Esri International Developer Summit

Palm Springs, CA

Creating and sharing Rule Packages with CityEngine

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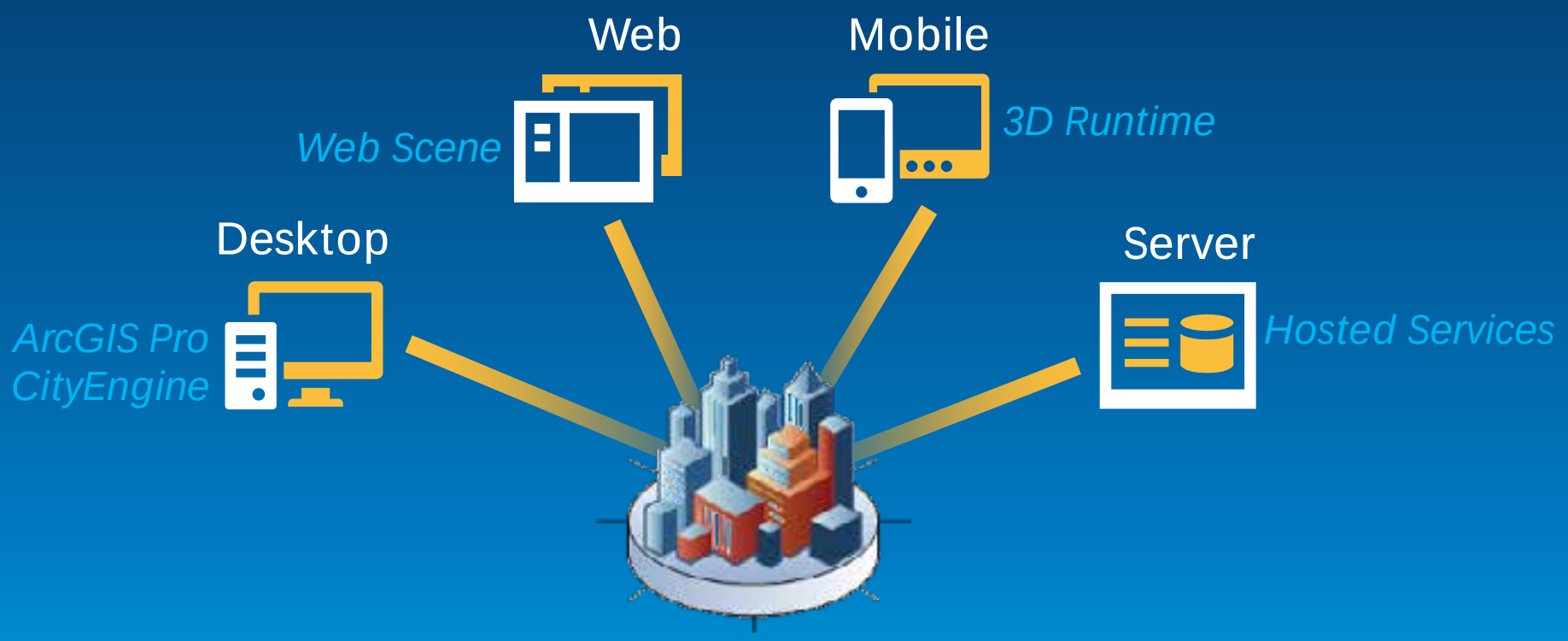
Agenda

- Examples (5 min)
- Introduction CityEngine (5 min)
- CGA 101 (25 min)
- Creating Rule Packages (5 min)
- Sharing / Consuming Rule Packages (5 min)

2014 - 3D Across the Platform

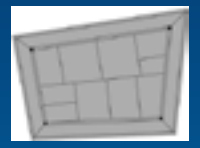


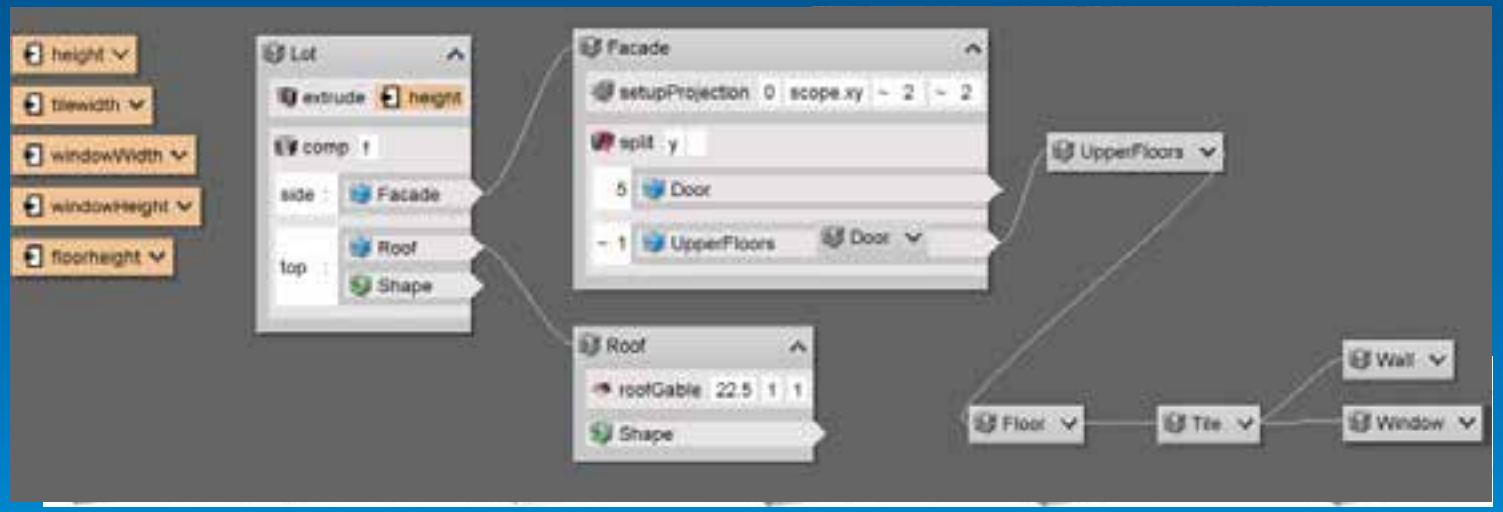
CityEngine

Procedural Modeling

3D model creation using rules / algorithms

- Base geometry





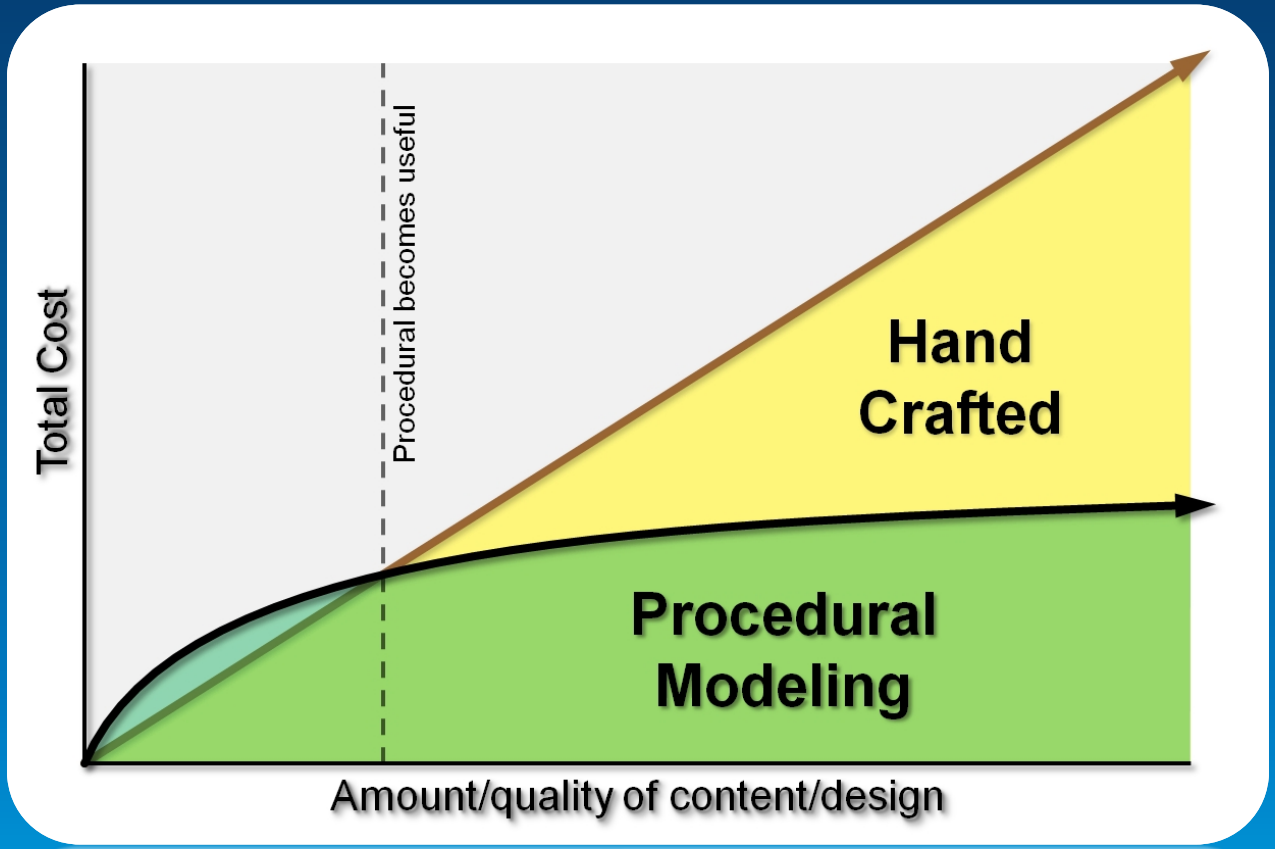
Base geometry

Final 3D model

Iterative refinement

iteratively refine a design by creating more and more detail

Procedural modeling vs. Manual modeling

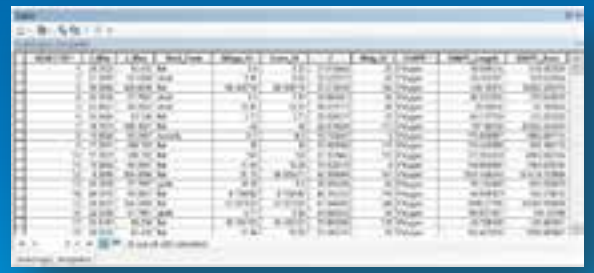


Time reduction / cost saving

3D City Content Creation

Procedural city modeling

Geometry



Attributes

Rule / Rule Package

3D City Content Creation

- Rule based 3D cities

3D City Design

Parametric editing

Add a floor

Add a roof

Dynamic editing

Procedural reporting

Rule based design

CGA and Rule Packages

CGA = Computer Generated Architecture

- Computer Generated Architecture
- Shape Grammar
- Programming language for 3D models of buildings

