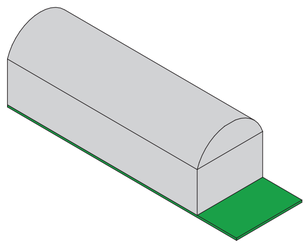


BUILDING TYPOLOGY ANALYSIS

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

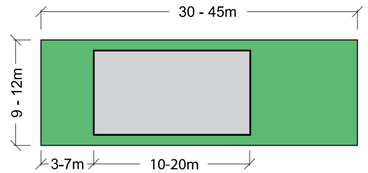
Exemplo:
Brique da Redenção

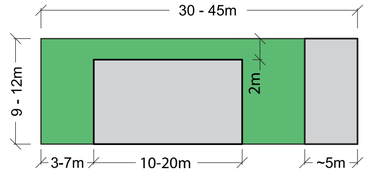
BUILDING TYPOLOGY ANALYSIS

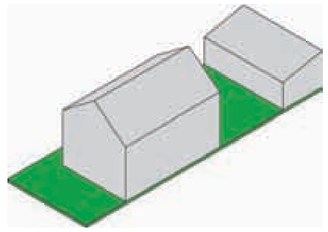
RESIDENCIAL DE MÉDIA RENDA | MIDDLE INCOME RESIDENTIAL

CASAS UNIFAMILIARES
INDIVIDUAL HOUSING

Exemplo: Bairro Bomfim

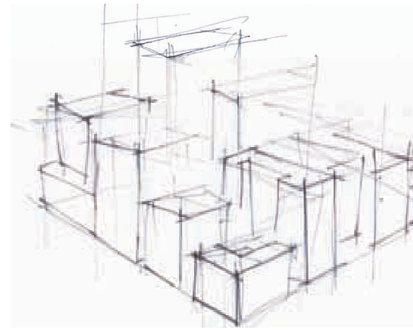


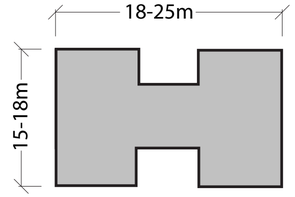




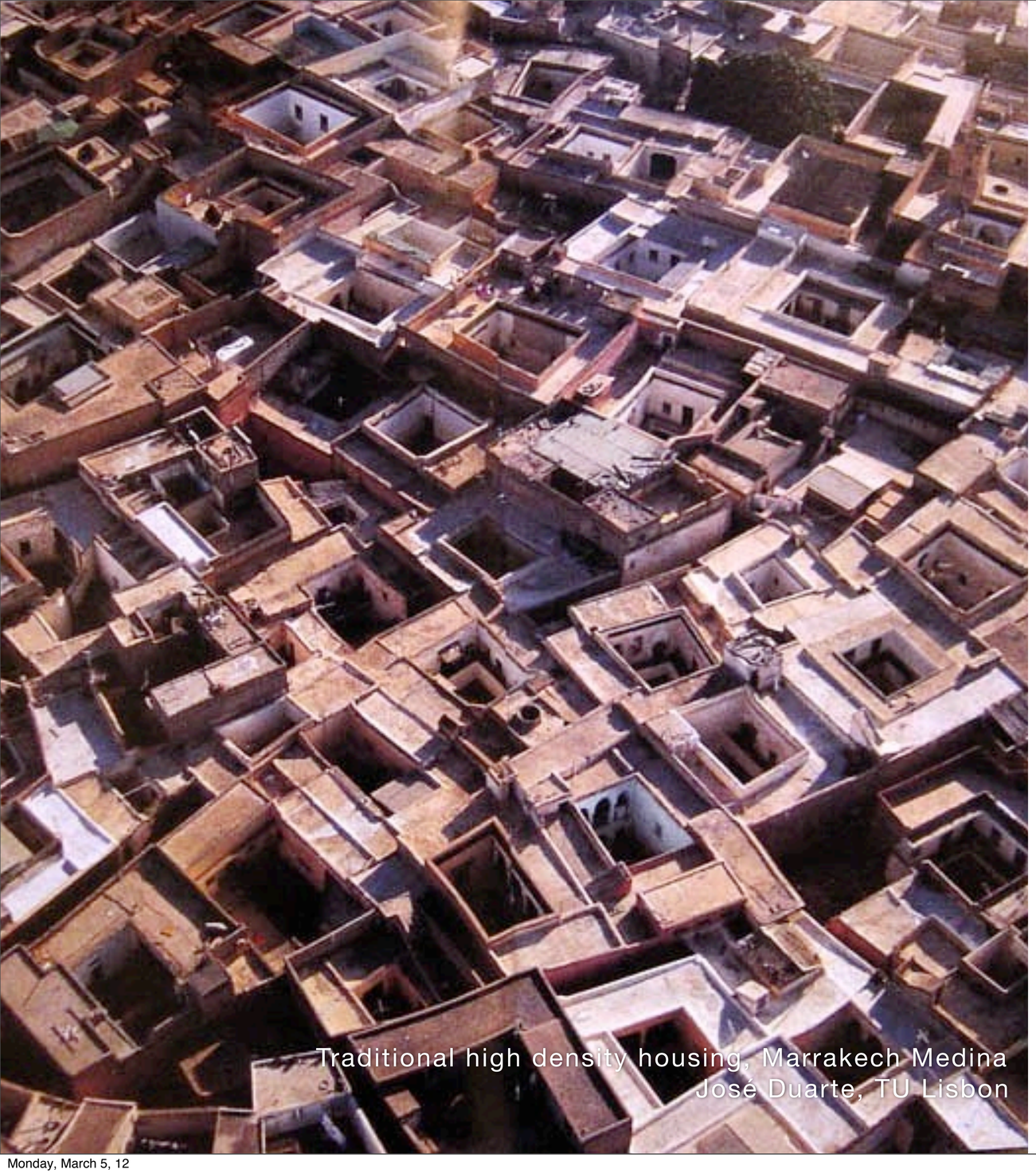
EDIFÍCIOS MULTIFAMILIARES
MULTISTOREY HOUSING

Exemplo: Bairro Jardim Itú-Sabará





DESIGN GRAMMARS



Traditional high density housing, Marrakech Medina
José Duarte, TU Lisbon

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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

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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

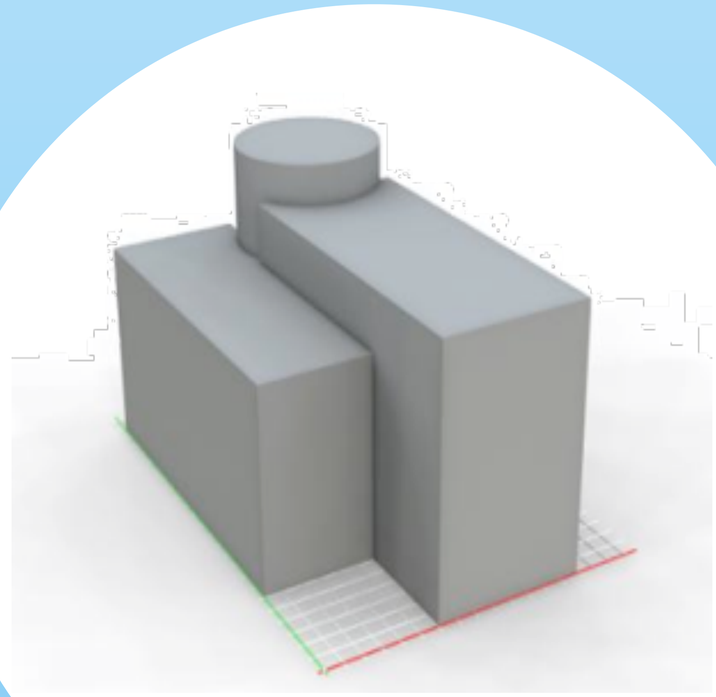
Resulting set of all strings (language):

