



Creating a 3D Virtual City Using ArcGIS

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What is 3D Mapping?

- Viewing spatial data in 3D: raster, vector, elevation
- Seamless transitions between global, local and street-level scale data
- Performing GIS analysis within a 3D context
- 3D Mapping has applicability in fields such as:
 - Geology
 - Meteorology
 - Climatology
 - Hydrology
 - Utility Management
 - Disaster Management
 - Archeology
 - Real estate, etc...

What can 3D Visualization do for you?

- **Accurately represent real-world GIS entities**
 - We live in a 3D world, our data should display that way
- **Create realistic 3D virtual cities**
 - Tourism, Advertising
- **Visualize ‘what if’ scenarios**
 - Planned construction (buildings, roads, transmission lines, etc)
 - Decision support systems (evacuation, mock attacks, etc)
- **Gain insights into your data, including:**
 - 3D spatial relationships
 - Sizes / Scales
 - Visibility / Line of sight

Solutions for 3D Visualization from ESRI

- **Out-of-the-box Desktop, Engine and Server solutions**
- **Desktop:**
 - ArcGIS 3D Analyst (ArcGlobe and ArcScene)
 - ArcGIS Explorer (available as Free Download)
 - ArcReader
- **ArcGIS Engine Solutions:**
 - Globe Control
 - Scene Control
- **ArcGIS Server Solution:**
 - Globe Server
 - Allows analysts to publish rich GIS web Services
 - No programming required

Creating the 3D Dataset

- **Plan**
 - Data Collection
 - Data Display
- **Out of the Box (using GUI)**
 - Symbology
 - 3D MarkerSymbols
 - Style Gallery
 - Using 3D Graphics
 - Extruding 2D datasets – Attribute Driven
- **Custom Solutions**
 - Develop 3D objects using multipatches
 - MultiPatch Geometry
 - IGeneralMultiPatchCreator

Data Collection

Surface Data

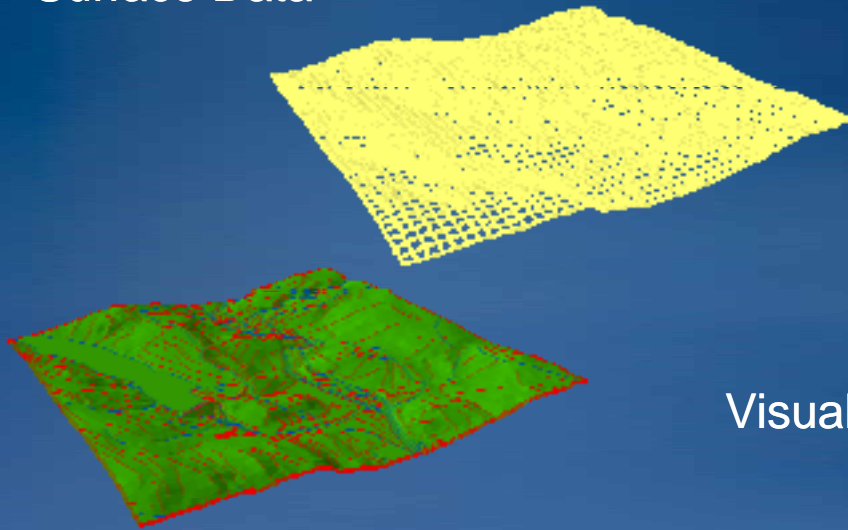


Image Data



3D
Visualization Data



Local



Regional



Global

3D Symbology

- **Points**

- 3D Geometric primitives: Spheres, Cones, etc.
- 3D Models: Street furniture, Houses, etc.
- 3D Character Markers
- 3D Billboarded Markers



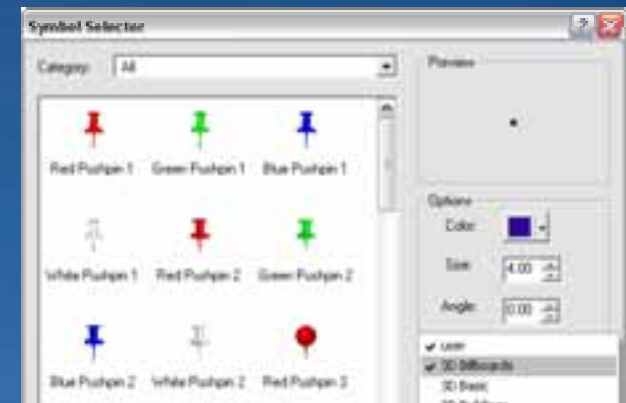
- **Lines**

- 3D Texture Line Symbols: Pavement, Concrete, etc.
- 3D Geometric primitives: Tube, Strip, Wall etc.