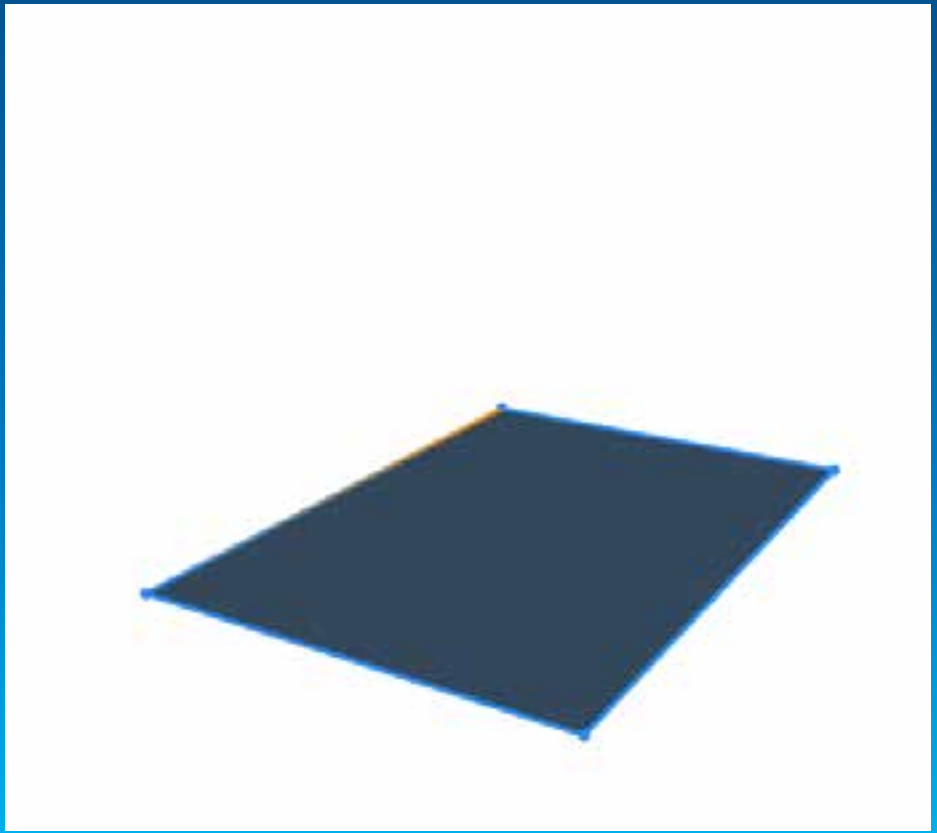
```
Envelope -->
  case scope.sx*scope.sz > 6000:
    15%: split(y){ '0.9 : Tower
                 | ~3   : s('0.8,'1,
                 | ~1   : s('0.6,'
    15%: split(y){ 'rand68        :
                 | ~rand(0.5,1.5):
                 | ~1            :
    15%: split(y){ 'rand48  : Towe
                 | ~1       : s('ran
    15%: split(y){ 'rand48  : Tower
                 | ~1       : t('ran
    else: Tower
  else: Tower
```

Basic Concepts: Rules & Shape Operations

- **Rules**
  - **Based on shape operations**

```
Init-->
  extrude(10)
  comp(f) {
    side : Facade. |
    top  : Roof
  }

Roof-->
   roofHip(30)
```



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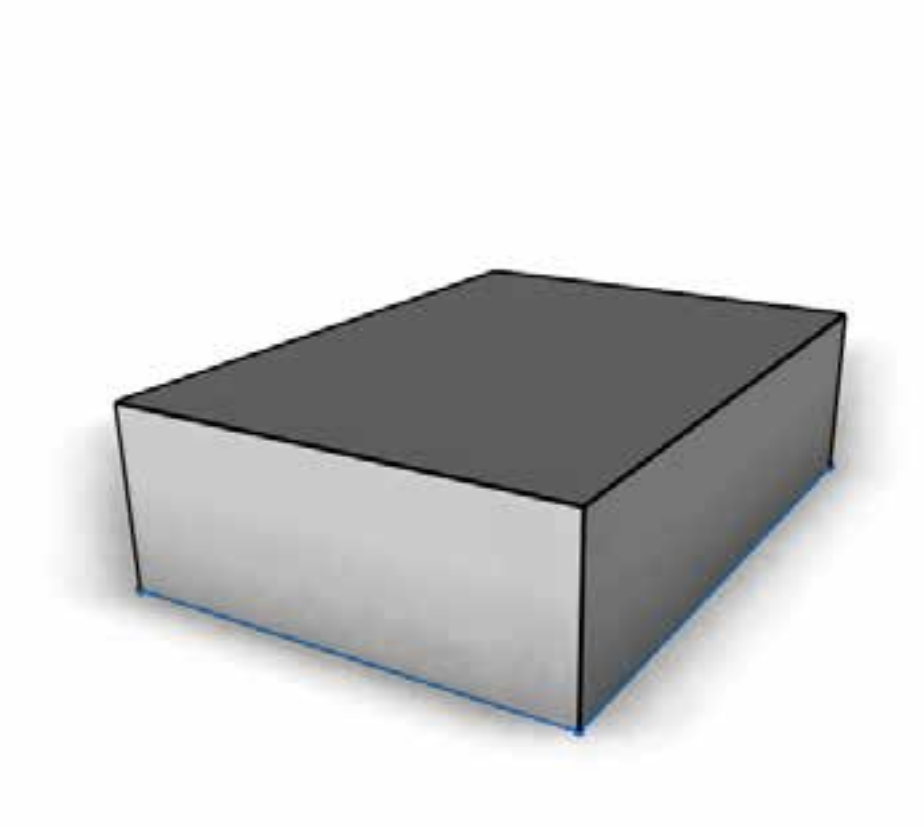

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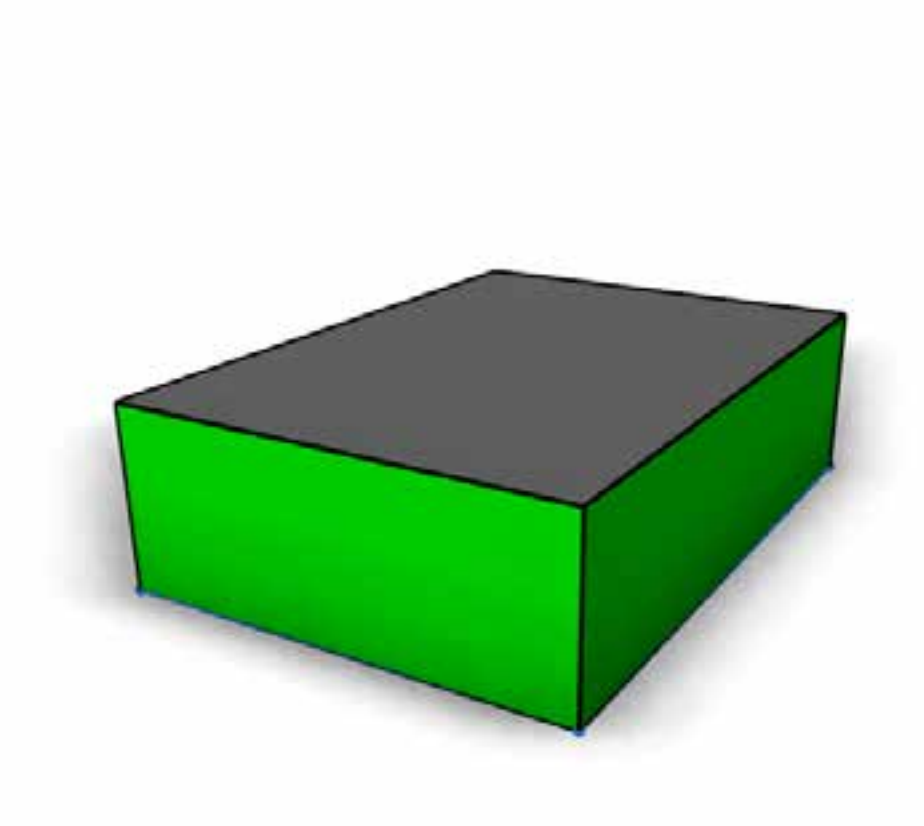

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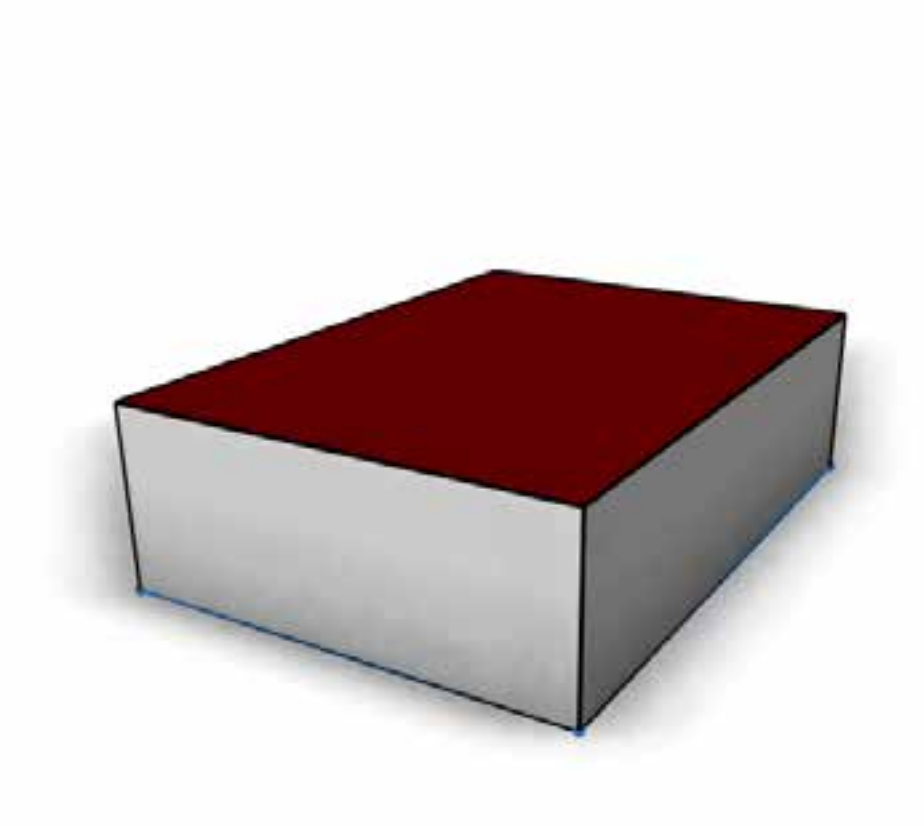

