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

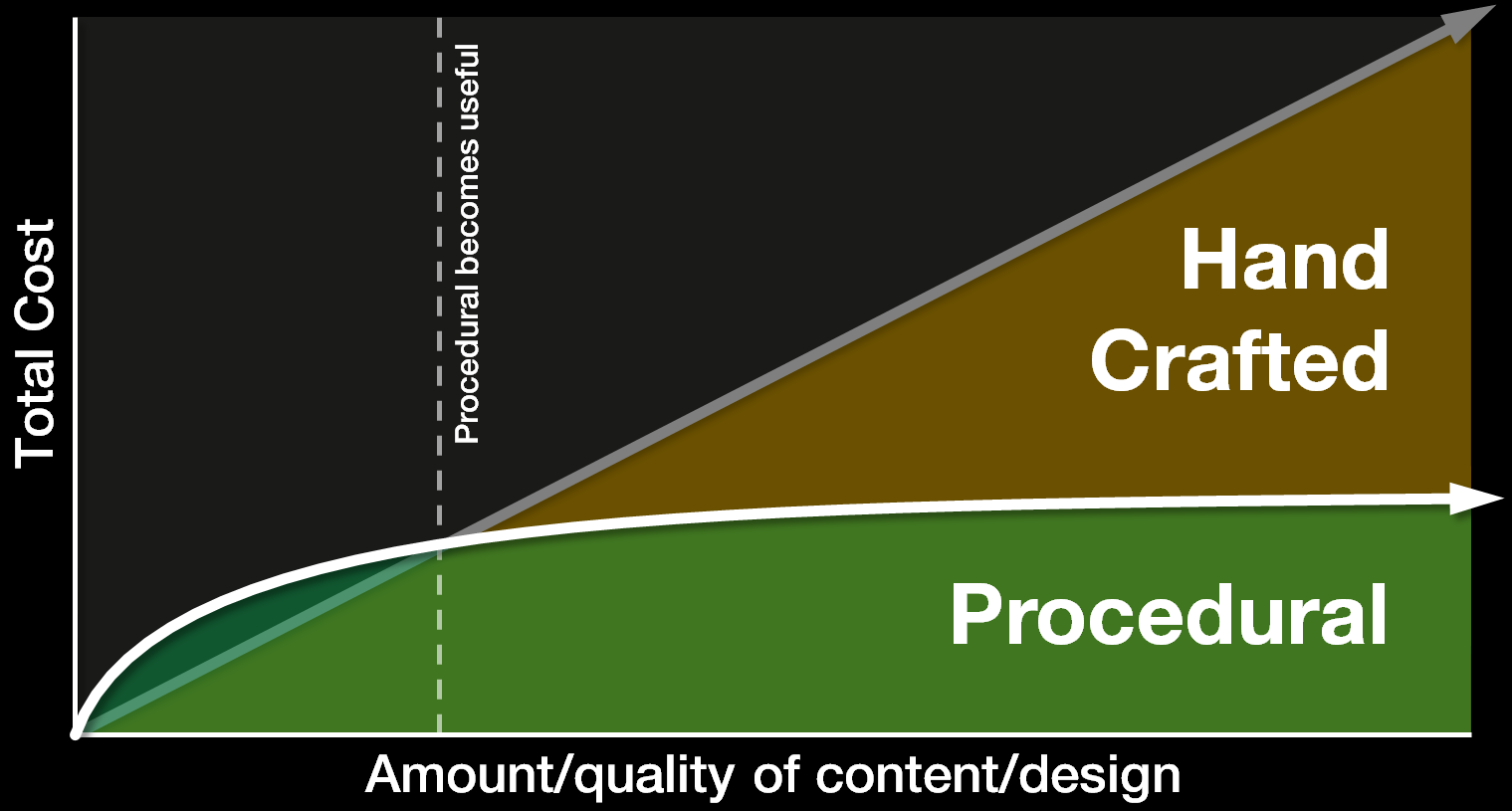
Procedural Urban Modeling in the Industry

Pascal Mueller

Industries

- **Media & Entertainment** Film, TV, Games …
- **Architecture** Urban Design, Visualization …
- **GIS** Urban Planning, Training & Sim, Navigation…
- **Others** Cultural Heritage, Education …