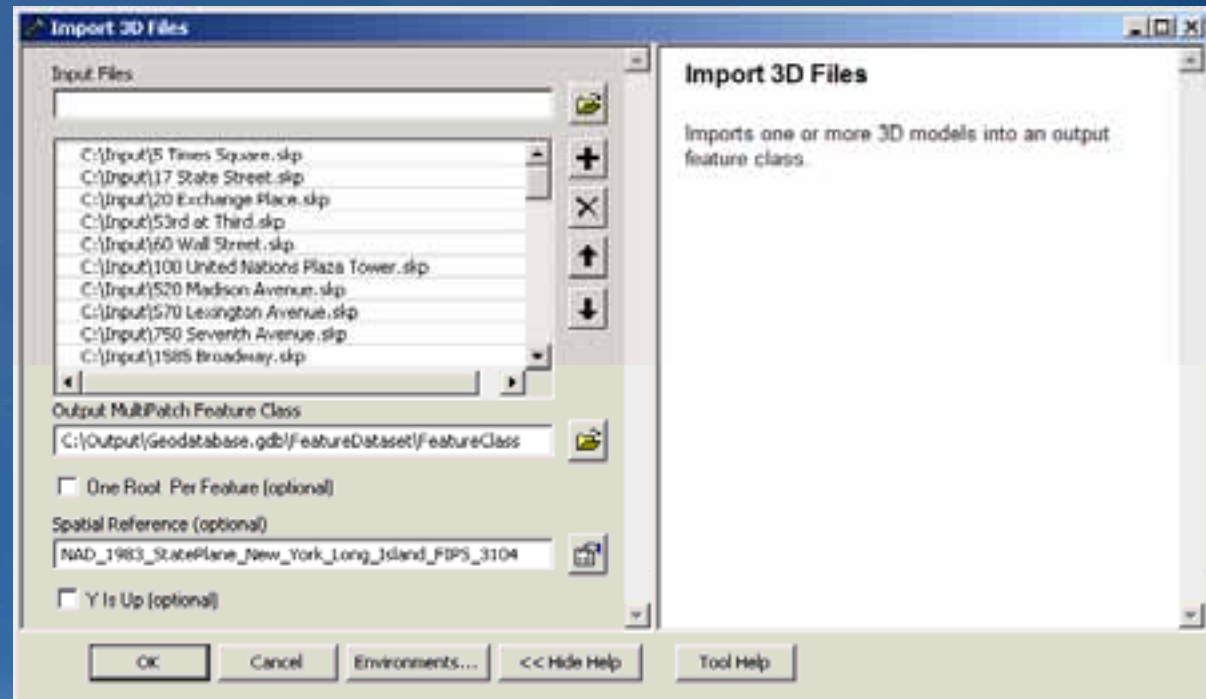
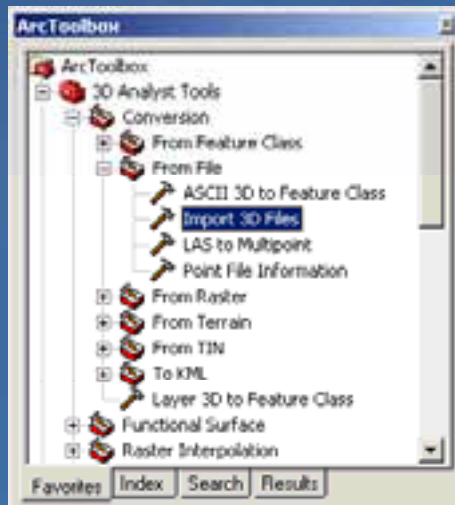
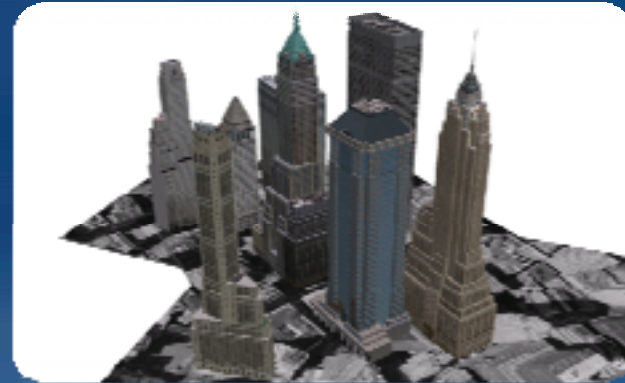
- **Polygons**

- 3D Texture Fill Symbols



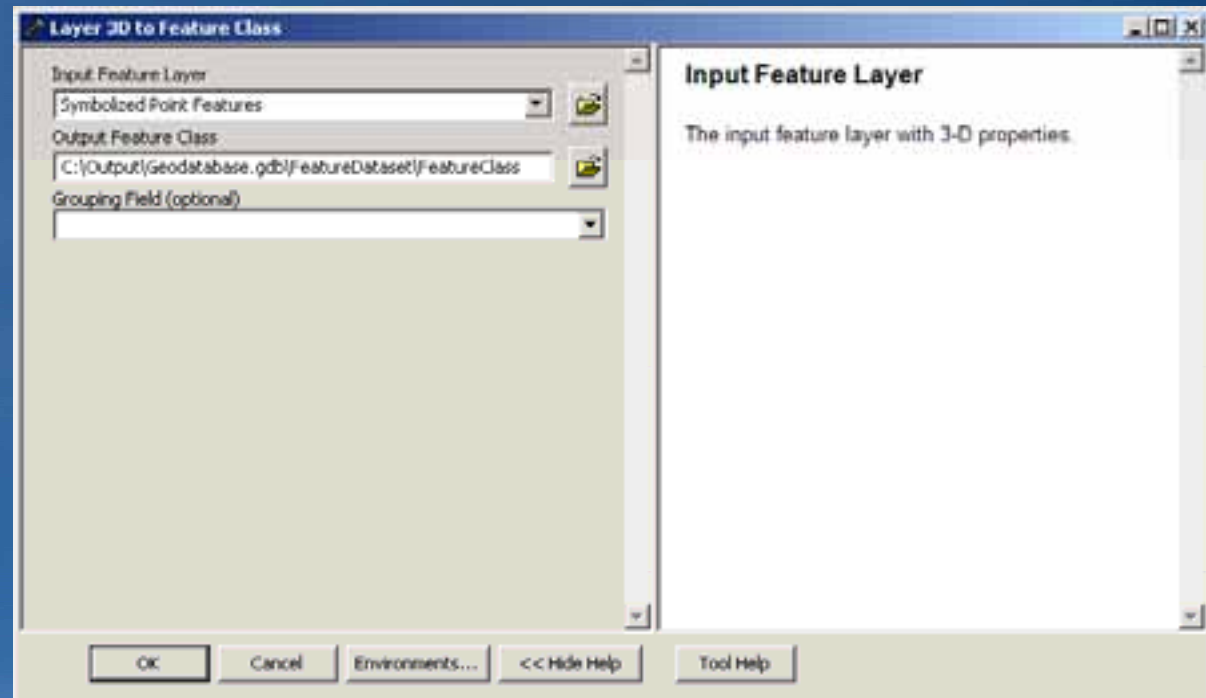
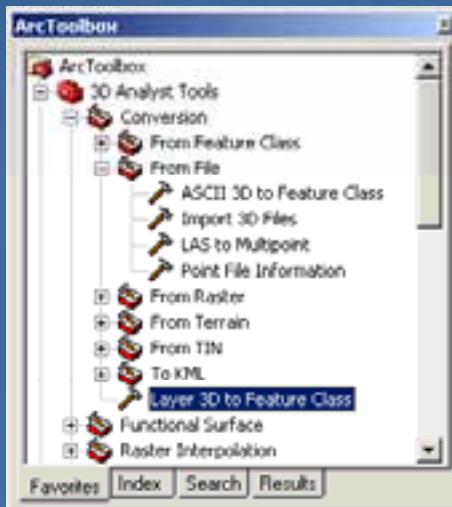
Geoprocessing Tool: Import 3D Files