Basic Concepts: Rules & Shape Operations

- **Rules**
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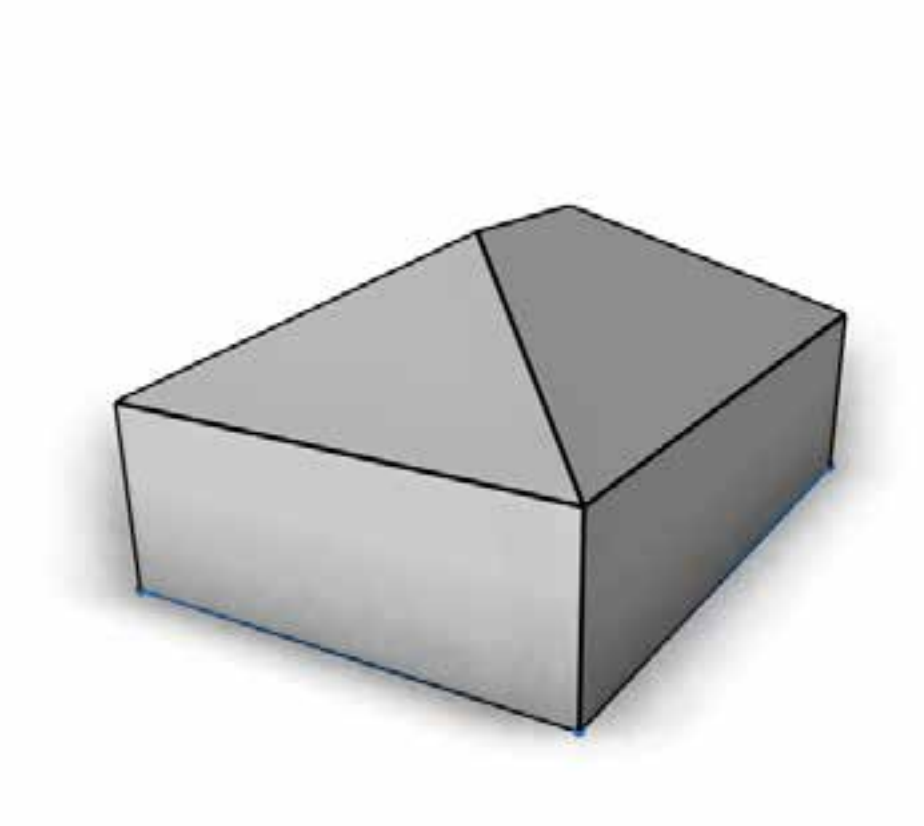


Basic Concepts: Functions

- **Functions**
  - **Strongly typed**
  - **Types “auto-deferred”**

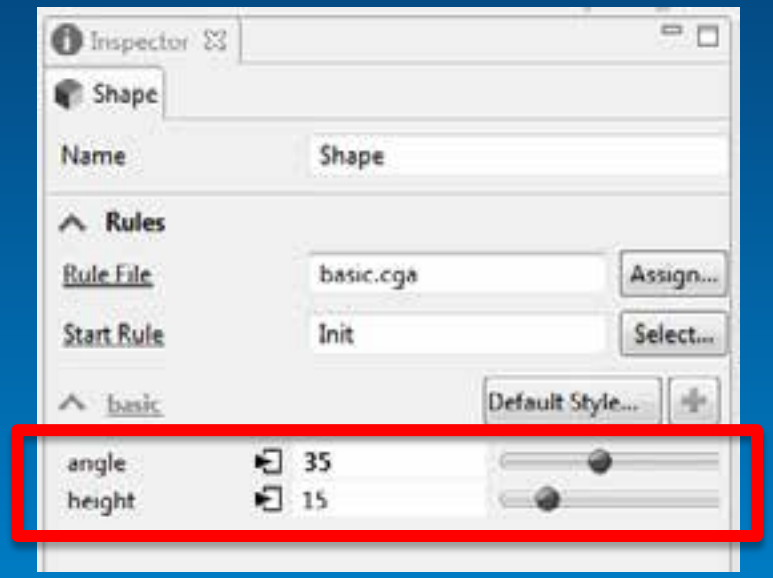
- **constant = simple function**

```
height = 15
angle  = 35

Init-->
    extrude(height)
    comp(f) {
        side : Facade. |
        top  : Roof
    }

Roof-->
    roofHip(angle)
```

Basic Concepts: Rule Attributes

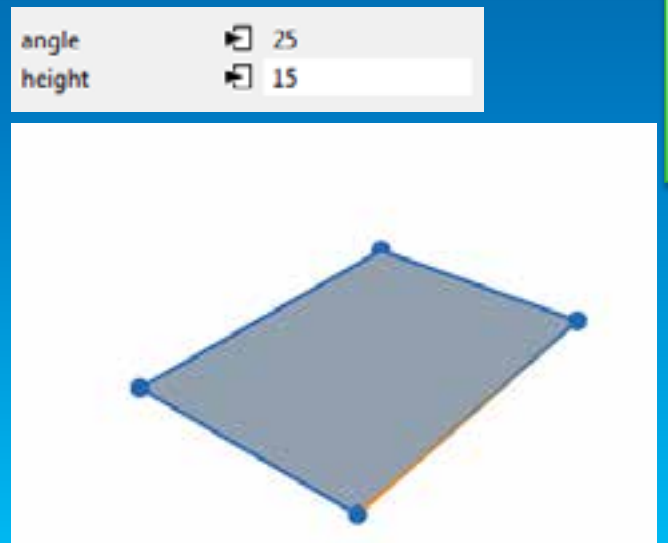
- attr functions can be set from outside, e.g. GUI

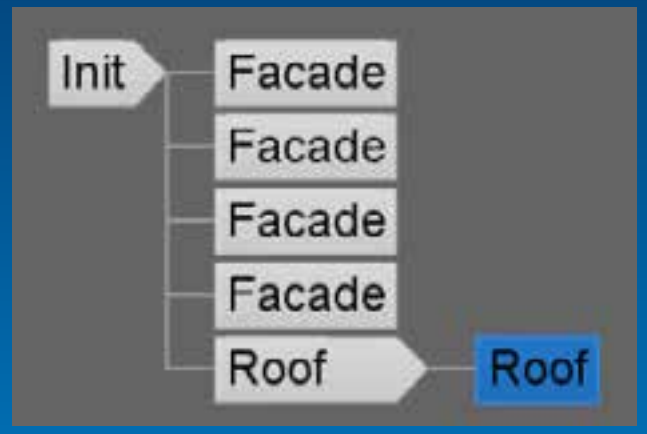
```
attr height = 15
attr angle  = 35

Init-->
    extrude(height)
    comp(f) {
        side : Facade. |
        top  : Roof
    }

Roof-->
    roofHip(angle)
```

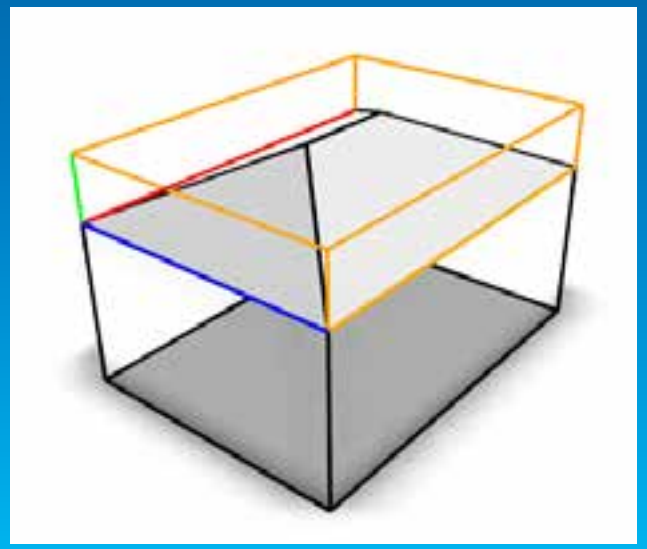


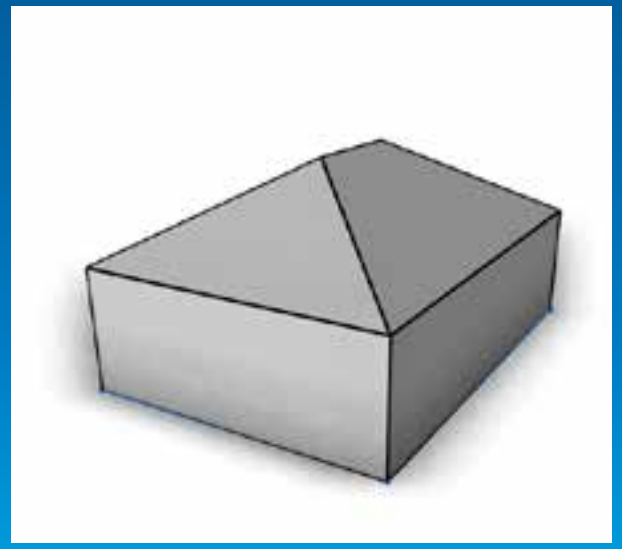
Shapes & 3D Models

```
attr height = 15
attr angle  = 35

Init-->
    extrude(height)
    comp(f) {
        side : Facade. |
        top  : Roof
    }

Roof-->
    roofHip(angle)
```









Conditional Rules

- case blocks in rules or functions

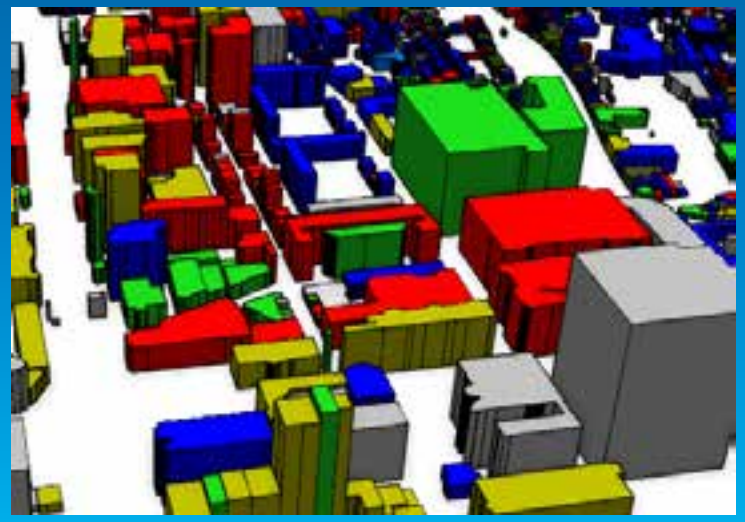
```
Roof-->
    case geometry.area > 1000:
        color(1,0,0)
        X.
    case geometry.area > 500:
        color(1,0.5,0)
        X.
    else:
        print(geometry.area)
        X.
```