Modeling Practices



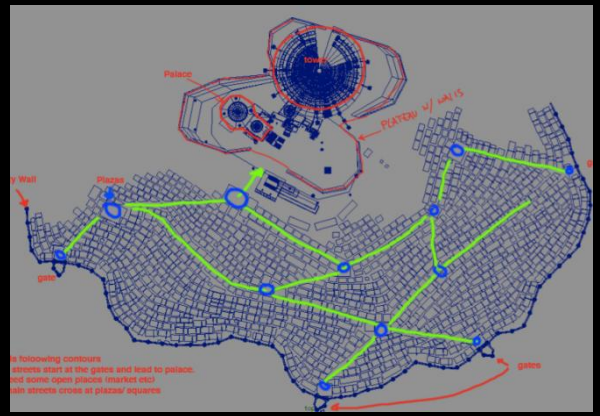
Tool Concepts

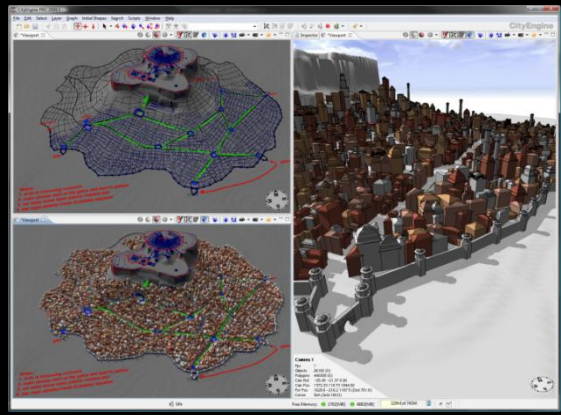
- **Scripting** Maya, Softimage, CityEngine …
- **Node-based** Shader editors, Houdini, ArcGIS …
- **Parametric modeling** Maya Construction History, Revit …
- **Hard-coded use-cases** Game editors, plugins …

WORKFLOWS

Designing Cities from Scratch

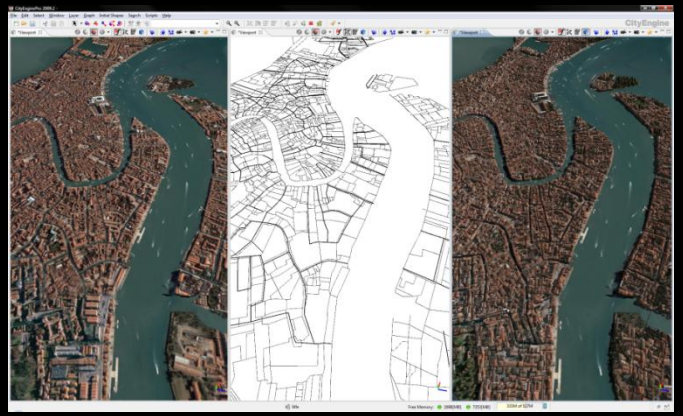
- Sketch main streets
- Define land use, densities & building types
- Layout detailed streetnetwork





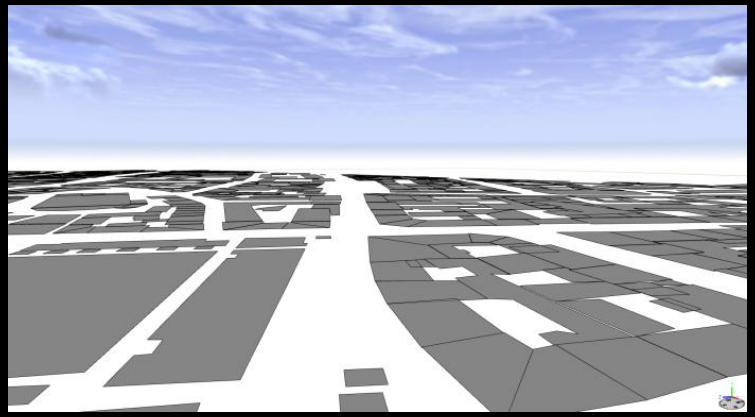
Cities based on Streetnetworks

- Real street data from GIS OpenStreetMap…
- Extract blocks from streetnetwork Space Syntax…
- Subdivide blocks into parcels Skeleton, recursive…



Cities based on Footprint Data

- Often with attributes height, rooftype, age ...
- Procedural building generation using given, approximate or random attributes



Existing Cities based on Photos

3D models from groundbased/aerial imagery

Covered in previous section of this course

V-City: Combine aerial imagery with GIS data:

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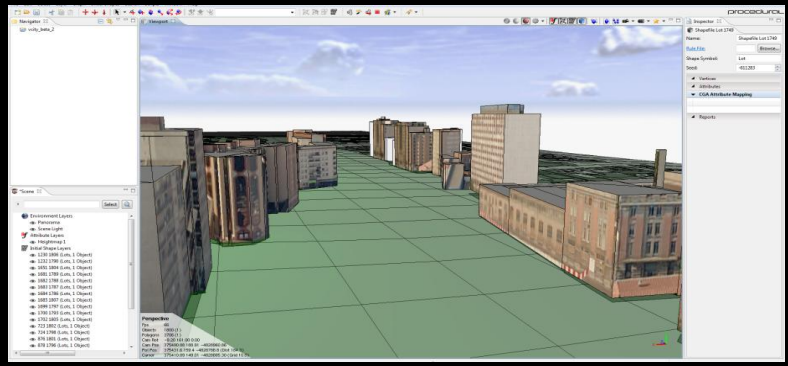
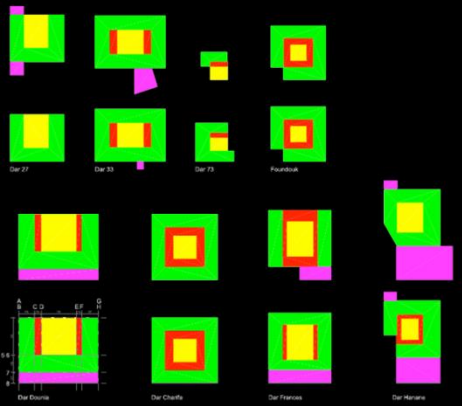