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

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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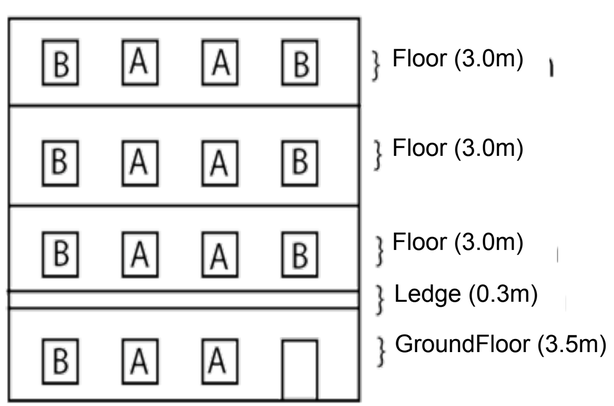
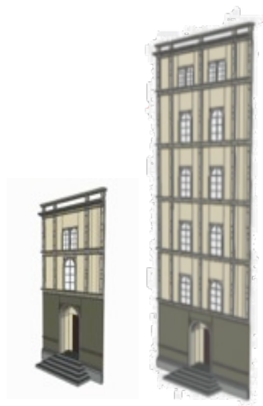
CGA SHAPE: OPERATIONS

Example

Facade -->

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





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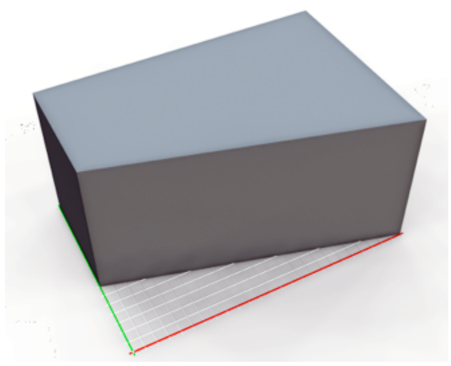
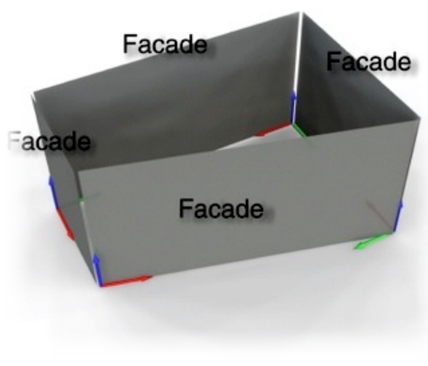
CGA SHAPE: OPERATIONS

Example

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





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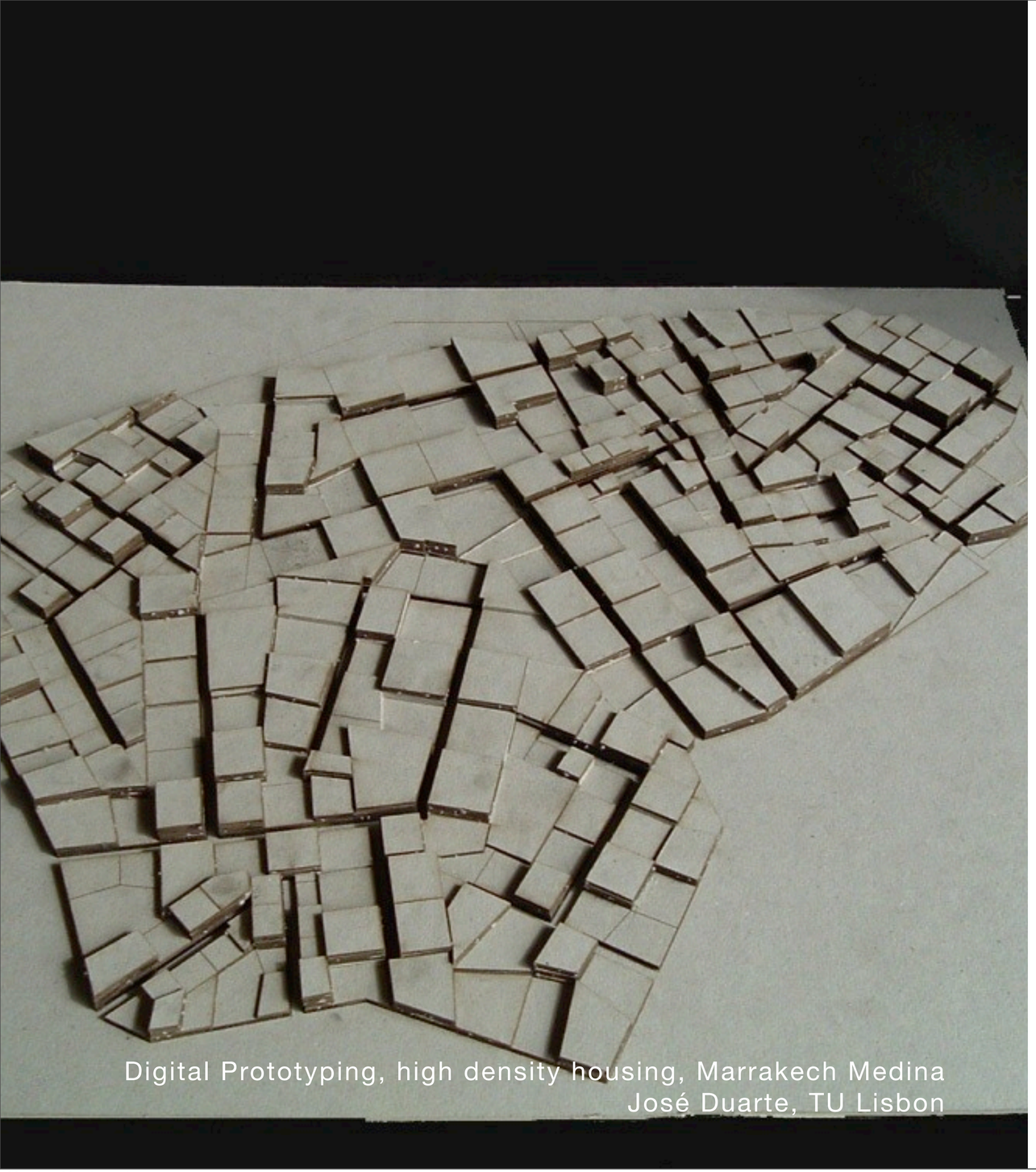
DESIGN PATTERNS