- Input Formats
 - COLLADA
 - SketchUp
 - OpenFlight
 - 3ds Max
 - GeoVRML



Geoprocessing Tool: Layer 3D to Feature Class

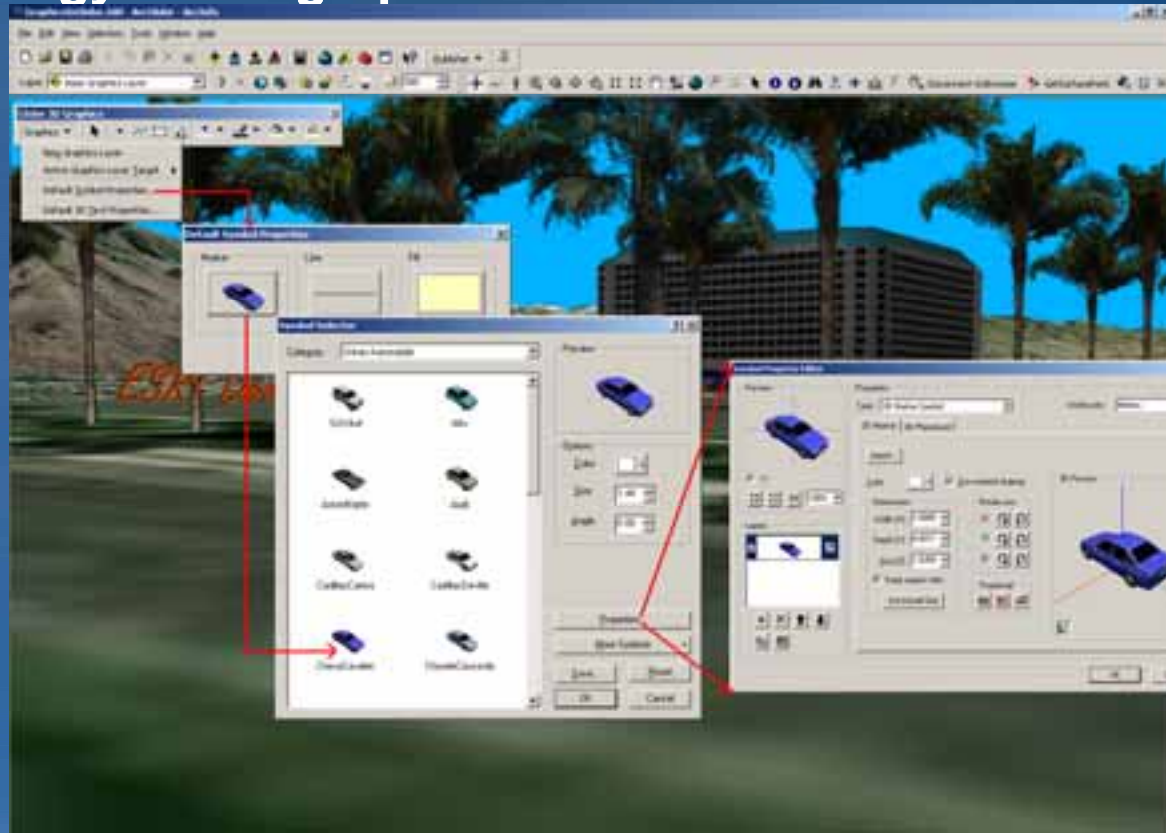
- 3D Symbology
- Extrusion Settings
- Texture Downsampling



3D Graphics

3D Graphics Toolbar and API

- Digitize a point, line, polygons and text graphics
- Apply 3D Symbology to the graphic elements



3D Graphics Layer API Usage (C++)

```
        //Create a new graphics layer
        m_ipGlobeGraphicsLayer.CreateInstance(CLSID_GlobeGraphicsLayer);
        ILayerPtr (m_ipGlobeGraphicsLayer)->put_Name(L"MyGraphicsLayer");

        //Add the new graphic layer to the globe
        IGlobePtr ipGlobe;
        m_ipGlobeDisplay->get_Globe(&ipGlobe);
        IScenePtr (ipGlobe)->AddLayer(ILayerPtr(m_ipGlobeGraphicsLayer), VARIANT_TRUE);
```

```
        //Activate the new graphics layer
        IScenePtr (ipGlobe)->ActiveGraphicsLayer(ILayerPtr(m_ipGlobeGraphicsLayer));
```

3D Graphics Layer API Usage (C++)

//Create the element's geometry

```
IPointPtr ipPoint(CLSID_Point);
IZAwarePtr (ipPoint)->put_ZAware(VARIANT_TRUE);
ipPoint->PutCoords(position.longitude, position.latitude);
ipPoint->put_Z(position.altitude);
```

//Create the element's color (red)

```
IRgbColorPtr ipColor(CLSID_RgbColor);
ipColor->put_Red(255L);
ipColor->put_Green(0L);
ipColor->put_Blue(0L);
```

//Set the element's symbol

```
IMarkerSymbolPtr ipMarkerSymbol(CLSID_SimpleMarker3DSymbol);
ISimpleMarker3DSymbolPtr (ipMarkerSymbol)->put_Style(esriS3DMSSphere);
ISimpleMarker3DSymbolPtr (ipMarkerSymbol)->put_ResolutionQuality(1.0);
ipMarkerSymbol->put_Size(700.0);
ipMarkerSymbol->put_Color(IColorPtr(ipColor));
```

//Create the new marker symbol element

```
IElementPtr ipTrackElement(CLSID_MarkerElement);
IMarkerElementPtr (ipTrackElement)->put_Symbol(ipMarkerSymbol);
ipTrackElement->put_Geometry(IGeometryPtr(ipPoint));
```

//Add the graphic element to the graphics layer

```
IGraphicsContainerPtr (m_ipGlobeGraphicsLayer)->AddElement(ipTrackElement);
```

KML Support

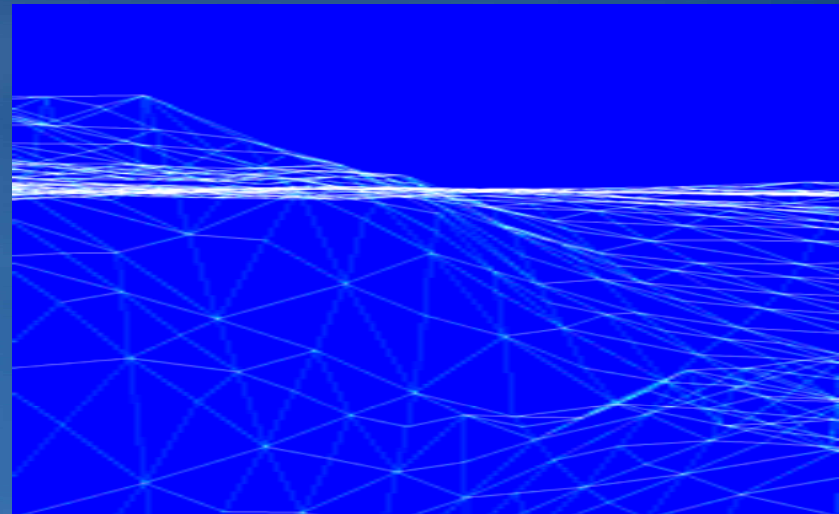
Keyhole Markup Language

- XML-based language for defining the display of 3D spatial data
- Add KML data using the KML toolbar in ArcGlobe
- Strong support for KML 2.1