ENCODING DESIGN

Parcels

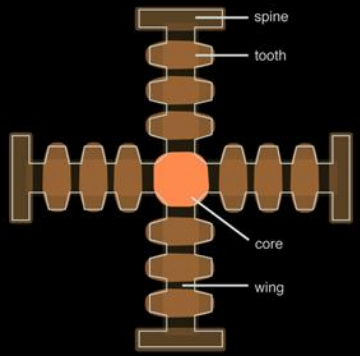
General Patterns & Zoning Laws

- **Max distances** building-street, between buildings…
- **Footprint layout** orientation, min area, access…



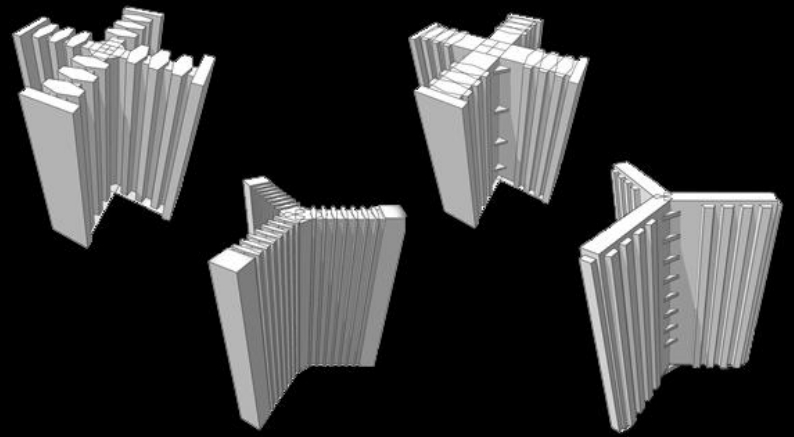
Mass Models 1/2

"Cruciform Skyscraper"
by Le Corbusier

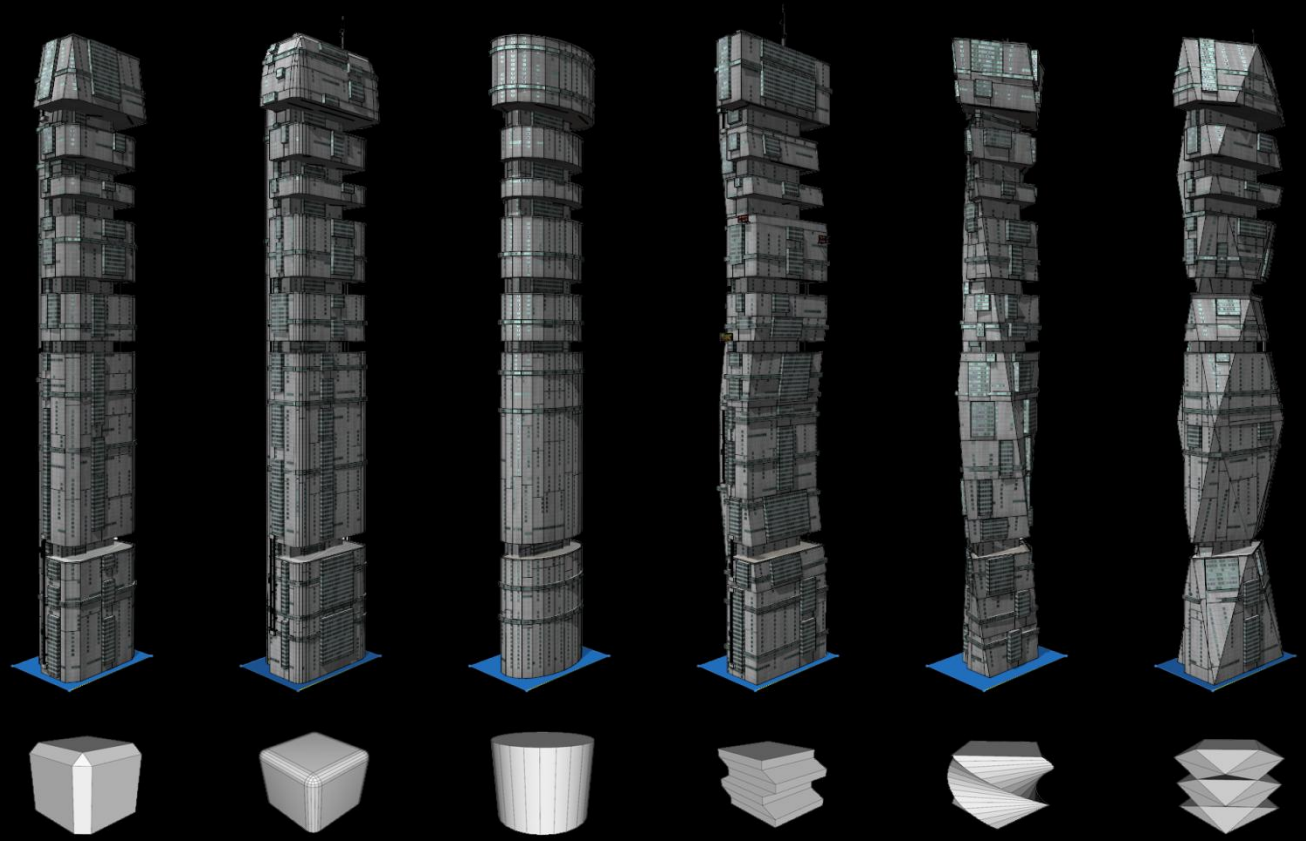


Control attributes:

attr Building_height = 220
attr Wings_n = 4
attr Wing_length = 100
attr Wing_width = 16
attr Spine_width = 50
attr Tooth_projection = 10
attr Tooth_distance = 12 ...