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

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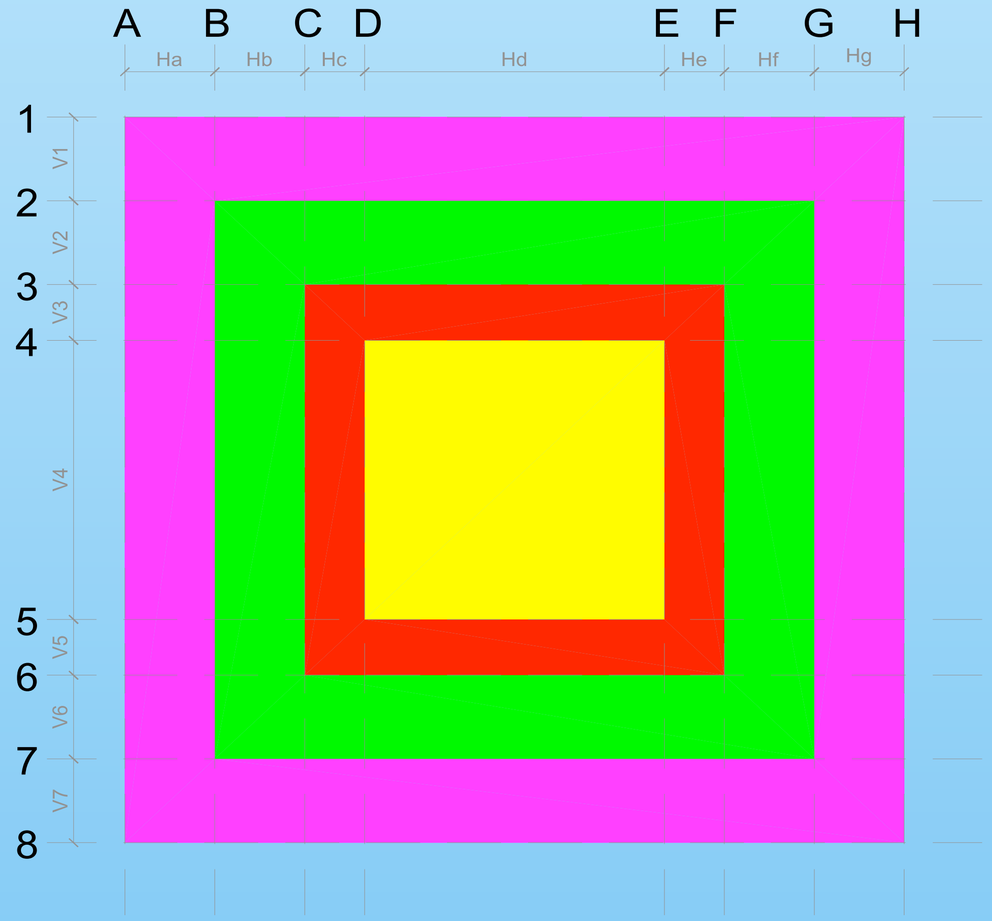
GENERIC BUILDING BLOCK PATTERN



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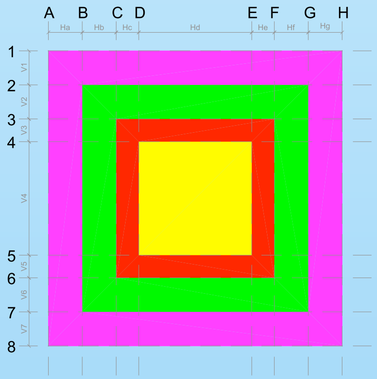

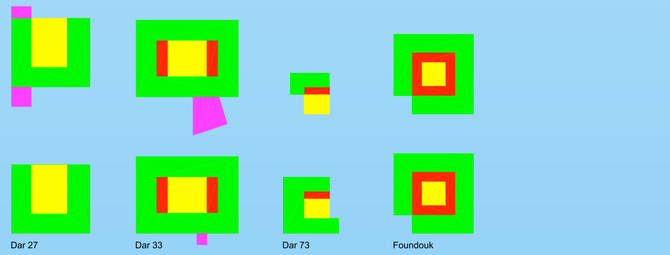
Dar 27

Dar 33

Dar 73

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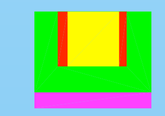

Dar Dounia


Dar Charifa


Dar Frances


Dar Hanane

GENERIC BUILDING AND SPECIALIZATION

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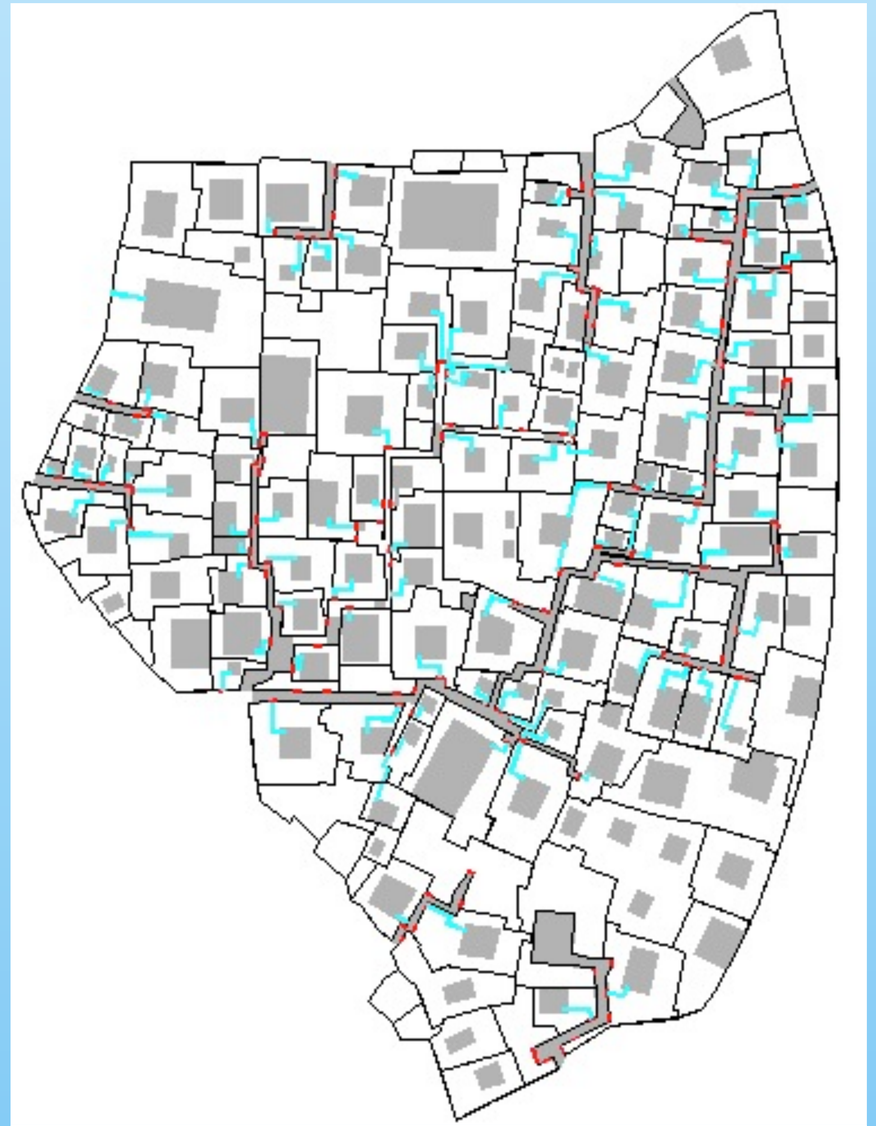