Use Case 1: Thematic Visualization

- Use CGA to visualize your data in 3D

Object Attributes

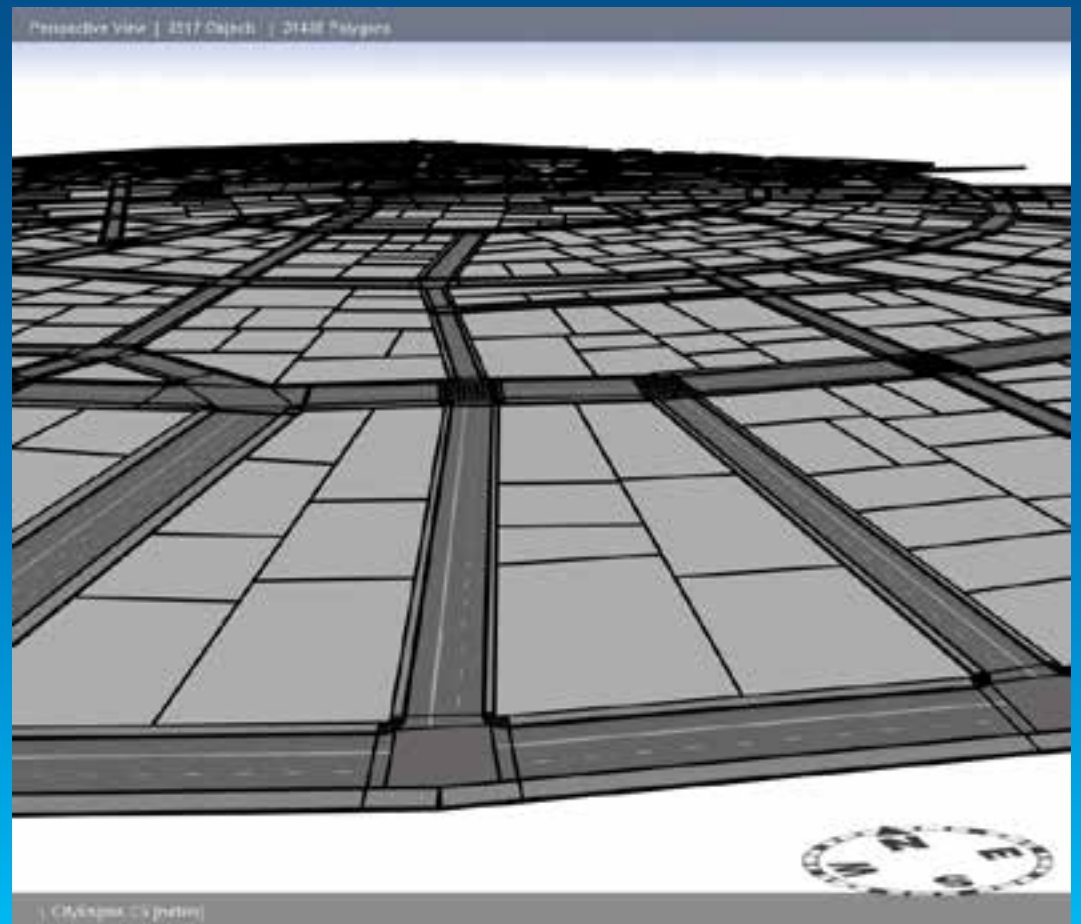
BuildingFID	Building/0599100000423926
OBJECTID	16652
Shape_Area	12826.692636
Shape_Length	534.682151
beginLifespan_date	30 Dec 0002 23:00:00 GMT
status	Completed
totalHeight	87.412849
usage	Public



```
attr usage = ""
attr totalHeight = 0

Init-->
  case usage == "Public":
   color(0.1,0.8,0.1)
   X
  case usage == "Educational":
   color(0,0.5,1)
   X
  ...

X-->
   extrude(totalHeight)
```

Use Case 2: Procedural Modeling for Urban Design

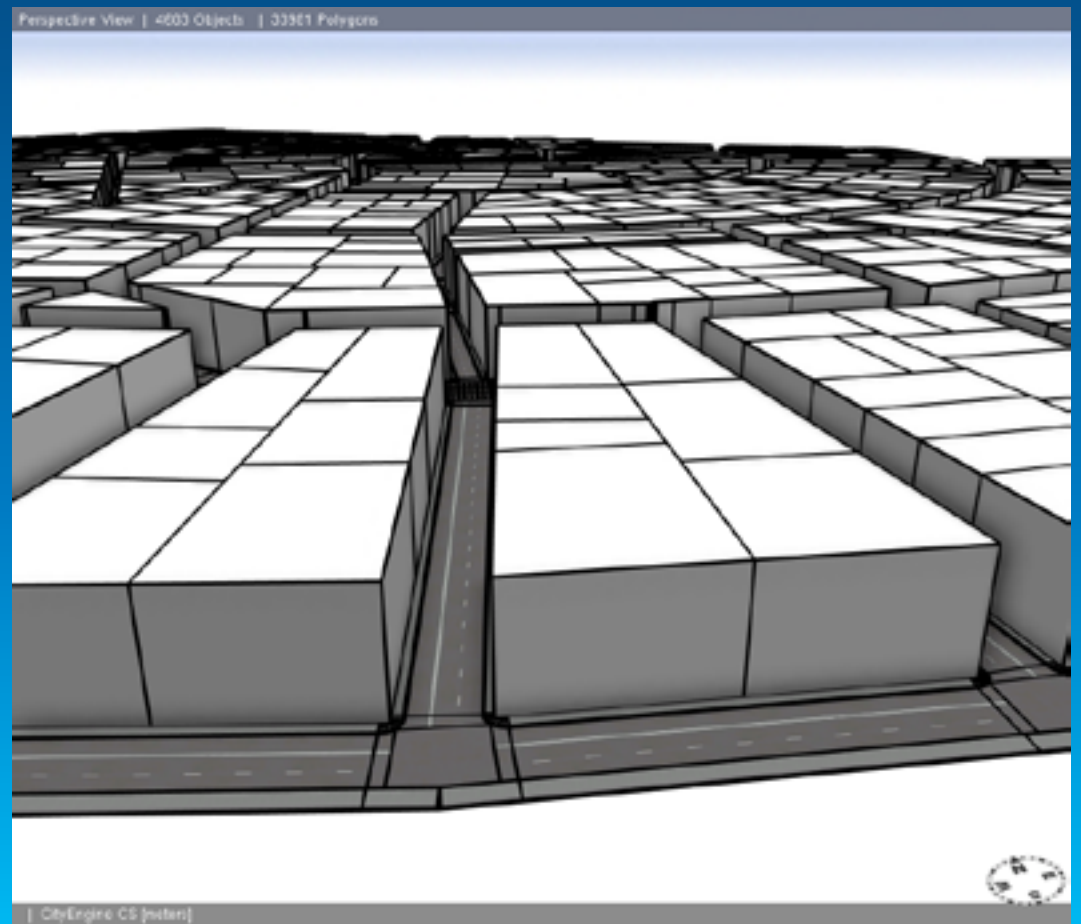
- **Let’s visualize a City based on those streets / paarcels**