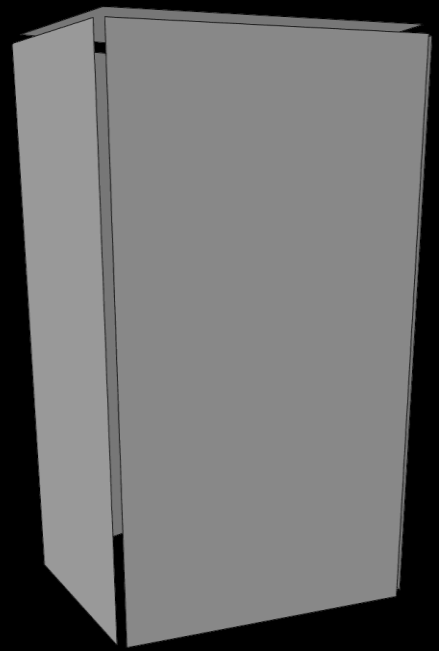
Mass Models 2/2

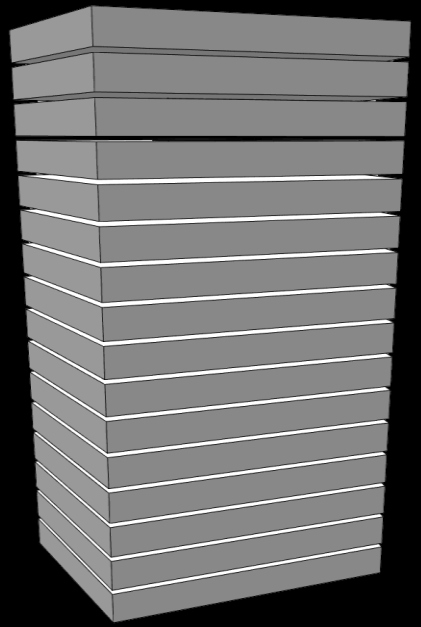


Facades vs. Floors

Two split strategies:

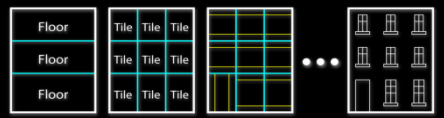
- Facade surfaces
  non-complex models
- Floor volumes
  required for interiors