DIGITAL MEDINA

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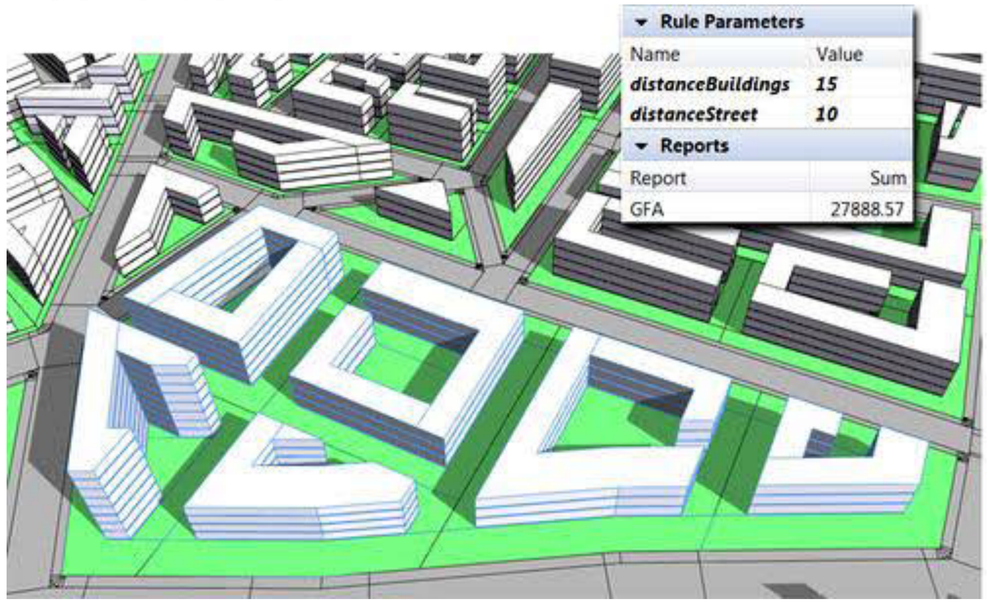
DESIGN PATTERNS

Grammar Implementation CGA

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



Pascal Müller, Jan Halatsch
Procedural AG, ETH Zurich

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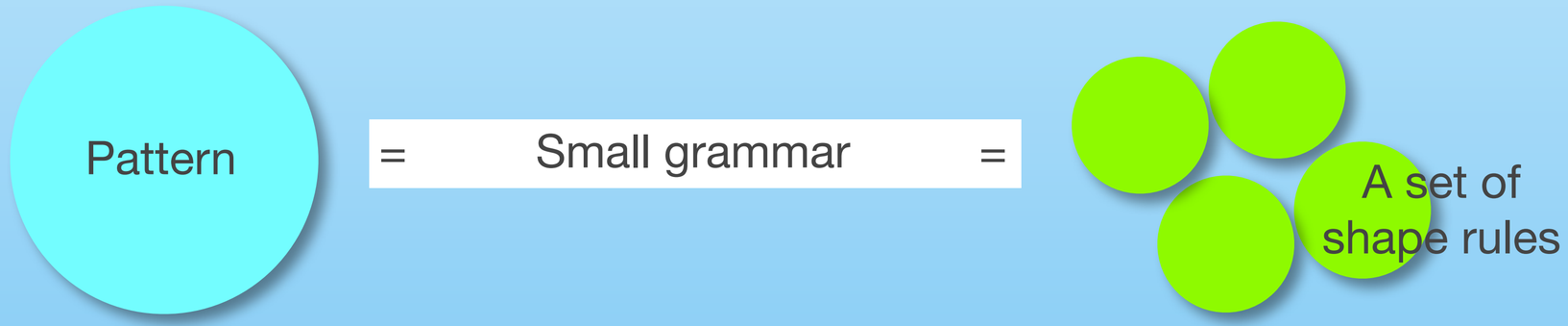
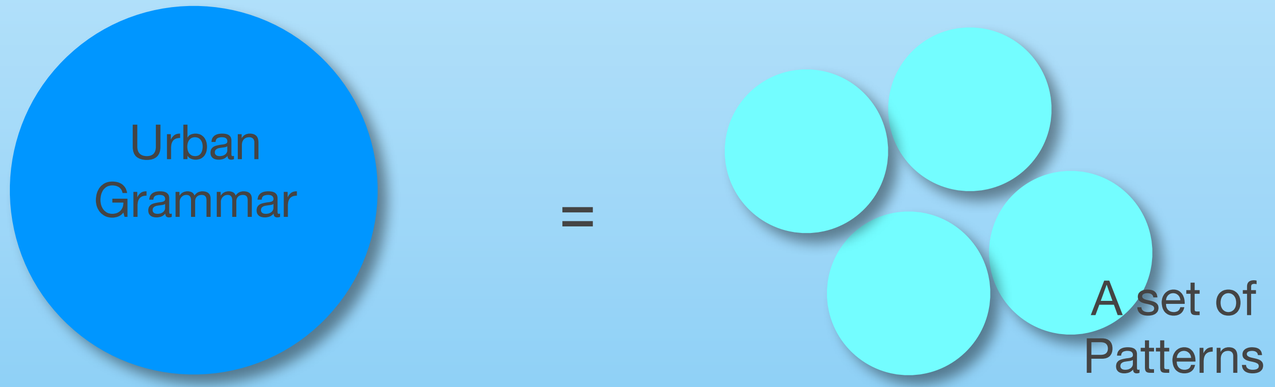
PATTERN MODELLING

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



José Beirão
TU Delft

PATTERN MODELLING



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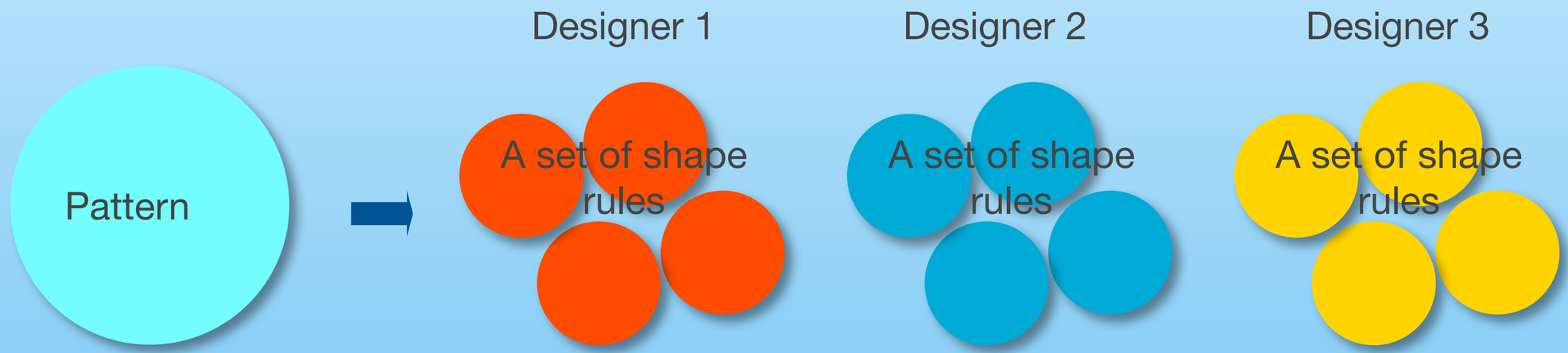
PATTERN MODELLING