Use Case 2: Procedural Modeling for Urban Design

- **Simple extrude**

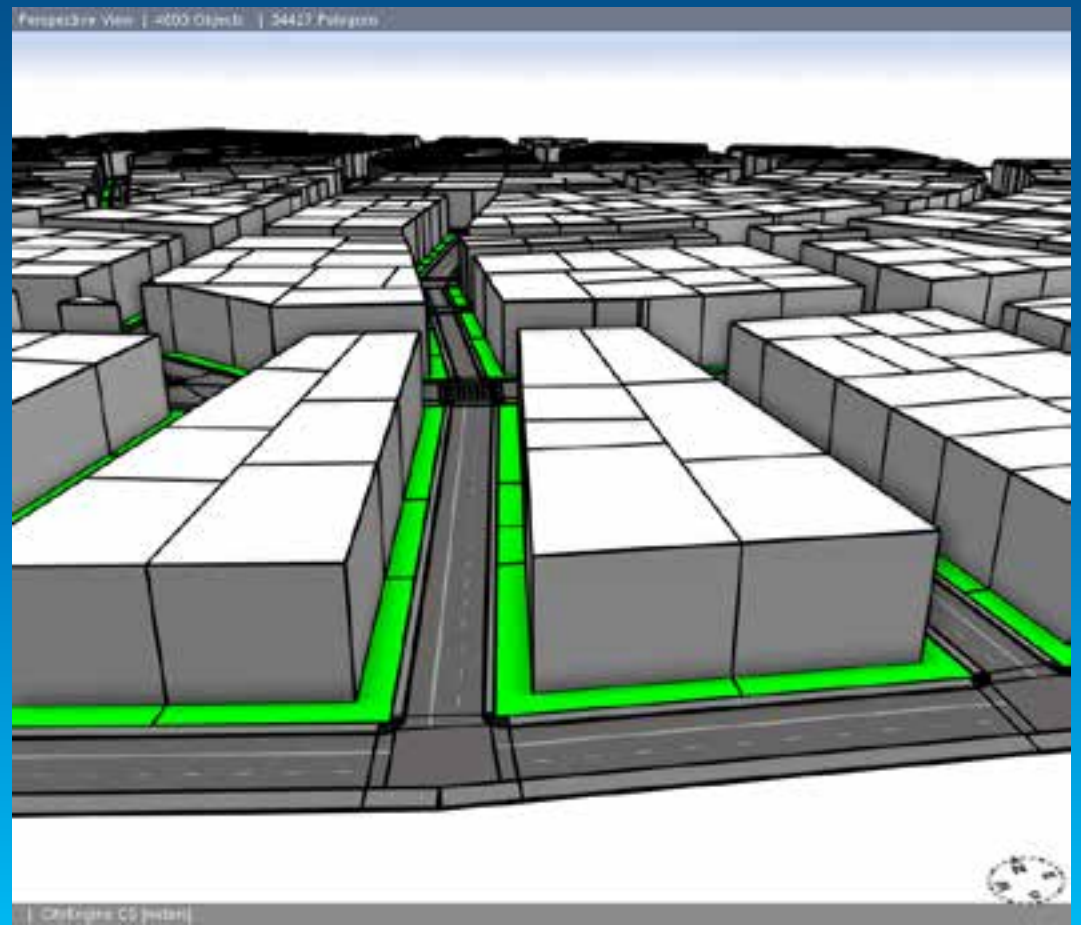
```
Lot-->
    extrude(20)
```



Use Case 2: Procedural Modeling for Urban Design

- setback operation
- selectors based on neighbouring streets

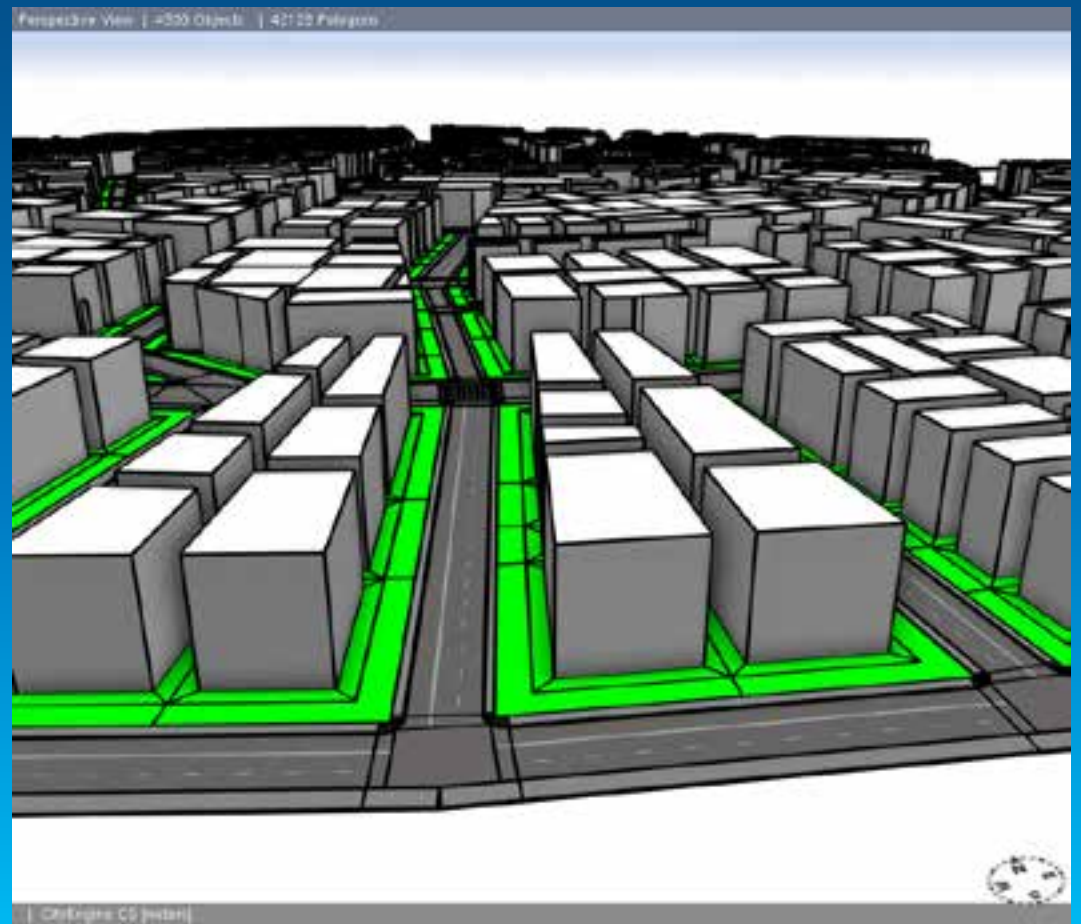
```
Lot-->
    setback(5) {
        street.front:
            color(0,1,0)
            X. |
       remainder:
            extrude(20)
            X.
    }
```



Use Case 2: Procedural Modeling for Urban Design

- **offset operation to subdivide parcels**

```
Lot-->
   setback(5) {
      street.front:
         color(0,1,0)
         X. |
      remainder:
         offset(-3)
         comp(f) {
            border:
               color(0,1,0)
               X. |
            inside:
               extrude(20)
               X.
         }
   }
```



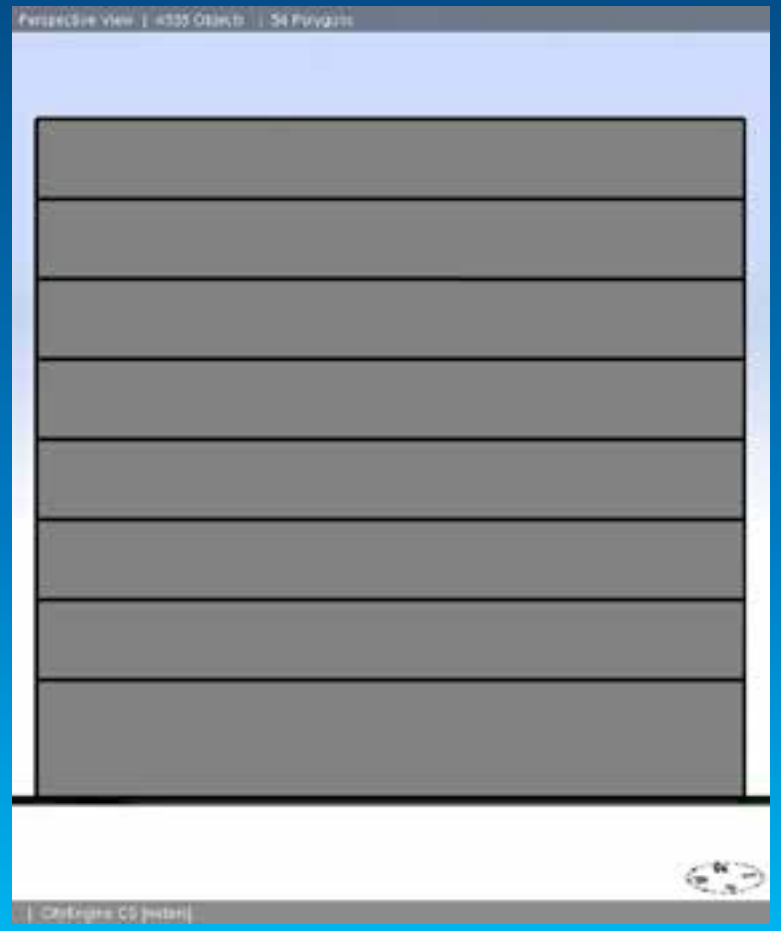
Use Case 2: Procedural Modeling for Urban Design

- split into floors and facades

Use Case 2: Procedural Modeling for Urban Design

- split mass model into floors

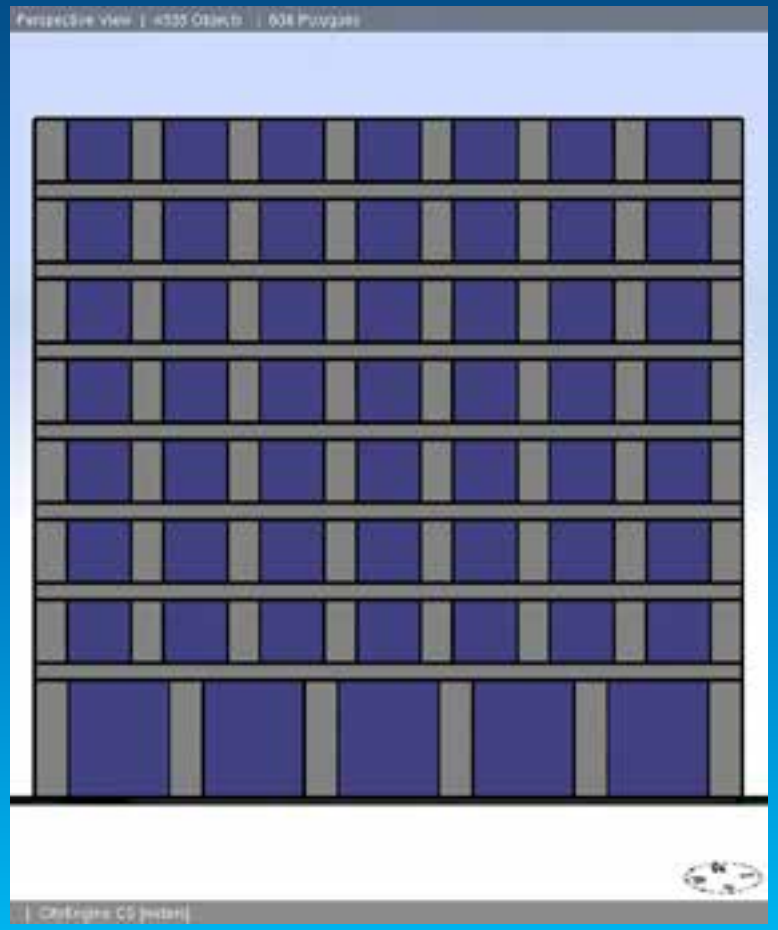
```
Mass-->
   split(y) {
         3.5 : GroundFloor. |
      { ~2.5 : Floor. }*
   }
```



Use Case 2: Procedural Modeling for Urban Design

- split floors into wall + windows

```
GroundFloor-->
  comp(f) { side : GFFacade }

GFFacade-->
  split(x) {
    { ~1 : Wall. | ~3 : Window }* | ~1 : Wall.
  }

Floor-->
  comp(f) { side : FloorFacade }

FloorFacade-->
  split(y) {
    0.5 : Wall. | ~1  : split(x) {
      {~1 : Wall. | ~2 : Window }* | ~1 : Wall. }
  }

Window-->
  color(0.5,0.5,1)
```