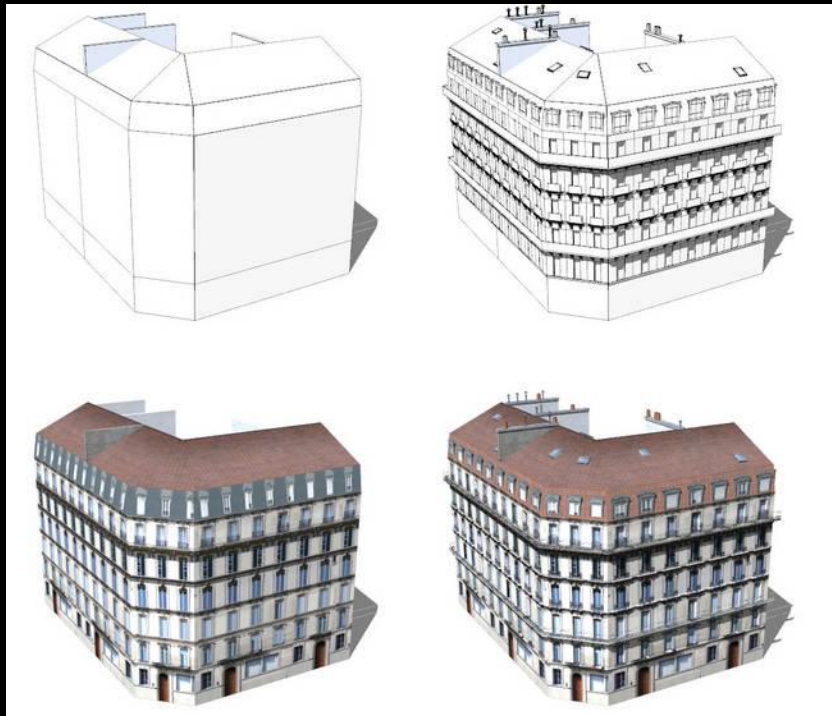
Refinement using subdivsion schemes

covered in previous section of course



Levels of Detail 1/2

- Photo textures for photorealistic looks



Levels of Detail 2/2

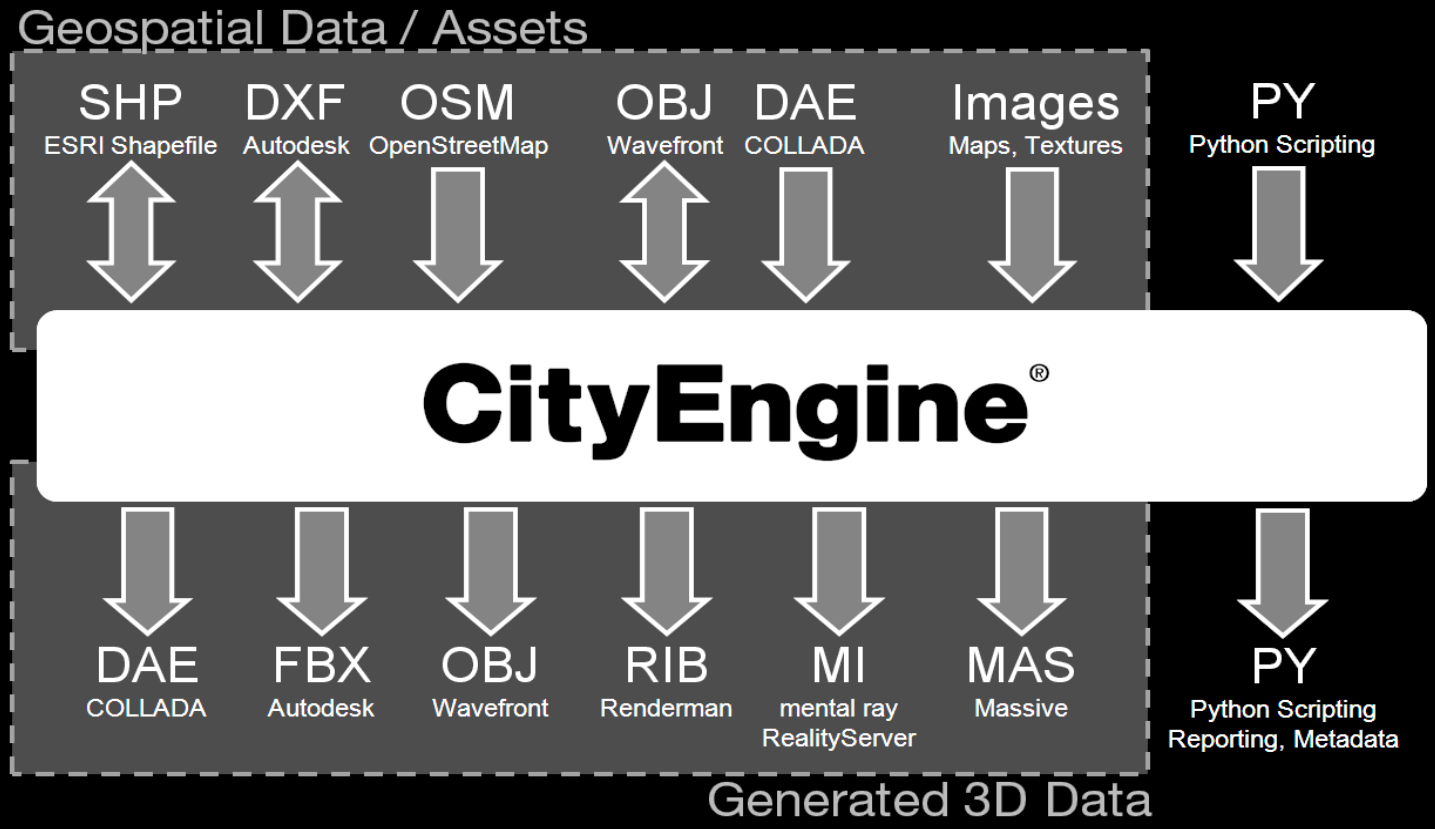
- Multiresolution assets for rendering performance

Roofs

- **Hipped roofs**
  Gable, gambrel, mansards …
- **Flat roofs**
  Complex asset distribution

PRODUCTION PIPELINES

Dataflow Example

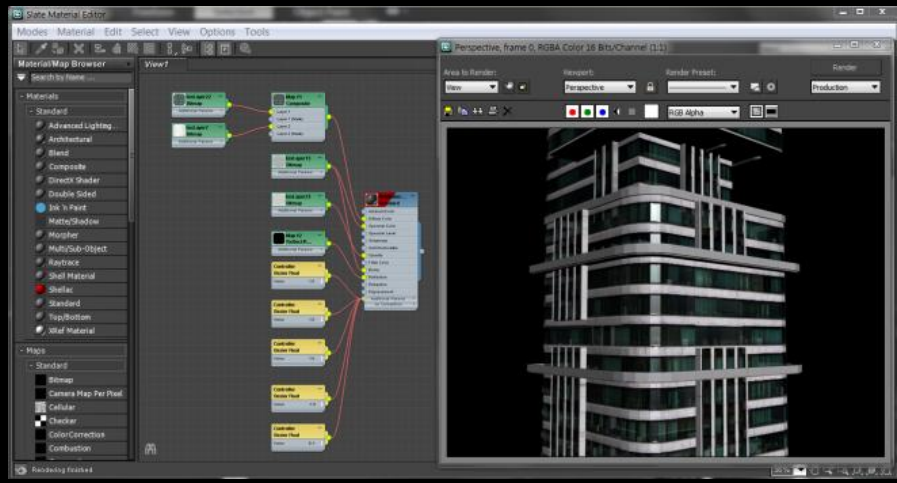


Production Requirements

- Generate reasonable polygon counts
  becomes less and less of a problem
- Support instances if possible
  instances in Collada/FBX often not supported
- Take high object counts into account
  hard to manage in traditional 3d editing tools
- Avoid high material counts
  affects performance in realtime rendering