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



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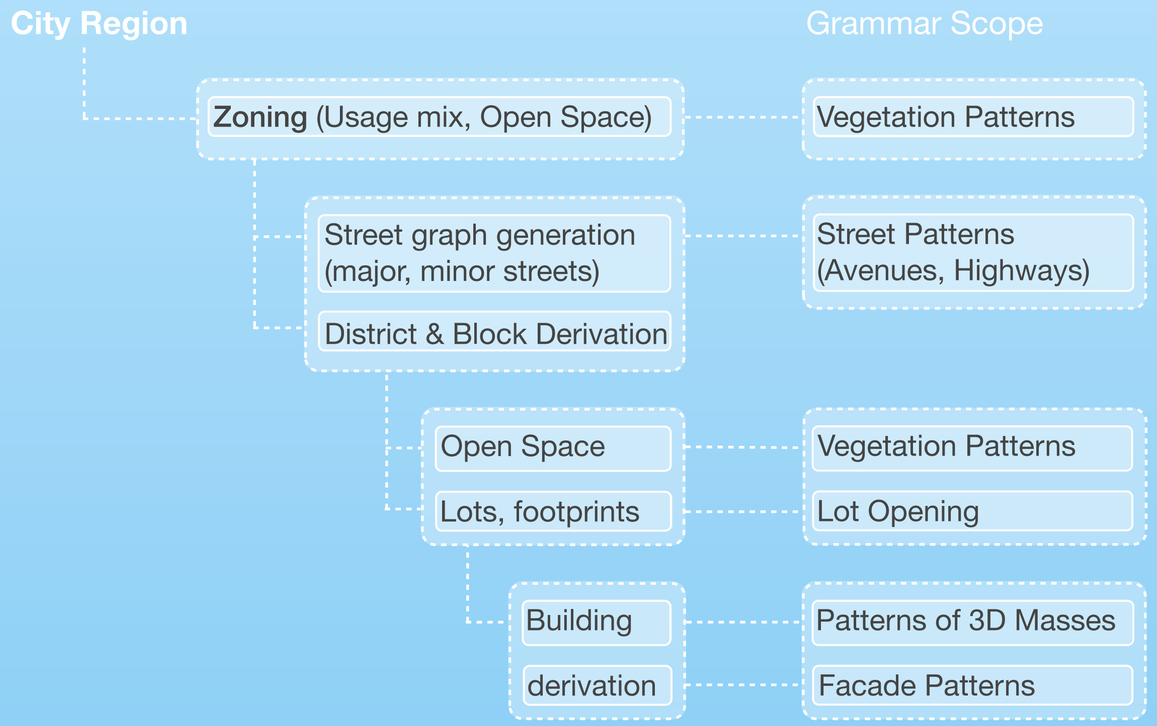
SCALE CLASSIFICATION



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ETH Zurich

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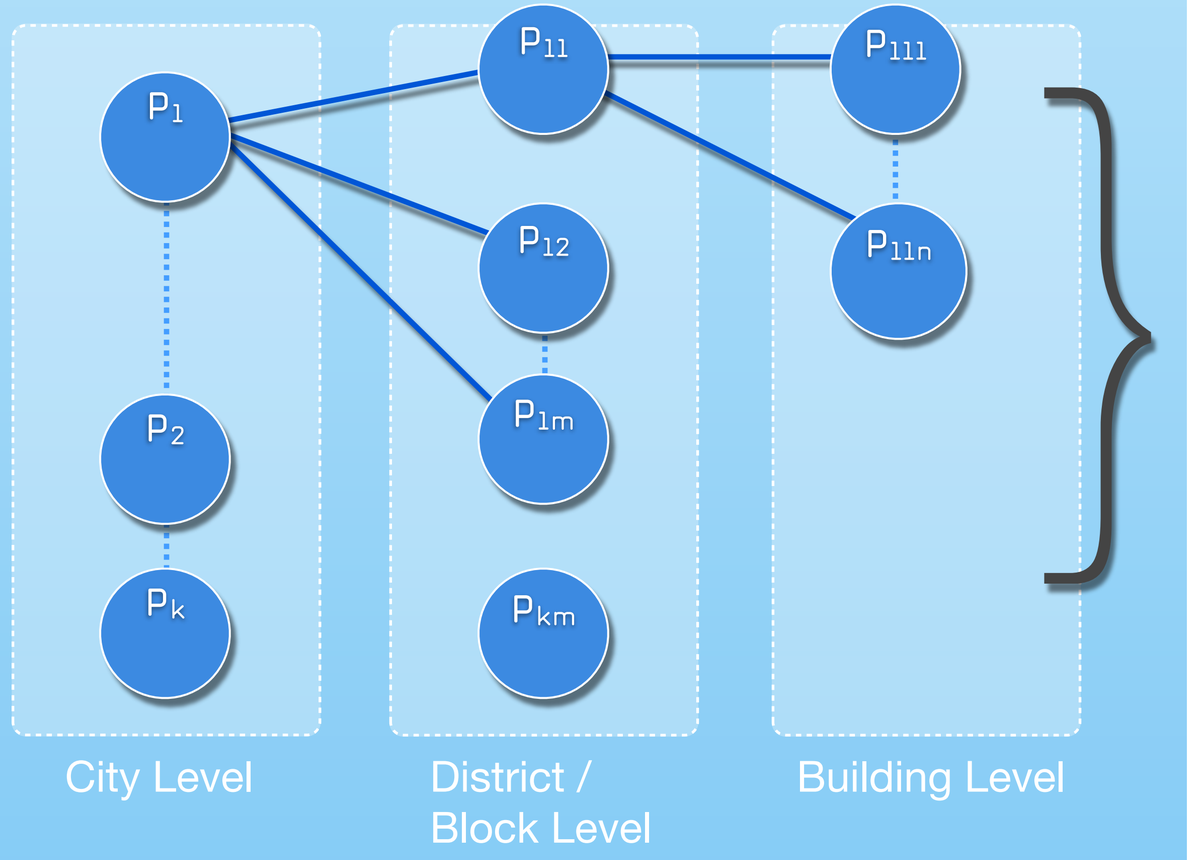
DESIGN PATTERNS



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

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ETH Zurich

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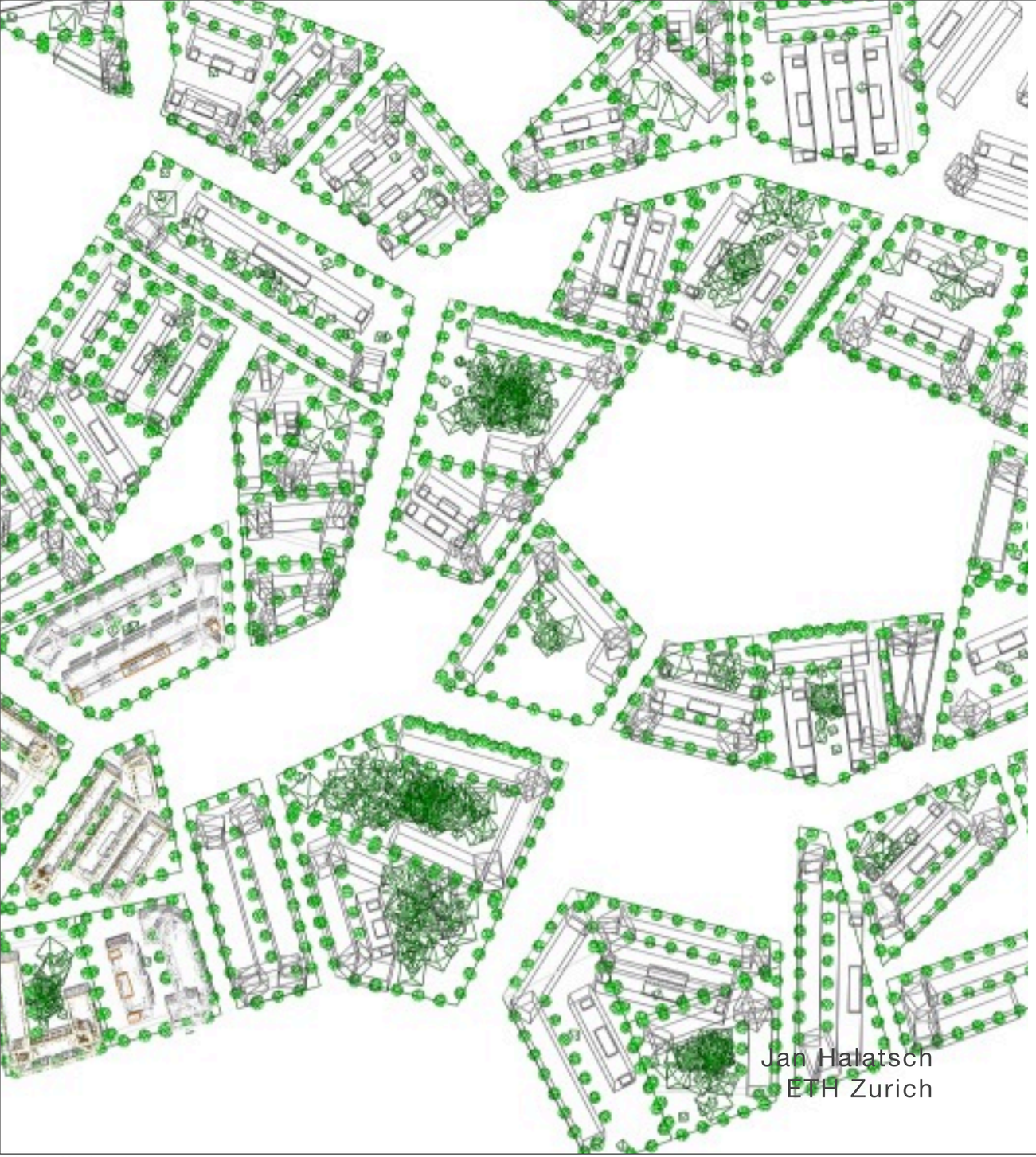