Demo 1: 3D Symbology

Data Collection: Backdrop

- **Transportation Routes**
- **Aerial Imagery**
- **Elevation Data**



Data Display: Elevation, Imagery



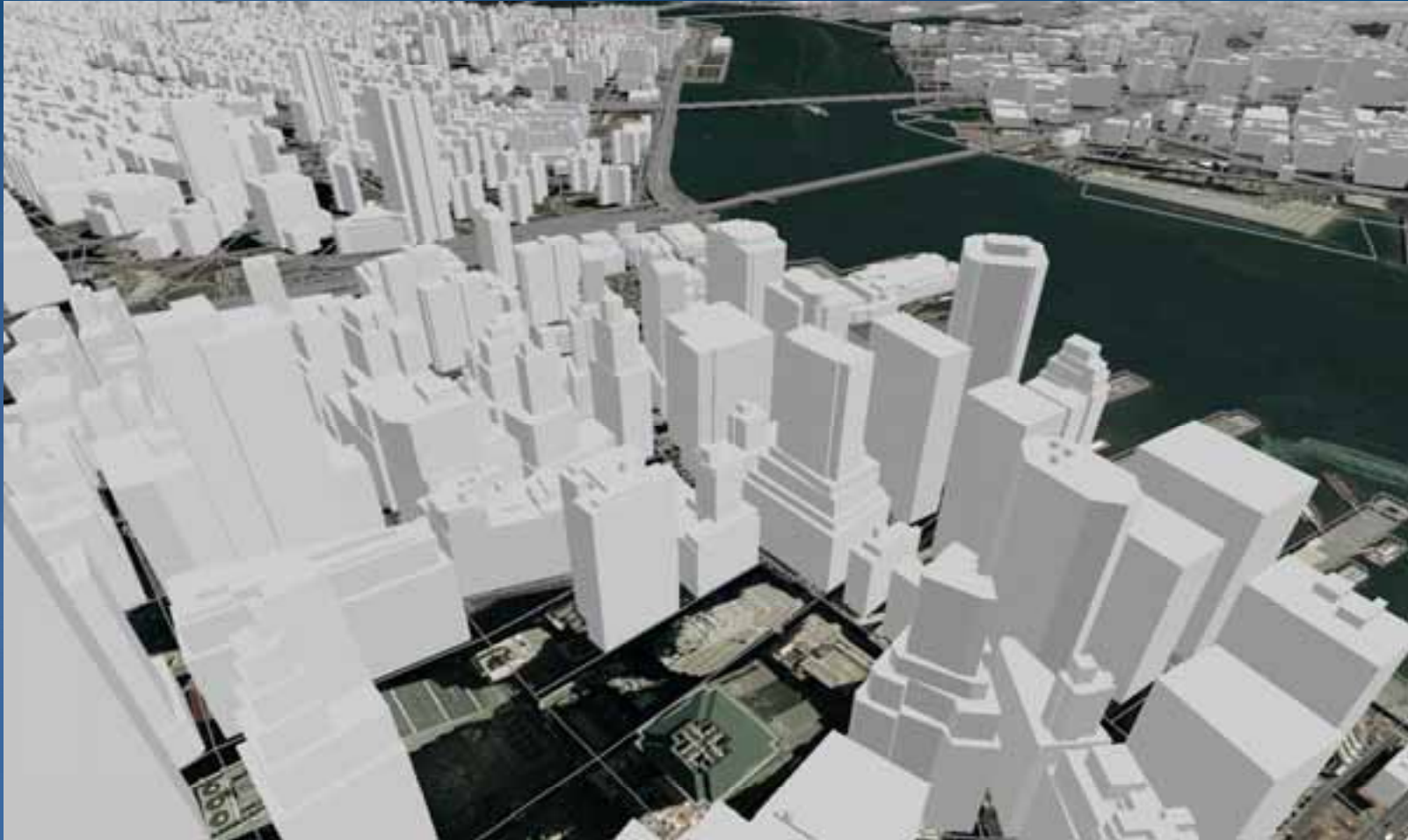
Data Display: Transportation Routes



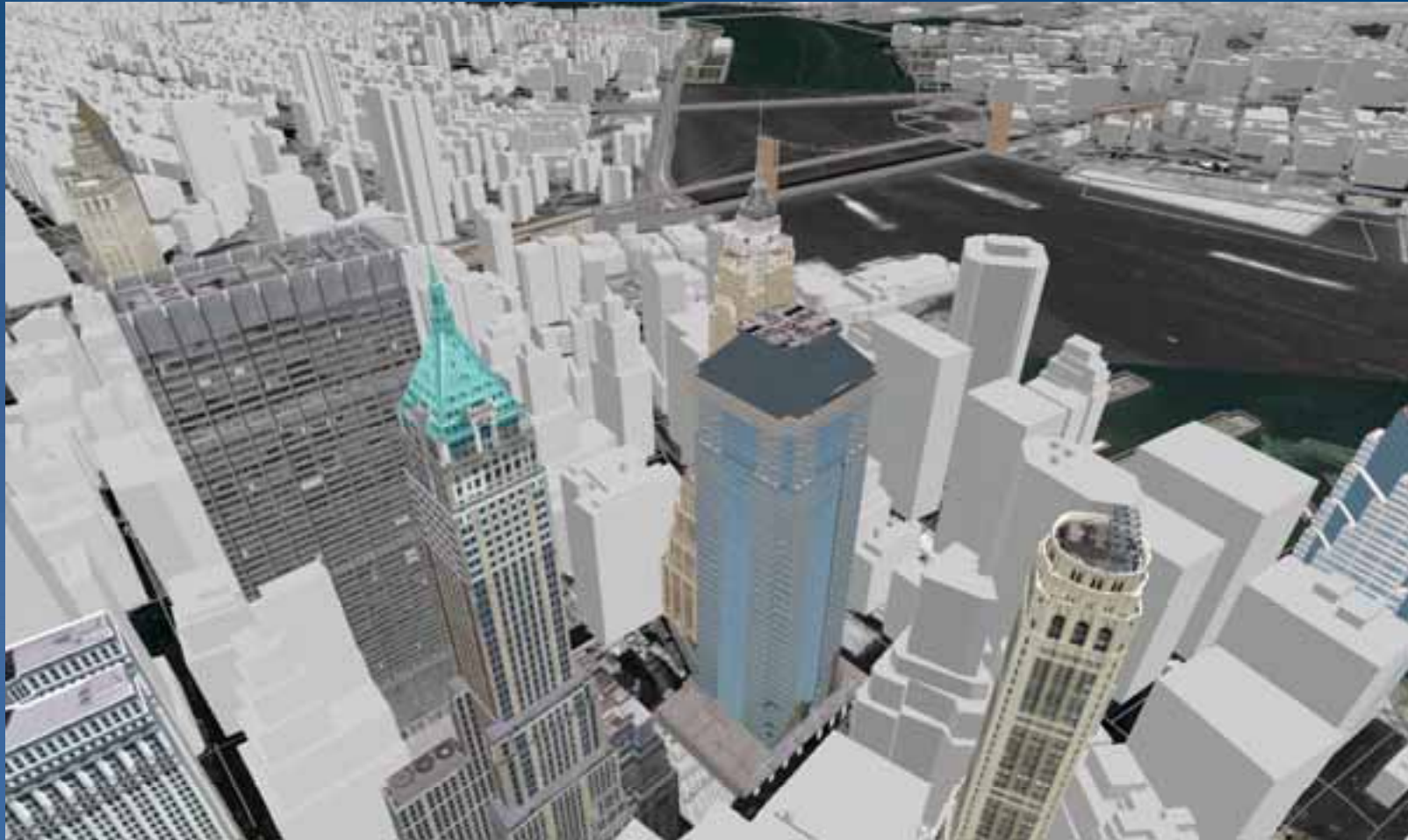
Data Display: Building Footprints



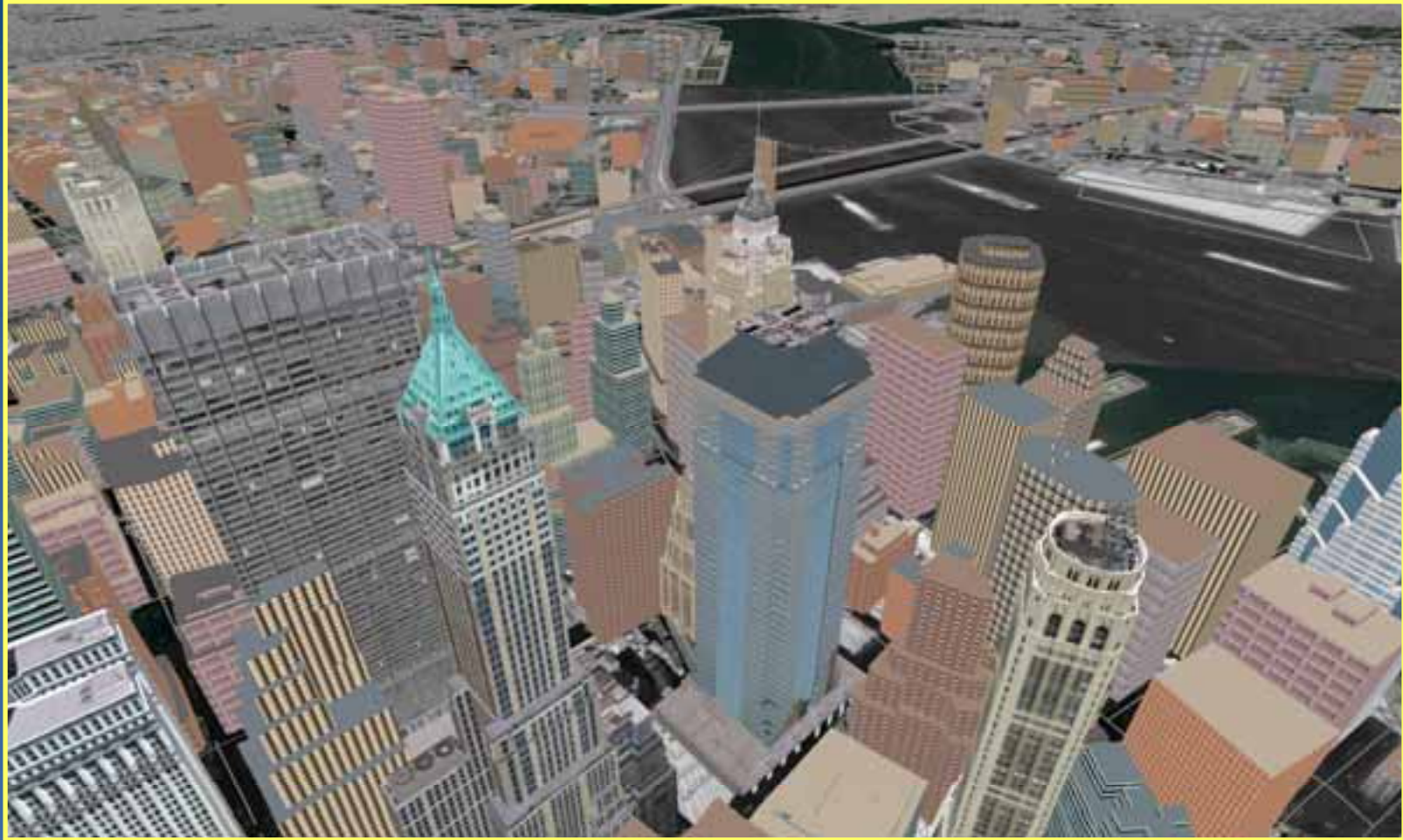
Data Display: Extruded Footprints



Data Display: Building Models



Data Display: Textured Buildings



Data Collection: Buildings

- Building Footprints
- Building Textures
- Building Models



3D Geometry Type

- **Multipatches are a native geometry type (like lines, points, polygons)**

Why are they key in a 3D content creation?