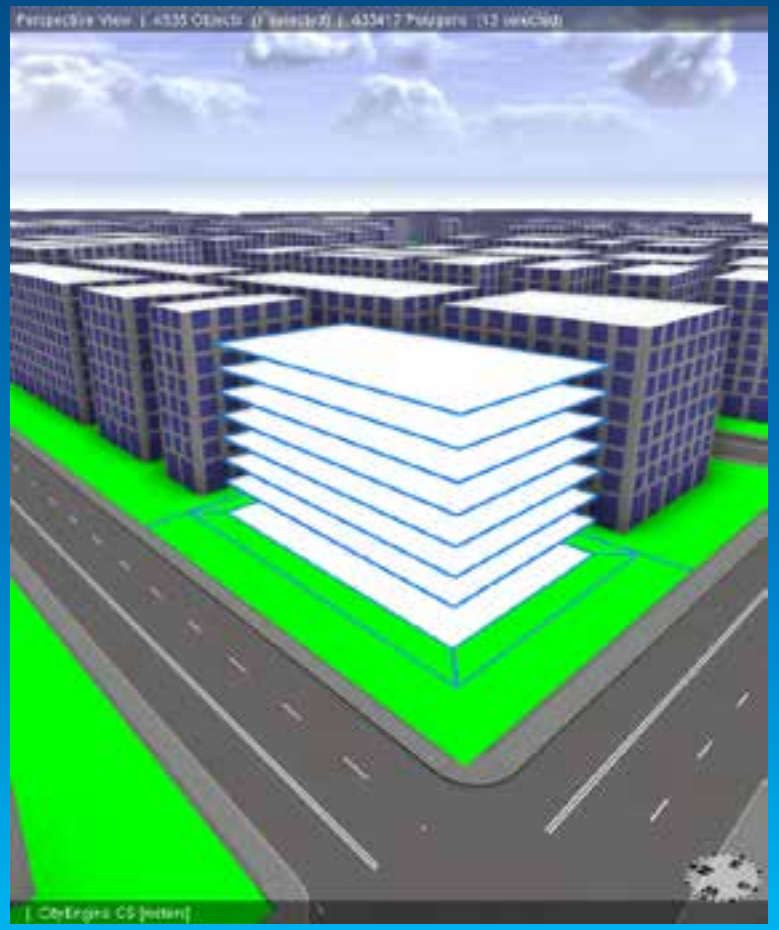


Use Case 2: Procedural Modeling for Urban Design

- **Use reporting for analysis, e.g. gross floor area**

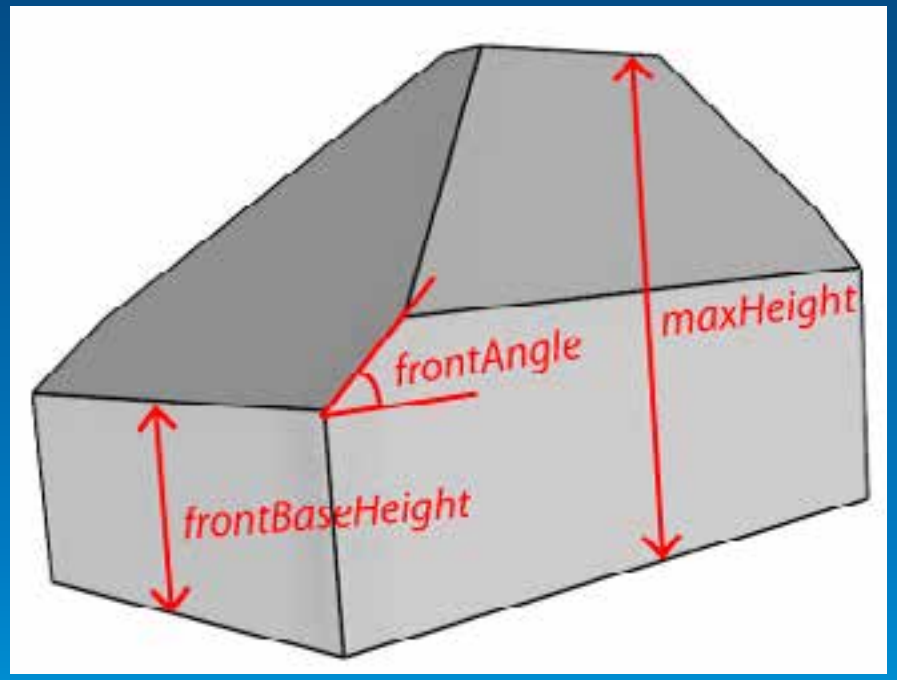
```
FloorGFA-->
  comp(f) {
    bottom:
      report("GFA", geometry.area)
  }
```