URBAN PATTERN EXAMPLE
Open Space Generation

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ETH Zurich

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URBAN PATTERN EXAMPLE

Open Space Generation

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ETH Zurich

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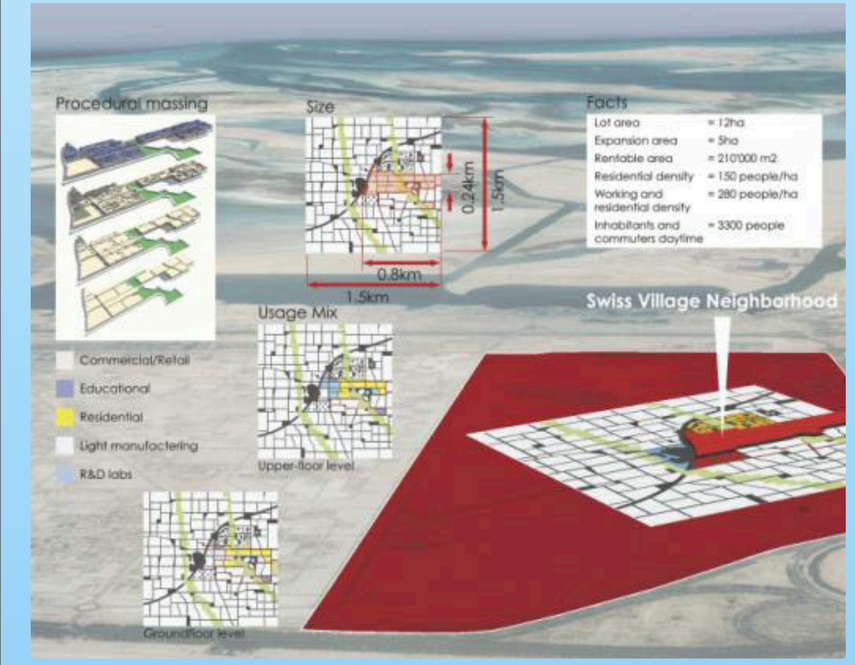
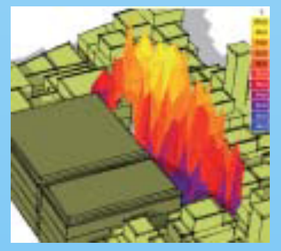
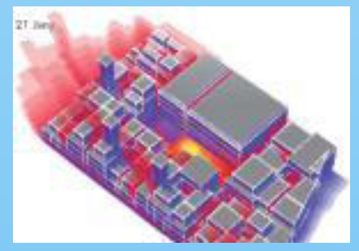
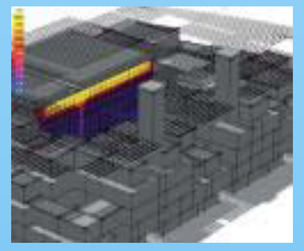
URBAN PLANNING EXAMPLES

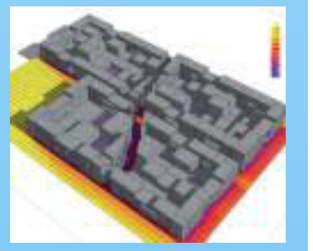
Masdar City, UAE











Foster + Partners

Jan Halatsch et al.
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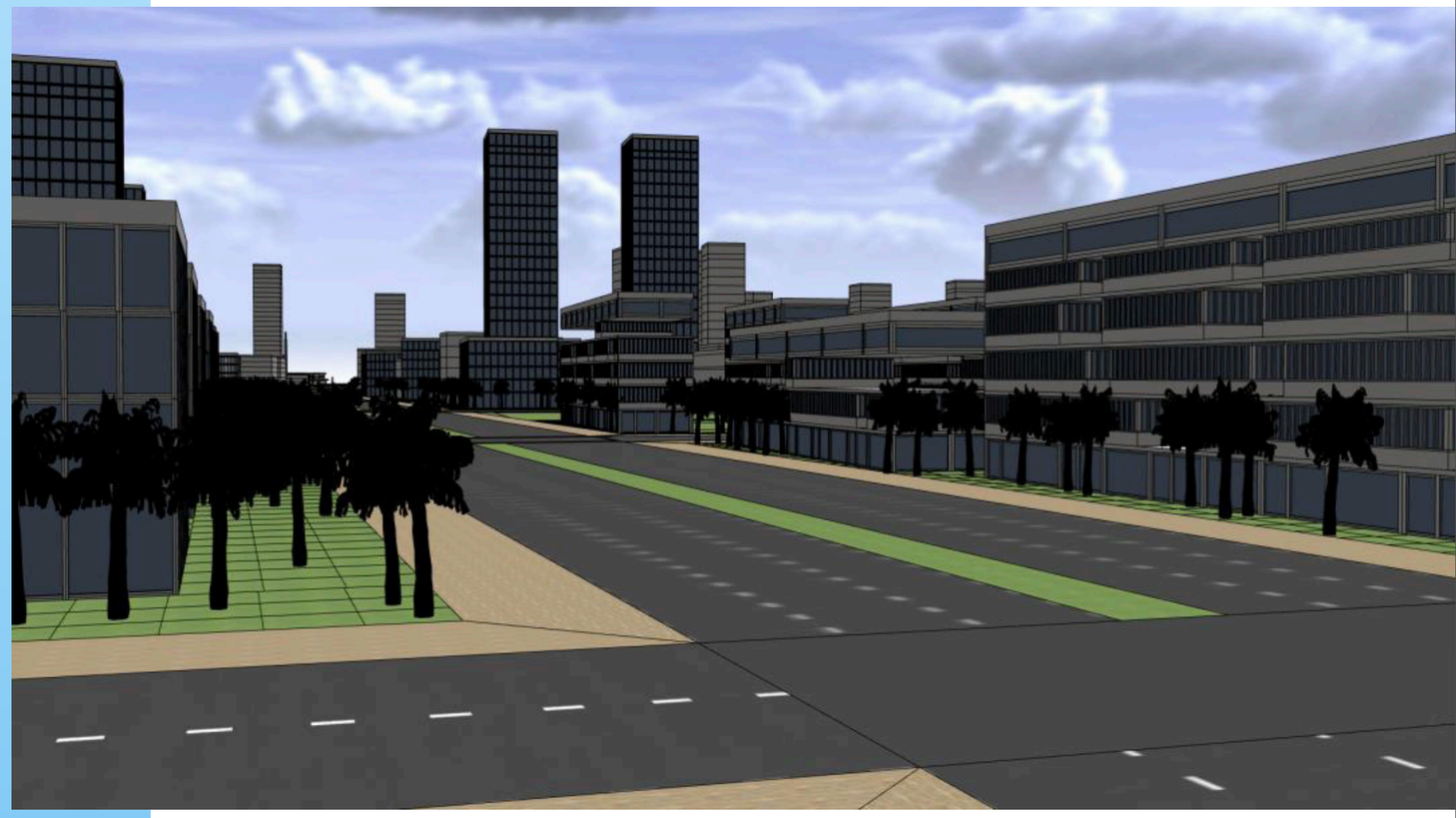
URBAN PLANNING EXAMPLES