- **3D textured models are stored in a GDB**
- **3D Analysis requires multipatch geometry**

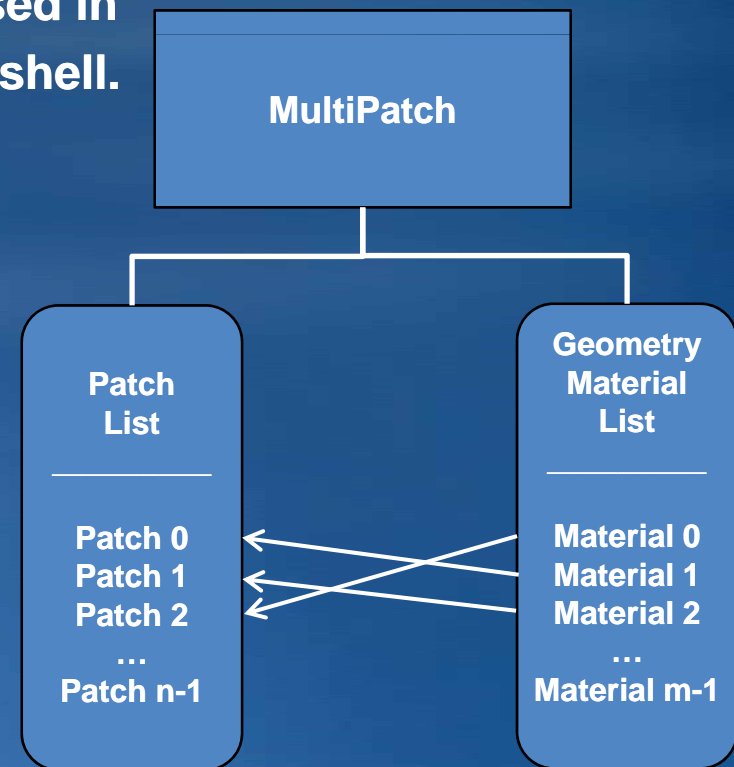
Create multipatches through:

- **UI – Import, GP tools**
- **ArcObjects – IGeneralMultipatchCreator**

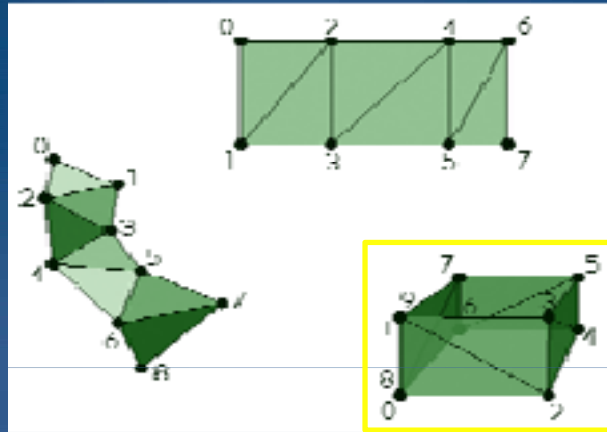
Custom Solution: MultiPatch Geometry

MultiPatch [definition]: a 3D geometry used to represent the outer surface/shell of features that occupy a discrete area/volume in three-dimensional space. MultiPatches comprise 3D rings and triangles that are used in combination to model a three-dimensional shell.

- One or More Patches
- Zero or More Geometry Materials
- 1 to Many Relationship (Geometry Material : Patch)

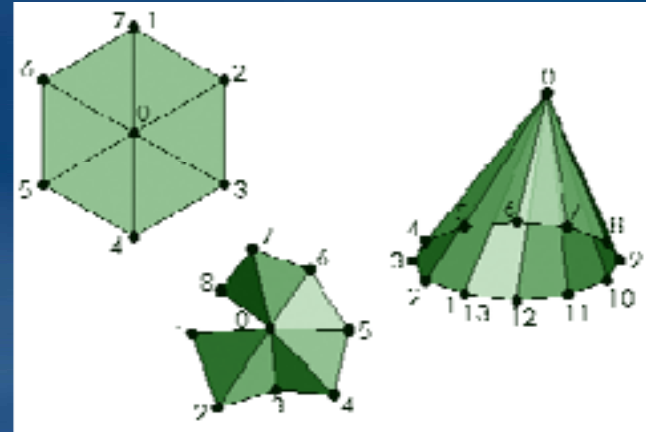


Custom Solution: what are Patches ?