Report	N	%	Sum	%	Avg	Min	Max	NaNs
GFA	8	0.00	4997.25	0.00	624.66	624.66	624.66	0

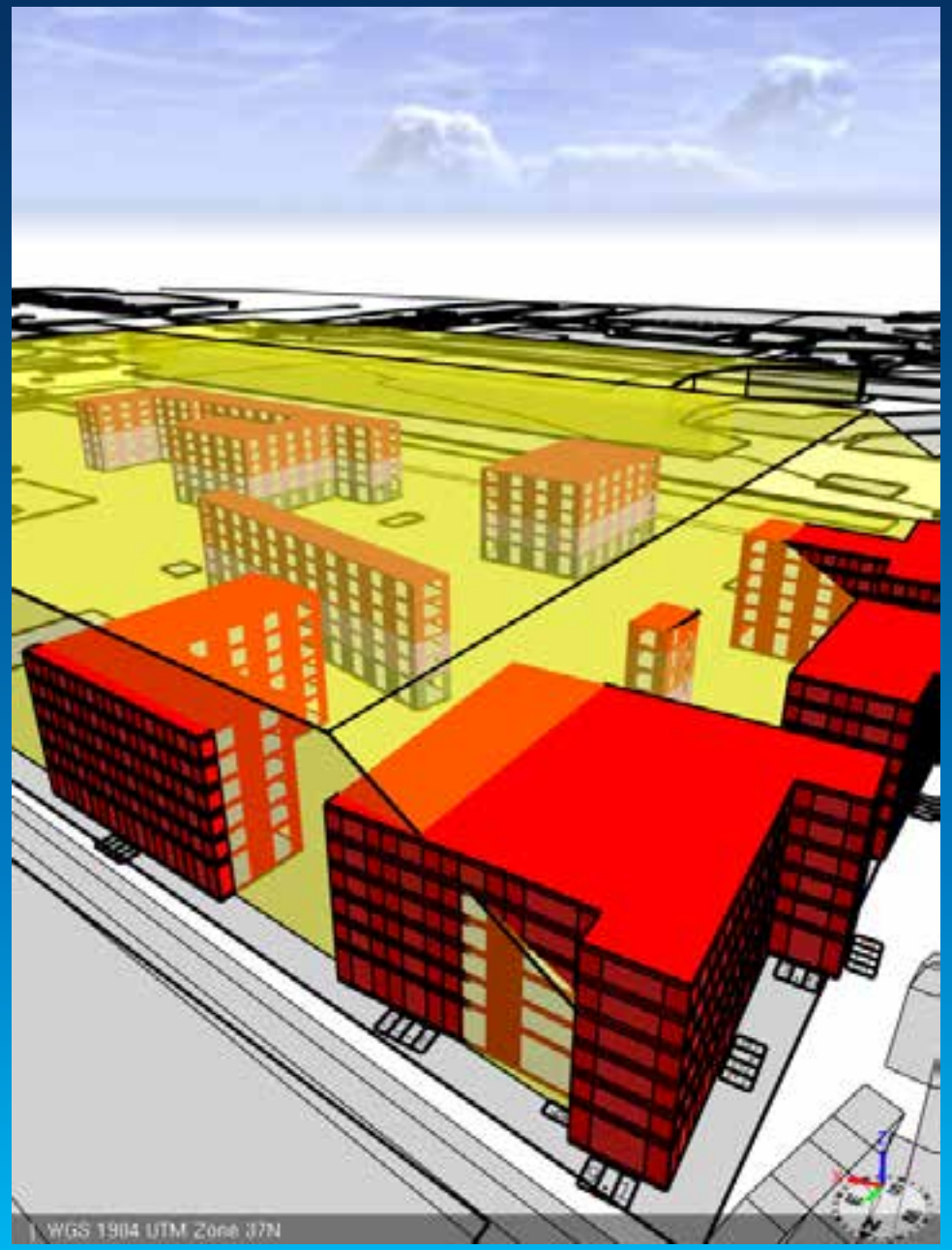


Zoning Volumes

- envelope operation



- Occlusion checks



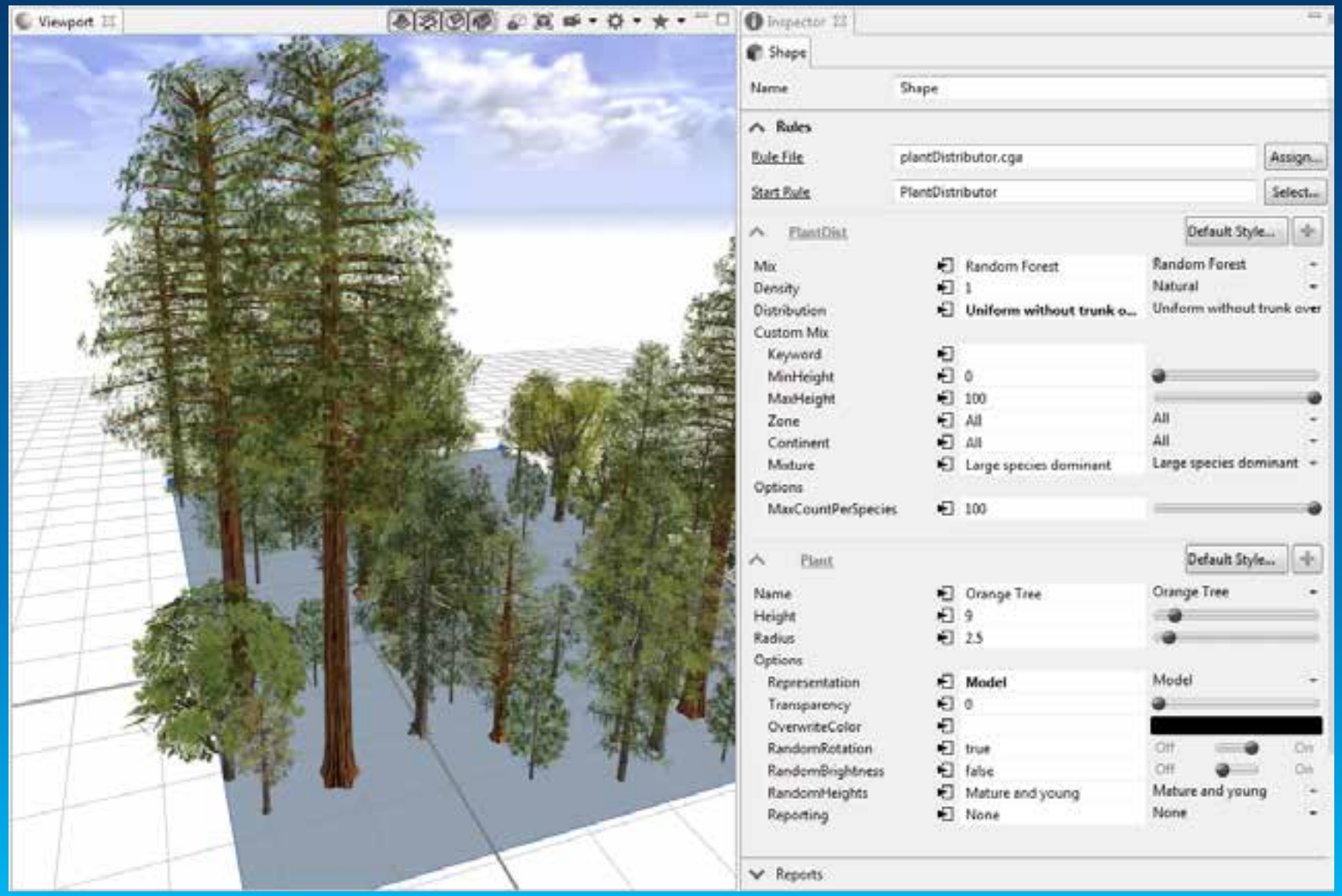
CGA Libraries

- CGA files can be imported

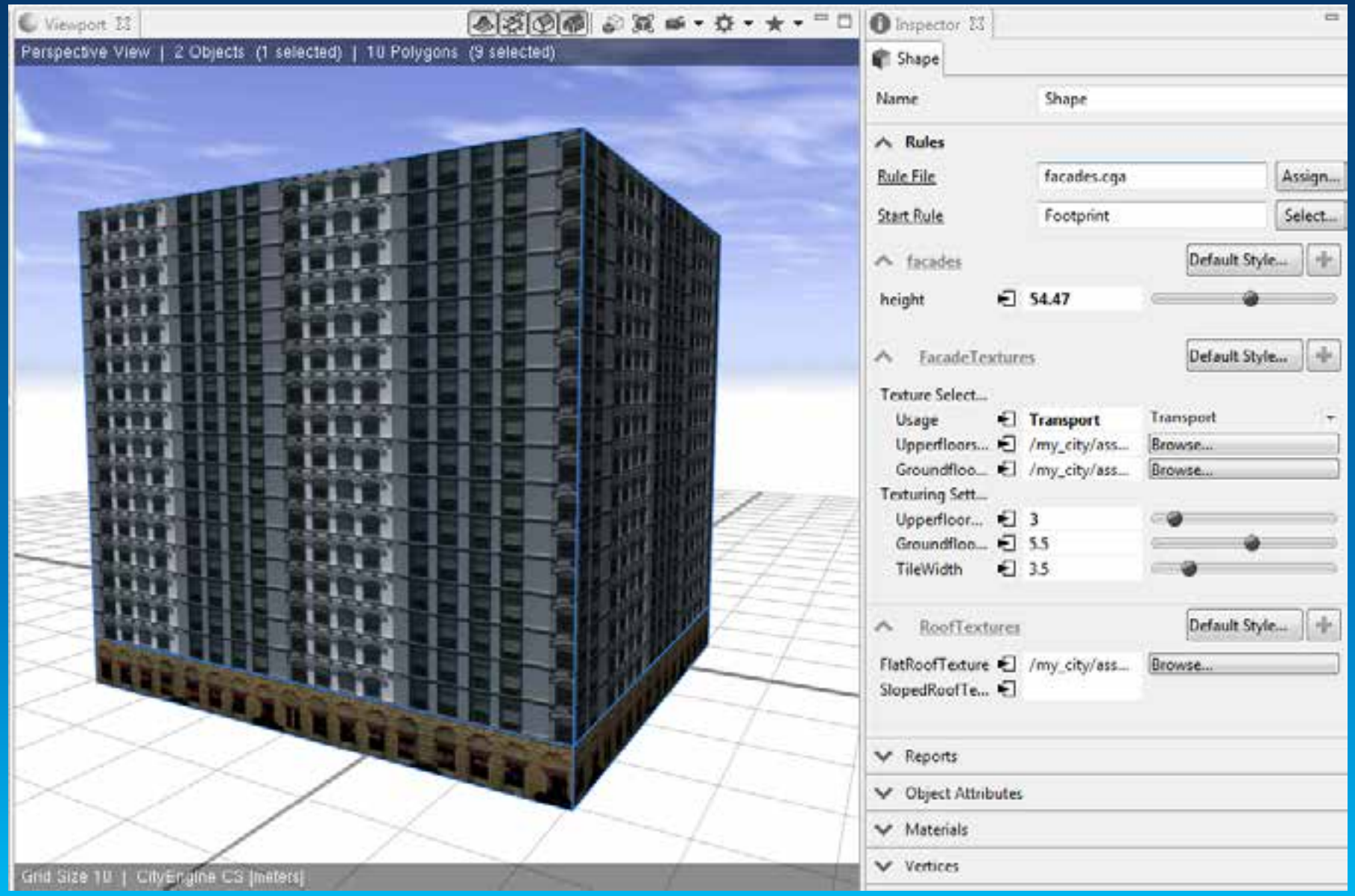
```
import PlantDist:"/my_city/rules/EsriVegLibDistr.cga"

PlantDistributor-->
    PlantDist.Generate
```

- Allows for complex rule & function libraries, e.g.
  - Vegetation
  - Façade Textures
  - Roof Textures
  - Street Construction
  - Utilities

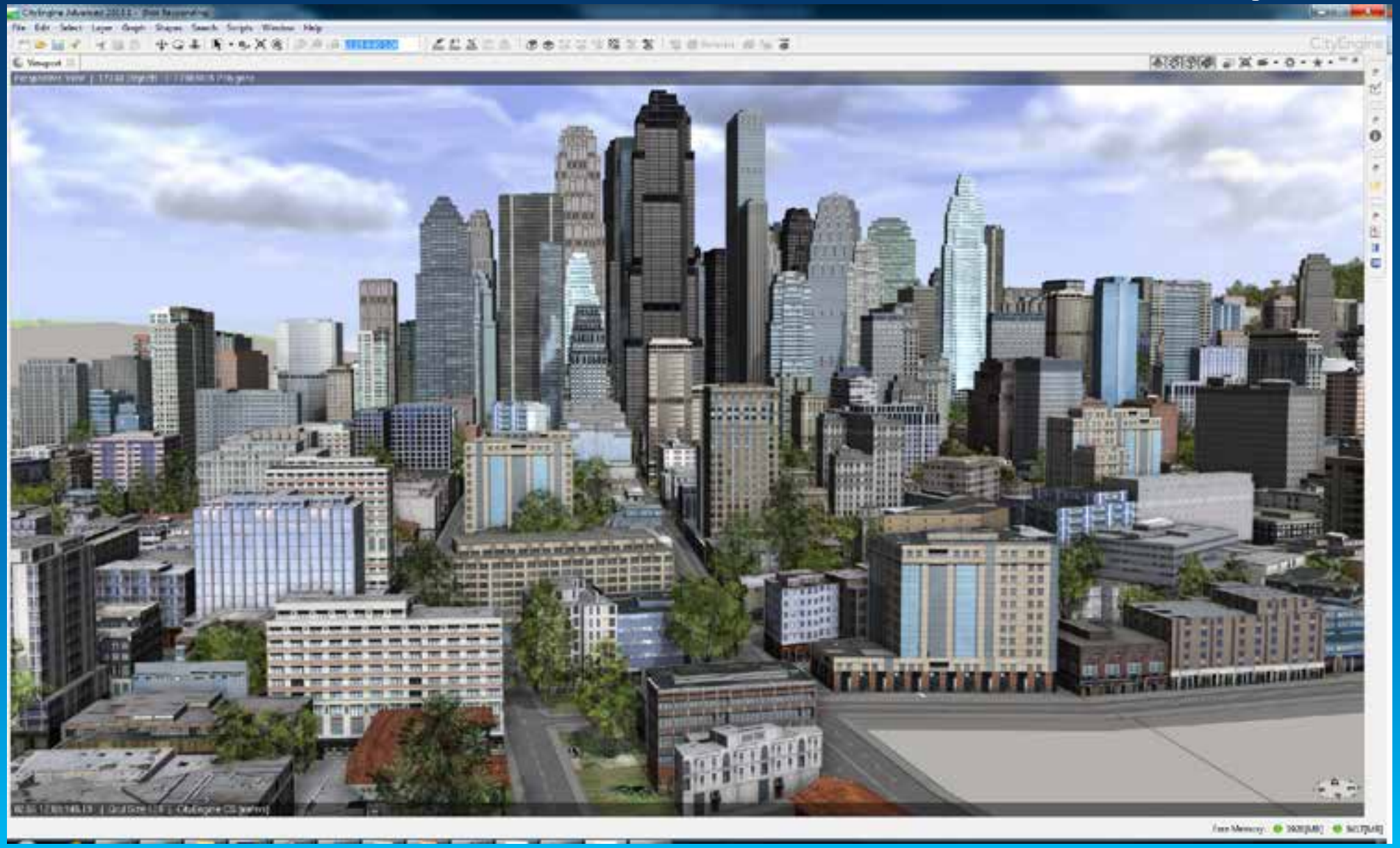
Use Case 3: Realistic Visualization - Plants