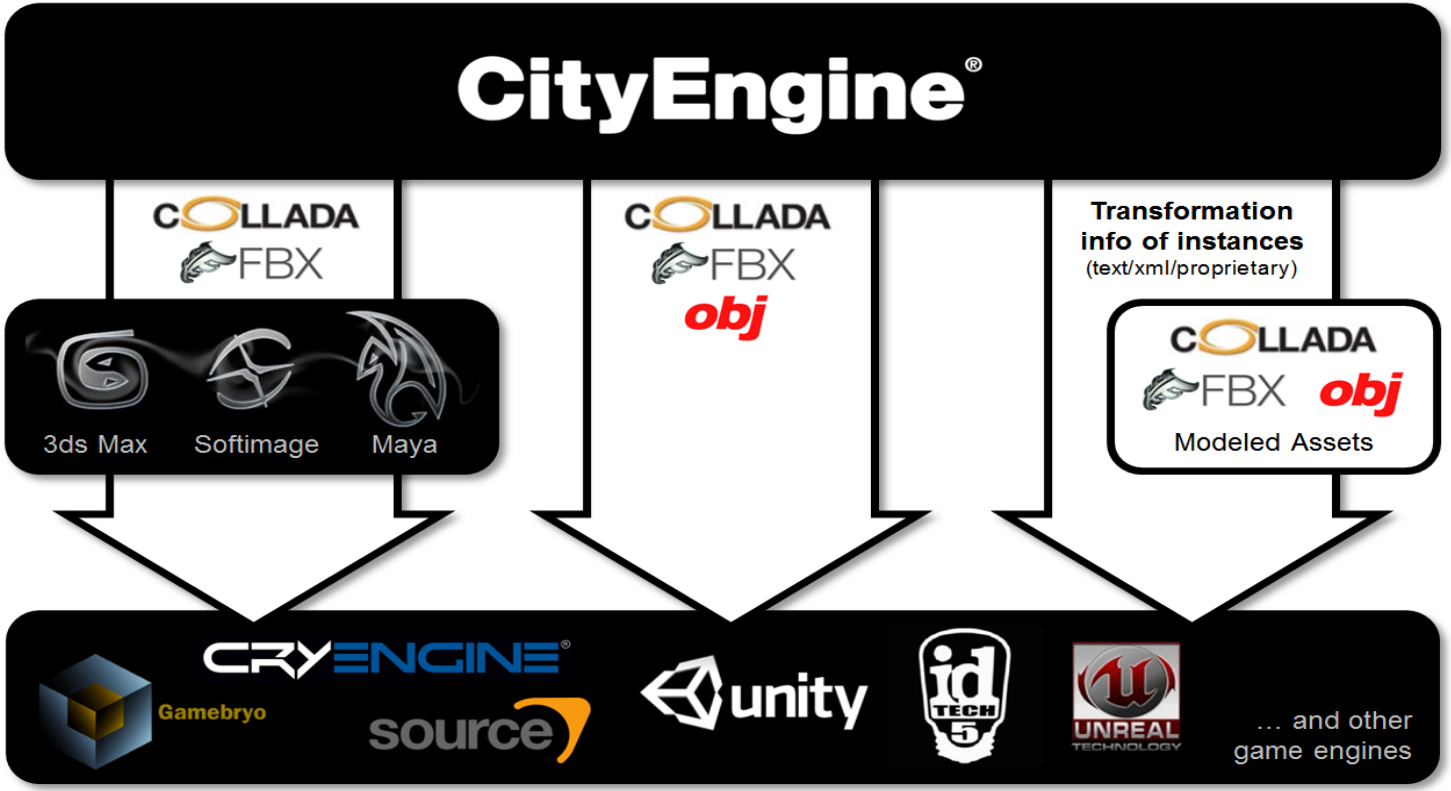
Procedurally Generated Materials

- Complex materials using different UV sets
- Material exchange capabilities often limited