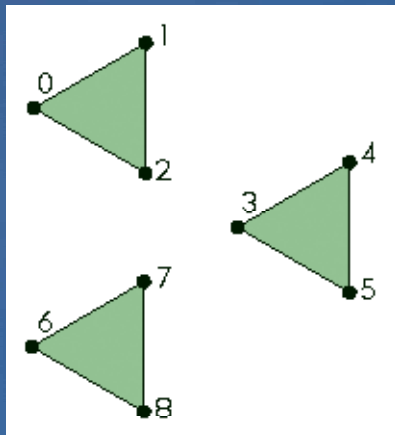


TriangleStrip

Building Walls



TriangleFan



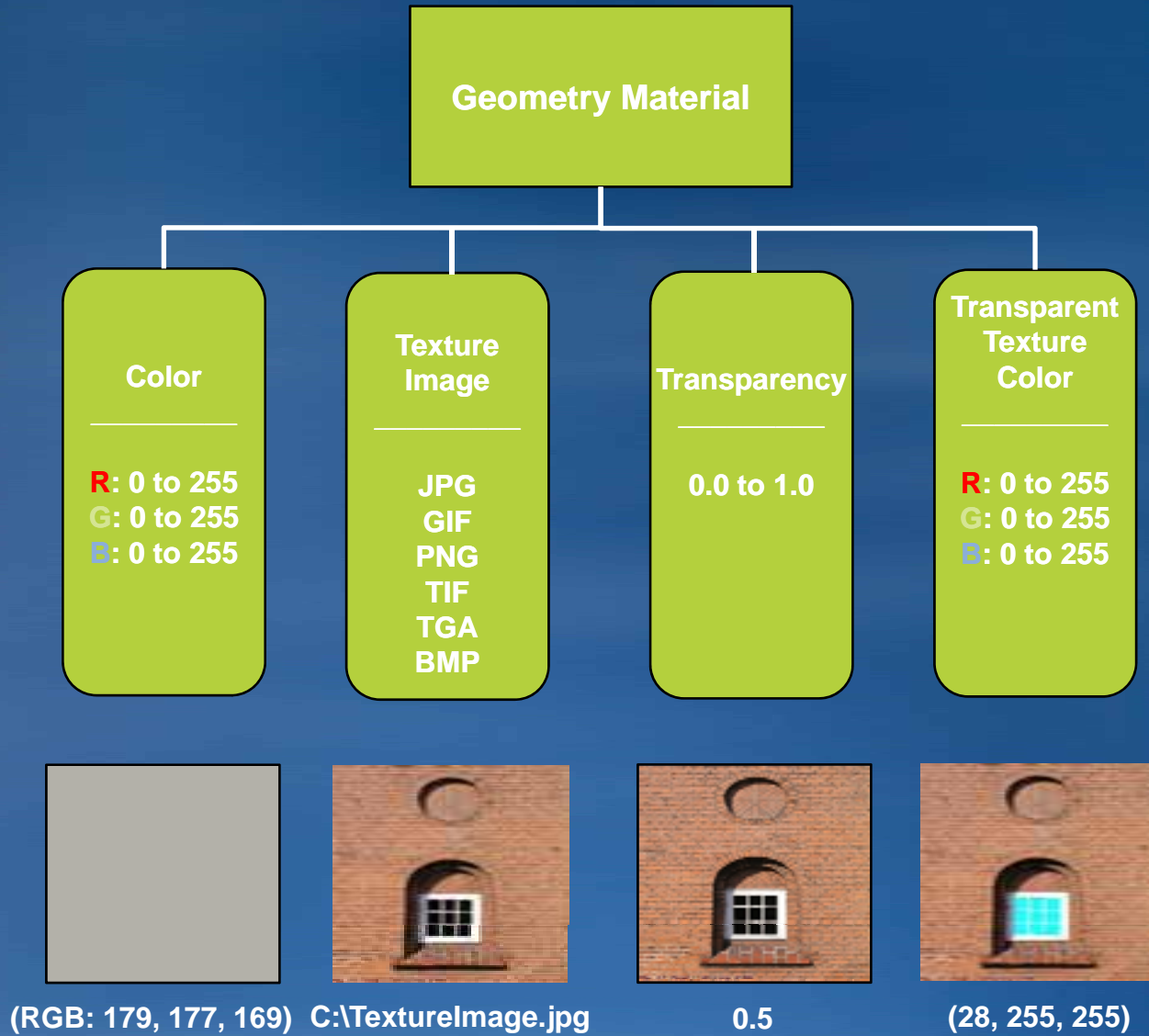
Triangles

Building Floors,
Building Roofs



Ring

Custom Solution: Geometry Materials



Custom Solution: Example of building a 3D Virtual City

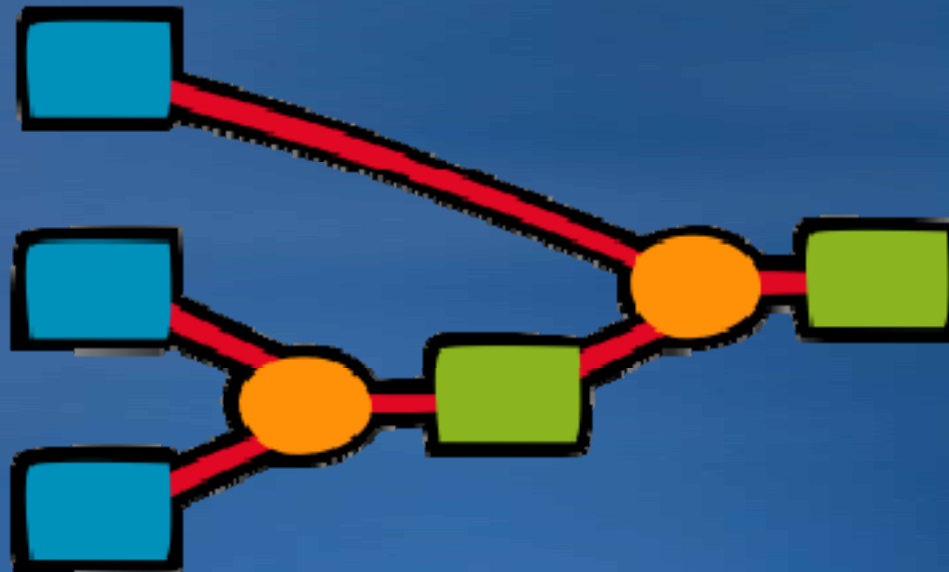


Custom Solution : Steps of Creating a Single Building

1. Define Geometry Material List
2. Initialize General MultiPatch Creator
3. Define Patch Types
4. Define Material Indices
5. Define Point Starting Indices
6. Define Texture Point Starting Indices
7. Define Points
8. Define Texture Points
9. Generate MultiPatch
10. Cleanup Resources

Entire City: Workflow

1. Construct Material Properties Table
2. Construct Building Properties Table
3. Construct Textured Buildings Feature Class



1. Construct Material Properties Table



Material Properties File



Material Properties Table

Attributes of MaterialPropertiesTB

OBJECTID	MaterialID	MaterialLocation	HasTextureImage	TextureImageFileName	TextureImageHeight	TextureImageWidth	TextureImageUnits
1	1	0	1	Floorred_brick_wall_4193171	4.89	8.67	3
2	2	0	1	Flooridirty_cream_coloured_bricks_021762	6.22	7.67	3
3	3	0	1	Floordagonal_patterned_long_bricks_011708	8.89	8.67	3
4	4	1	1	Roofmarble_8110070	0.75	1	3
5	5	1	1	Roofspecked_marble_9261515	0.75	1	3
6	6	1	1	Roofwhite_marble_4131373	0.75	1	3
7	7	1	1	Roofrose_coloured_marble_9181131	0.75	1	3
8	8	2	1	Wallrepetitive_office_windows_23734	73.33	100	3
9	9	2	1	Wallmetal_square_hotel_windows_040521	40	53.33	3
10	10	2	1	Walloffice_windows_1987123	30	40	3
11	11	2	1	Wallwindows_011710	30	40	3
12	12	2	1	Wallanonymous_glass_metal_building_40519	50	50	3
13	13	2	1	Wallsquare_modern_windows_5291381	20.56	23.33	3
14	14	2	1	Wallsquare_traditional_office_windows_9261486	50	66.67	3
15	15	2	1	Wallmodern_windows_021791	25	33.33	3
16	16	2	1	Wallbalcony_deco_mobi_4152396	20	15	3
17	17	2	1	Wallmetal_balconed_window_4152384	9	12	3
18	18	2	1	Wallwindow_ornate_brickwork_30923	11.25	15	3
19	19	2	1	Wallscandinavian_window_with_circle_934345	13.87	7	3
20	20	2	1	Walltraditional_window_23932	15	11.25	3