Riad, Saudi Arabia



Foster + Partners

Jan Halatsch et al.
ETH Zurich

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URBAN PLANNING EXAMPLES

KACARE, Saudi Arabia

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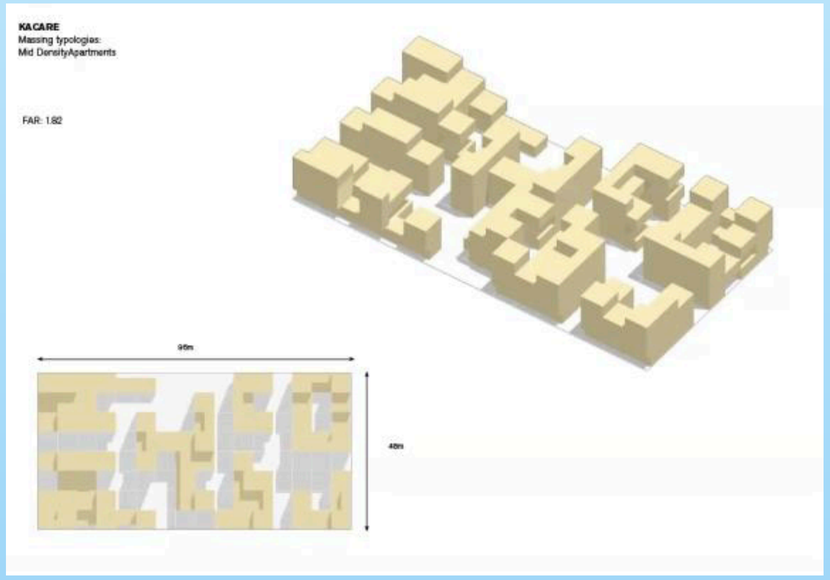

URBAN PLANNING EXAMPLES

KACARE, Saudi Arabia

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ROME REBORN 2.0

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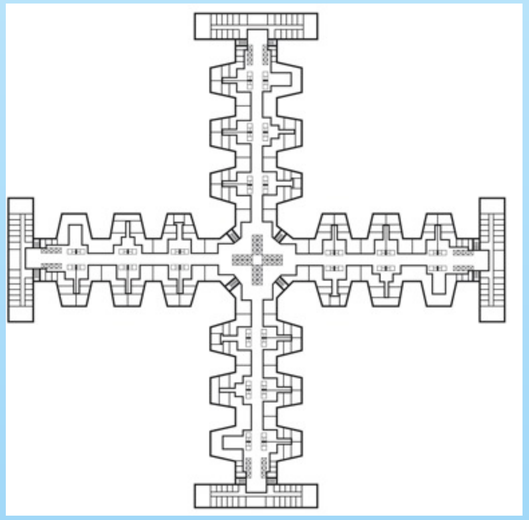

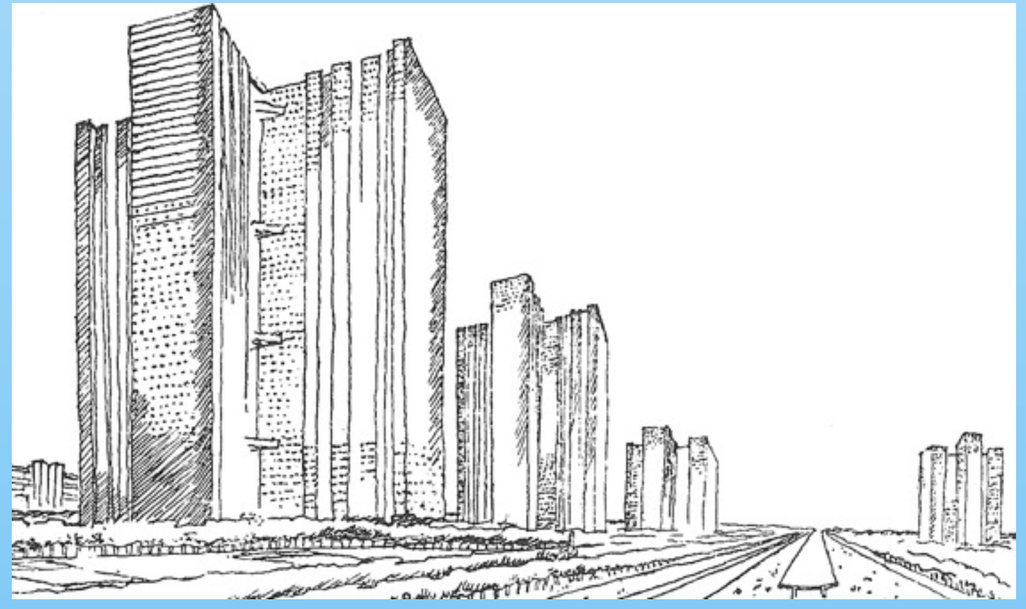

PARAMETERIZED PATTERNS

Example

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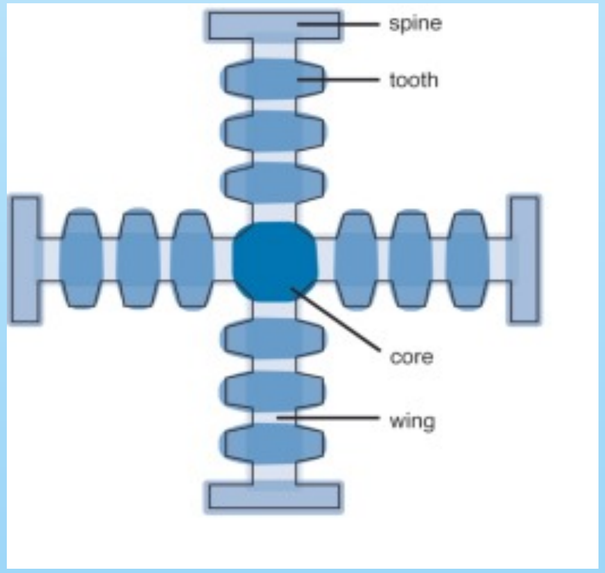