GAME DEVELOPMENT

Game Development Pipeline

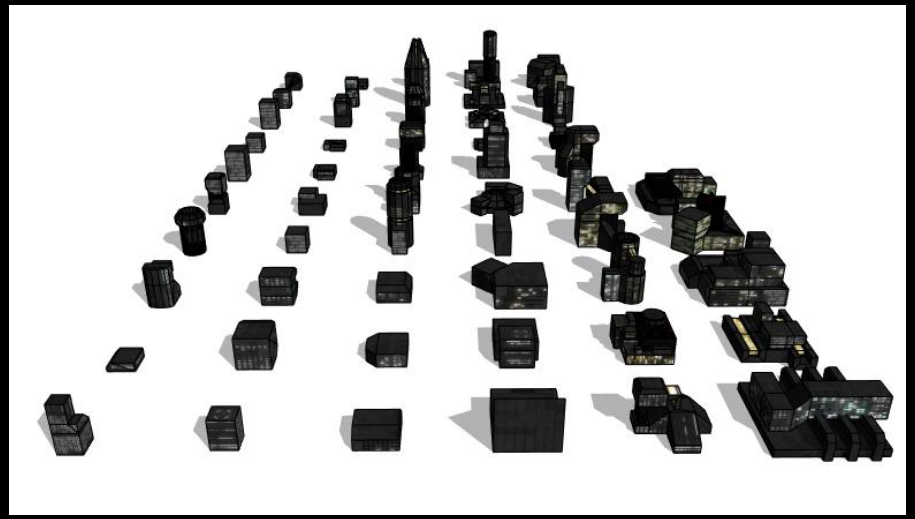


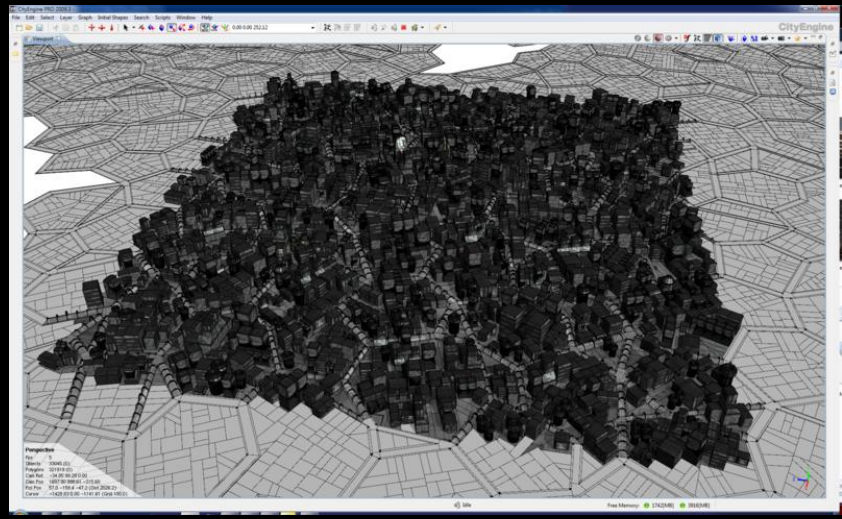
Procedural Content in Games

- Procedural map generation
- Procedurally distributed asset instances
- Pre-processed procedural models
  geometry by 3rd party tools or engine editor
- Realtime procedurally generated geometry
  usually hardcoded due to different requirements

Example: Instancing Assets 1/2

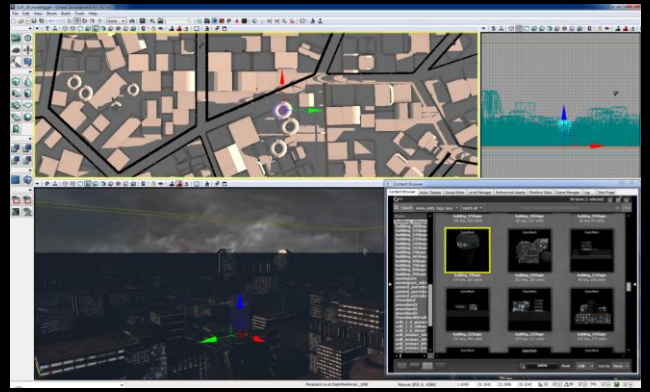
- Procedural creation of streets
- Positioning of buildings assets





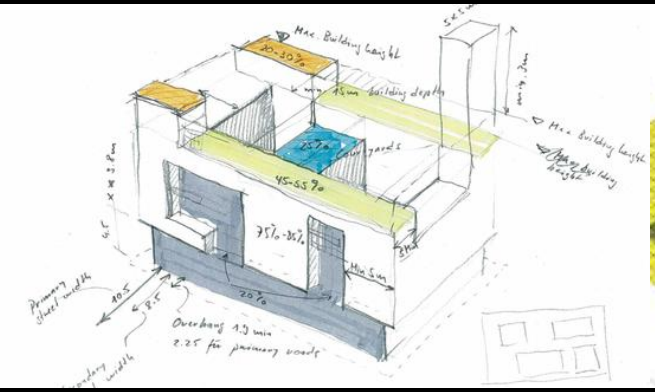
Example: Instancing Assets 2/2

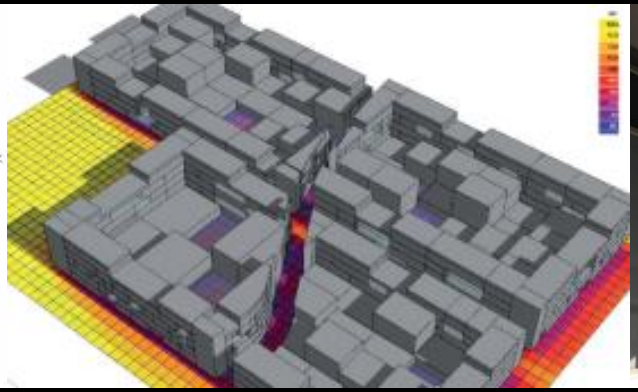
- Import assets & other elements as geometry
- Import positioning info of assets into engine