Use Case 3: Realistic Visualization – Façade Textures



Use Case 3: Realistic Visualization – International City



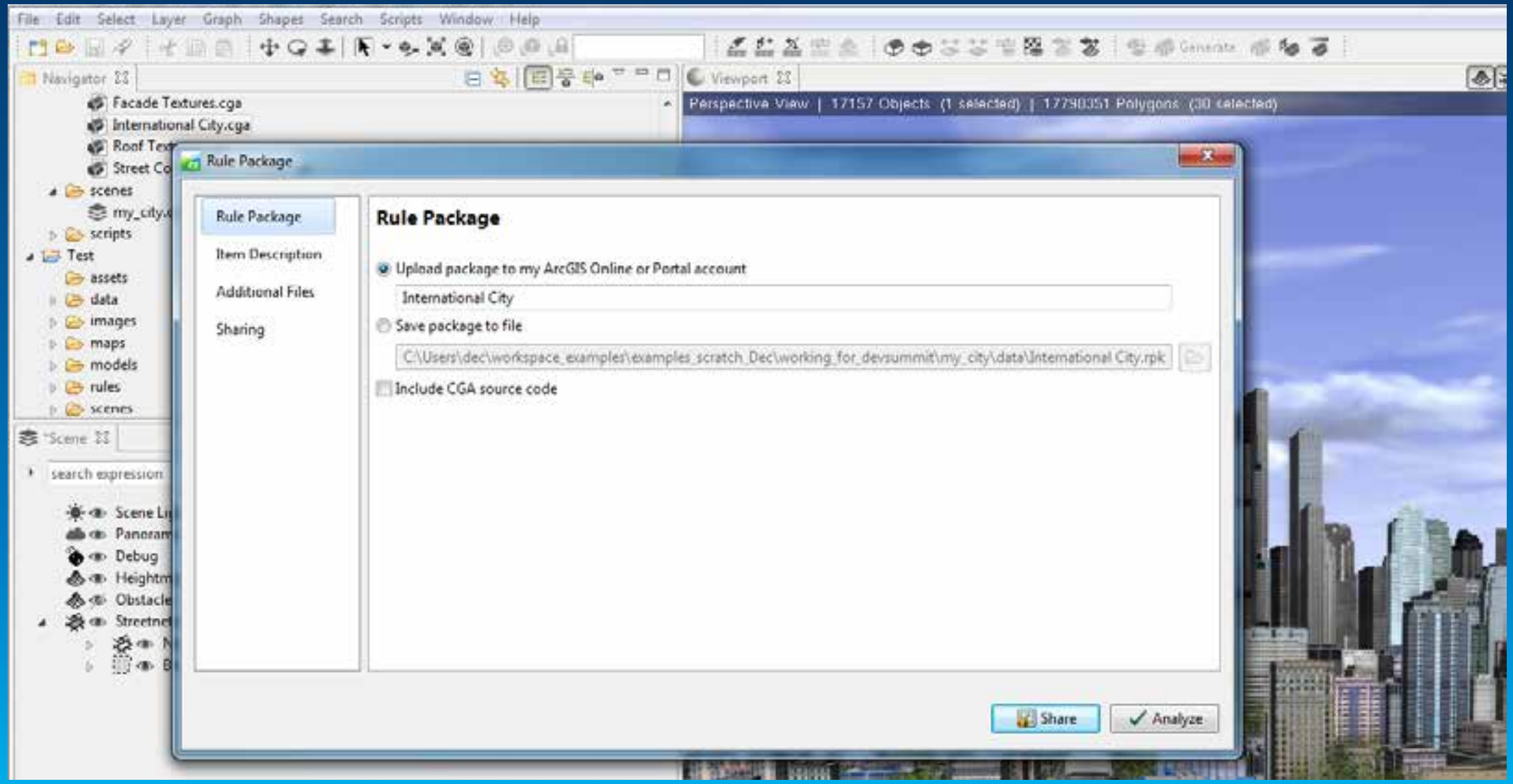
Other CGA Features

- …I don’t have time for:
- Stochastic Rules / Random
- Recursions for loops
- Texturing
- Roofs
- Styles
- Occlusion
- Geometry cleanup / reduction
- Asset search, (stochastic / best ratio) insertion

Rule Packages (RPKs)

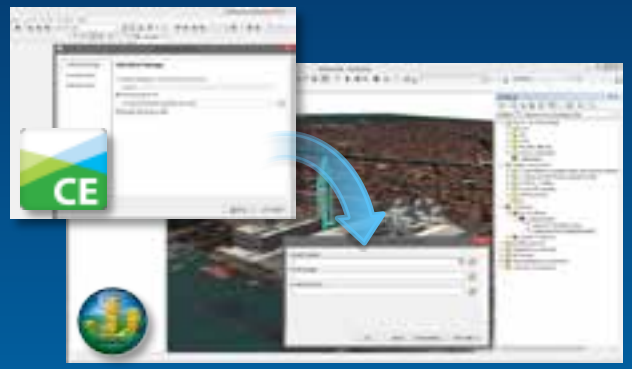
- Format to share and exchange compiled CGA code + assets
- Compiler compiles textual CGA code to binary CGB
  - Based on java classfile / bytecode
- Platform independent
- Procedural runtime = virtual machine to execute CGB, RPK = “executable”
- Can be used wherever Procedural Runtime is used:
  - GPTool (ARGGis 10.2)
  - ARCGis Pro
  - Maya plugin
  - Your own specialized application

Creating a RPK

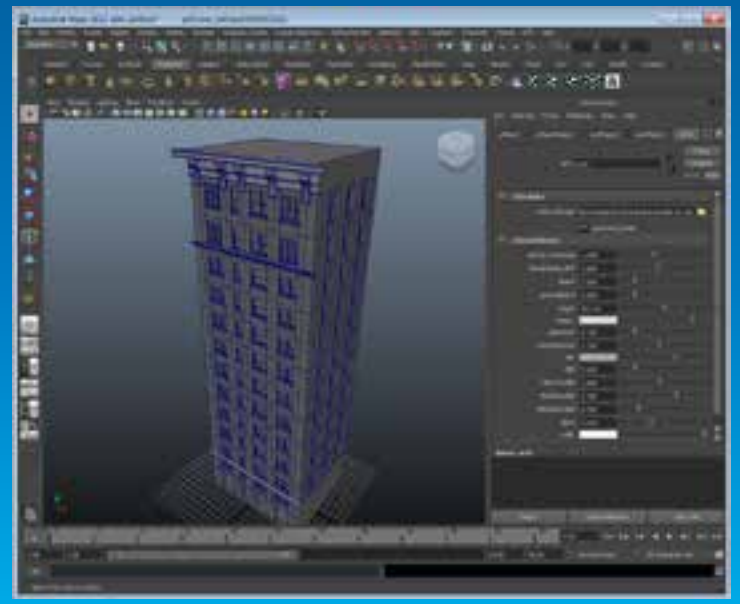


Sharing / Consuming Rule Packages

- Write CGA rules in CityEngine
- Share as rule package
  - Within your organization
  - Item on Portal
  - Item on AGOL
- Consume in:
  - ArcGIS 10.2
  - ArcGIS Pro
  - 3rd party 3D apps
    - CityEngine SDK

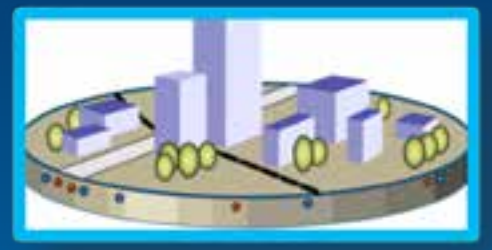


ArcScene 10.2



Maya

3D Cities Information Model



Built Environment

- ***Created and actively managed by people***
  - **Structures, utilities, transportation networks, installations**

Legal Environment

- ***Defines restrictions on land use***
  - **Land use zones, property ownership boundaries, regulations**

Natural Environment

- ***Naturally occurring features on, above, or below the earth's surface***
  - **Land cover, subsurface geology, atmosphere/climate/weather**

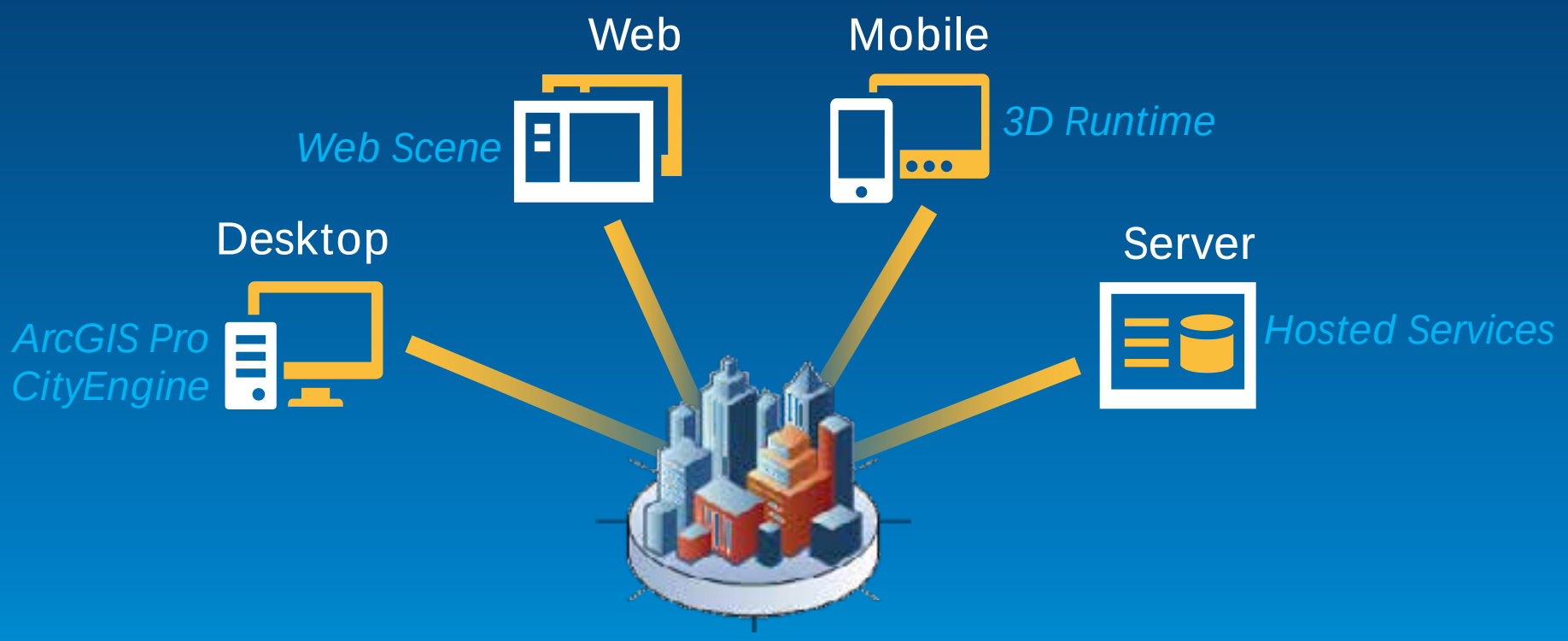
Rule Packages on AGOL

- User item on AGOL

- Esri Rule library

- ArcGIS Marketplace
  - *planned for future releases*

2014 - 3D Across the Platform



Where to go from here

- **Get a free trial version of CityEngine at:**
  - **http:// www.esri.com/cityengine**
- **Have a look at our tutorials**
- **Check out the CityEngine help**
  - **Also available online: http://cehelp.esri.com**

- **Have a look at the forum:**
  - **http://forums.arcgis.com/forums/206-CityEngine-CGA-Shape-Grammar**

- **http://www.esri.com/events/devsummit/session-rater**
  - Session id: 55 offering 261

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