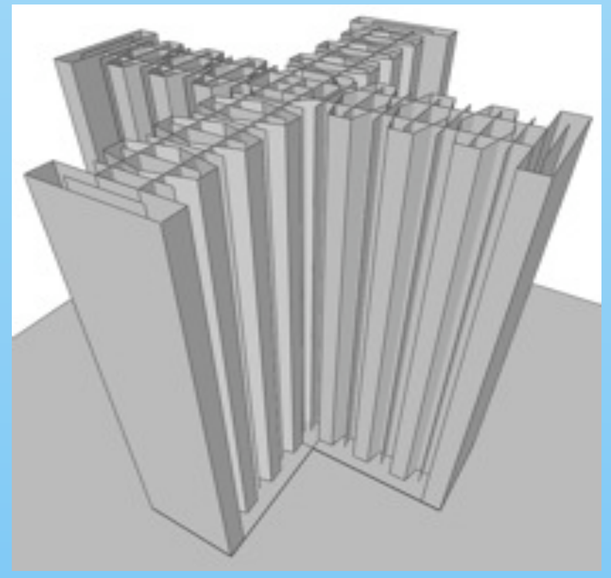

CONTROL ATTRIBUTES FOR VOLUME

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

Jan Halatsch
ETH Zurich

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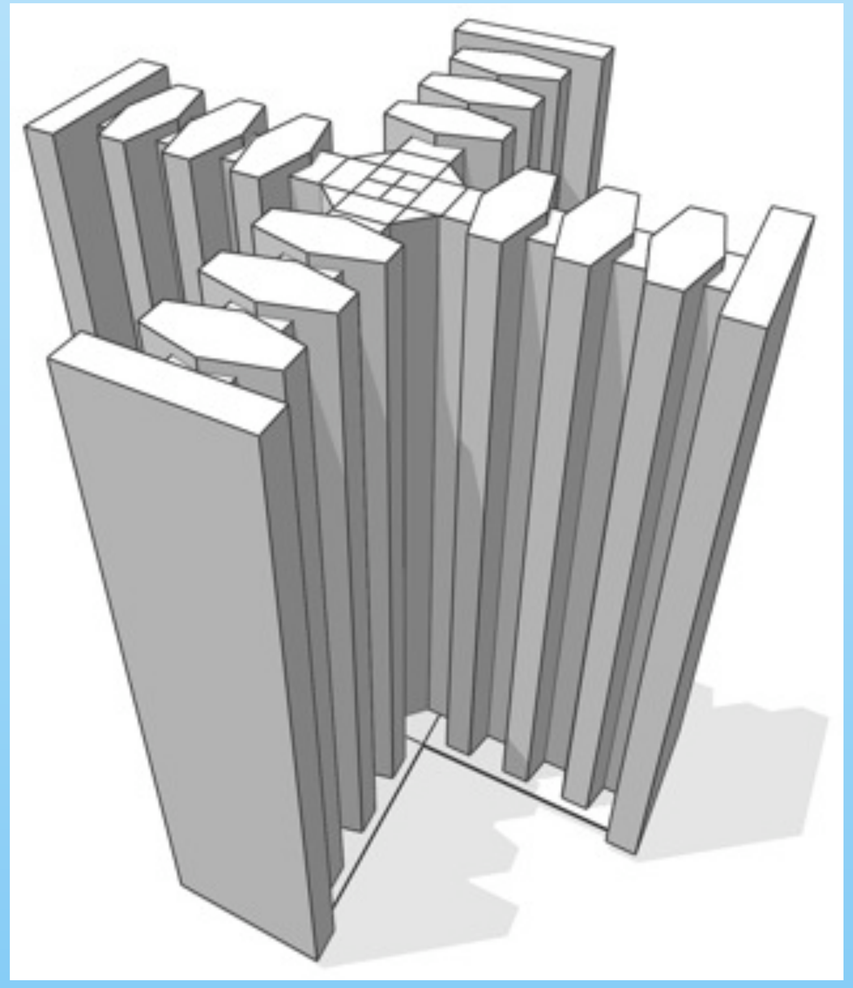
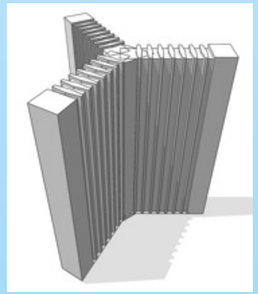
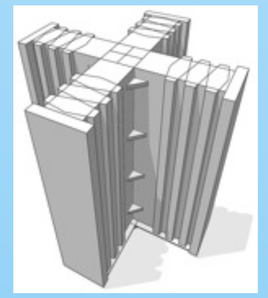
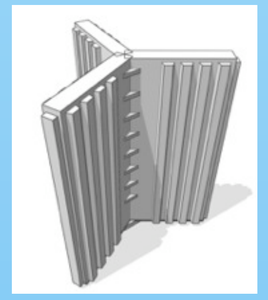
PARAMETERIZED PATTERNS

Example









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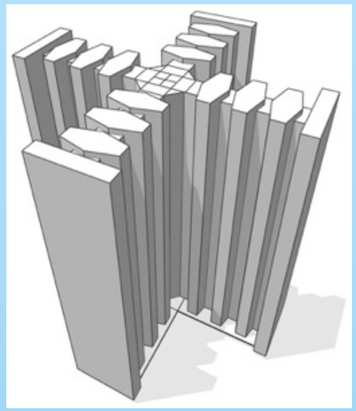

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PARAMETERIZED PATTERNS

Example

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VISUALIZATION PIPELINE

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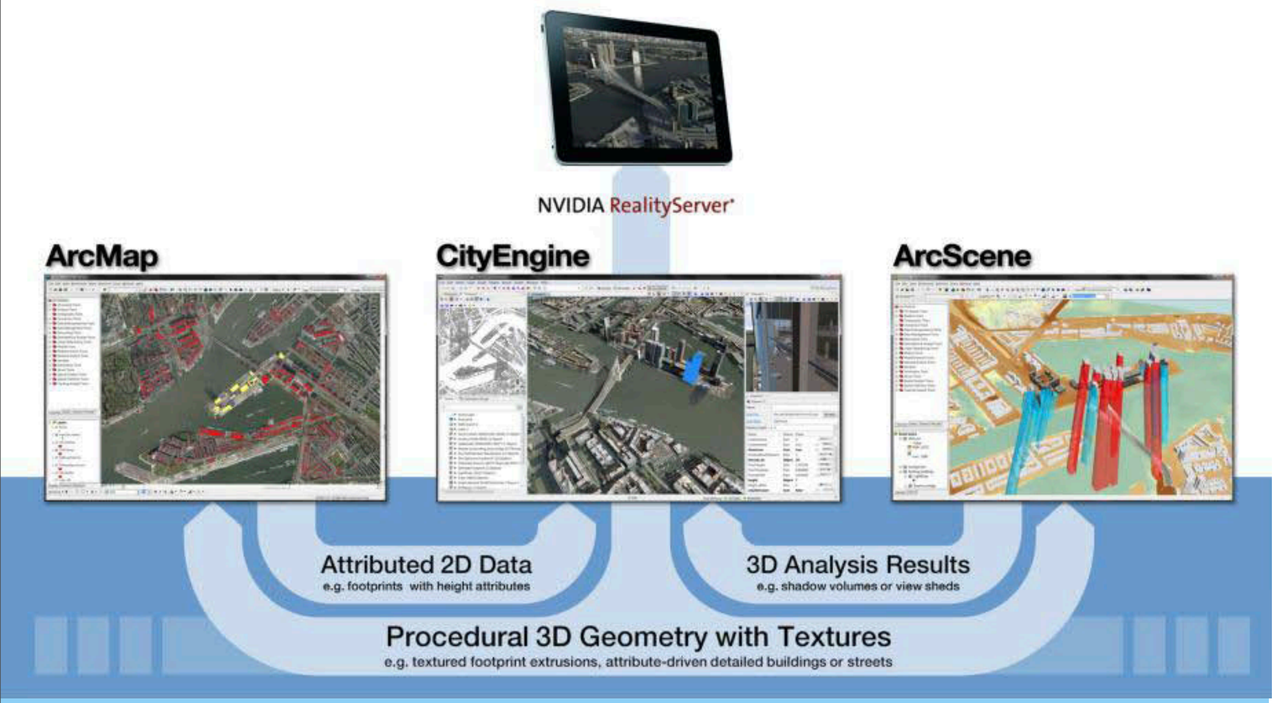

CLOUD-BASED RENDERING OF LARGE SCALE MODELS

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

Pascal Müller, Jan Halatsch
Procedural AG, ETH Zurich

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Following material 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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