URBAN PLANNING

Urban Planning Pipelines

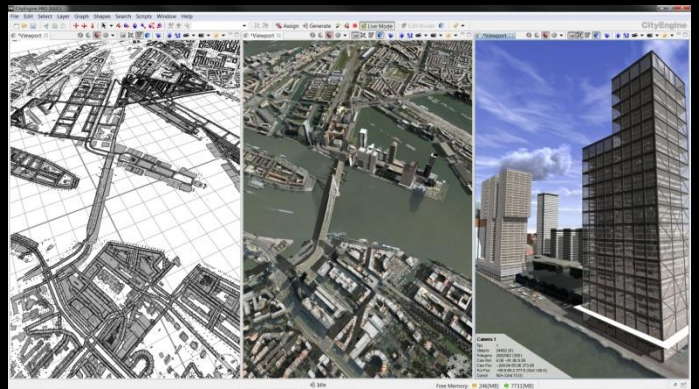


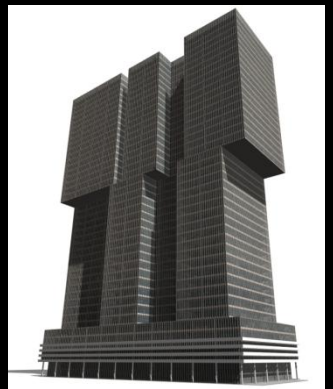


- **Design** Parameterize & encode buildings
- **Analyse** Shadow, energy, agent-based simulation…
- **Visualize** For decision makers & public

Example: City of Rotterdam

- Data aggregation
  From various 2d and 3d sources
- Procedural new developments
  Encoding of designs for analysis & visualization





File Edit Select Layer Graph Shapes Search Scripts Window Help

Assign Generate Live Mode Edit Model

*Scene

Scene Light
Panorama
Satellite
Footprints1 (29583 Objects)
Footprints2 (30106 Objects)
Dev DeRotterdam NewOrleans (12 Objects)
Dev Baltimore Havana SF (10 Objects)
TeleAtlasModels (24 Objects)
TeleAtlasLayer (2 Objects)
LightPoles (21421 Objects)
Trees (30042 Objects)
Streets (4428 Objects)

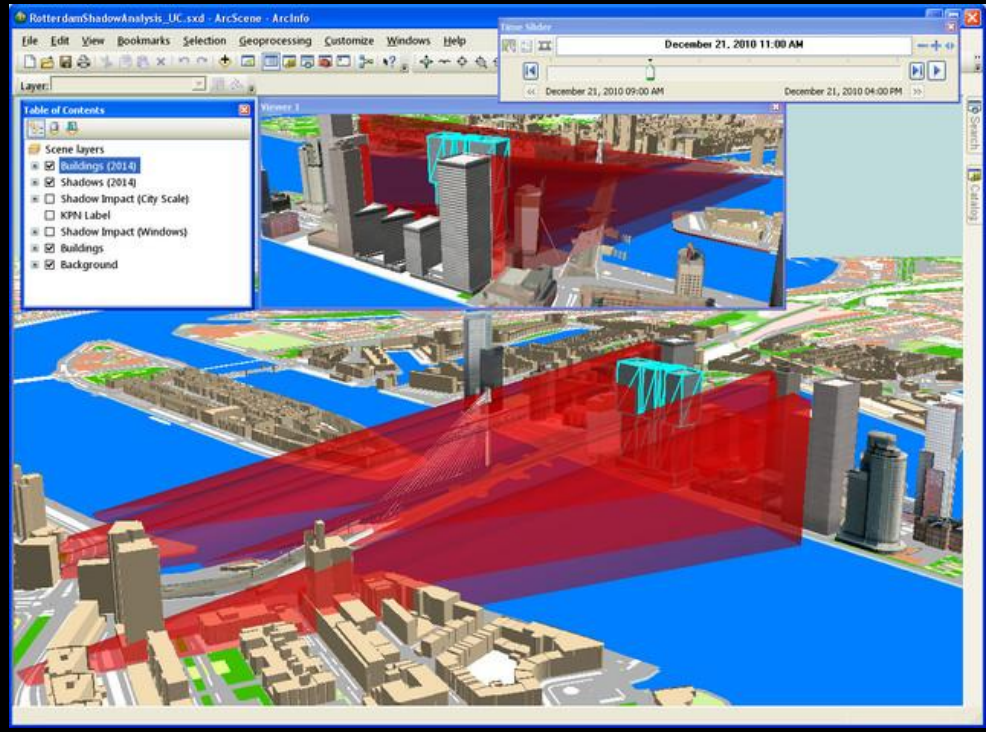
Inspector

*Viewport

Analysis

- Shadowing impacts
- View sheds
- ...

Esri
ArcGIS 3D Analyst



Visualization

- Cloud-based rendering in web browser

Nvidia RealityServer