Record: 1 | Show: All Selected | Records (0 out of 20 Selected) | Options

2. Construct Building Properties Table



Building
Footprints
Feature Class



Material
Properties
Table



Building
Properties
Table
Generator



Building
Properties
Table

Attributes of buildingPropertiesTB

OBJECTID	BuildingID	Elevation	ExteriorRingID	FloorMaterialStyle	FloorMaterialID	RoofMaterialStyle	RoofMaterialID	WallMaterialStyle	WallMaterialIDString
1	1	14.9	0	2	3	2	4	7	10
2	2	14.1	0	2	2	2	6	7	10
3	3	38.71	0	2	3	2	4	7	14
4	4	53.47	0	2	2	2	5	7	19
5	4	50.69	0	2	1	2	6	7	12
6	4	74.75	0	2	1	2	7	7	8
7	5	27.68	0	2	1	2	4	7	20
8	6	16.67	0	2	3	2	4	7	9
9	7	96.04	0	2	1	2	5	7	10
10	8	19.7	0	2	2	2	6	7	17
11	9	30.99	0	2	3	2	6	7	9
12	10	14.92	0	2	2	2	6	7	15
13	11	50.31	0	2	2	2	5	7	16
14	11	69.49	0	2	3	2	6	7	13
15	12	19.2	0	2	1	2	7	7	15
16	13	13.47	0	2	2	2	7	7	10
17	14	15.02	0	2	1	2	6	7	19
18	15	38.36	0	2	1	2	4	7	13
19	16	39.91	0	2	3	2	7	7	8
20	17	39.31	0	2	1	2	6	7	9

Record: 1 | Show: All Selected | Records (0 out of 107133 Selected) | Options

3. Construct Textured Buildings Feature Class



Building
Footprints
Feature Class



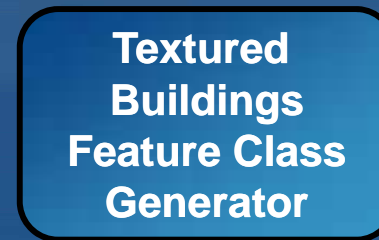
Texture
Images



Building
Properties
Table



Material
Properties
Table



...

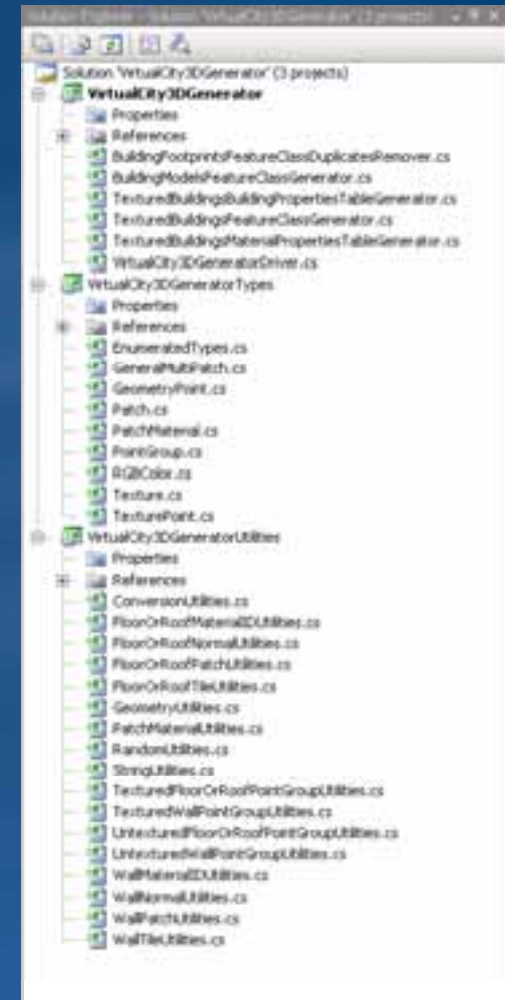
Example of a Custom Solution: Entire City Output



Custom Solution: Results

- 58,085 Textured Buildings
- 4.6 GB Feature Class
- Average Feature Size: 79 KB

- ArcObjects C# Solution
- Source Code Provided
- MultiPatch Whitepaper
 - > 150 Pages of Fully Illustrated Code Samples
 - Tips and Best Practices
 - In-Depth Walkthrough of Solution



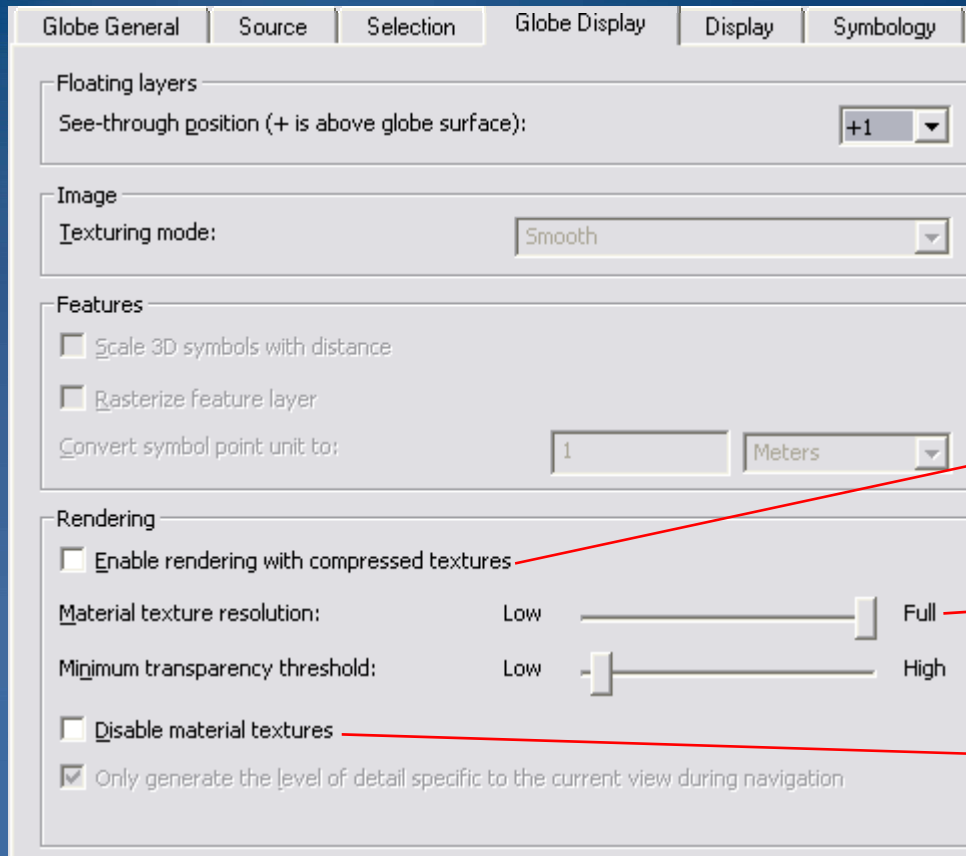
Demo 2: 3D Content Creation

Texture Management

- Textures on 3D objects can be memory intensive
- Data can take longer to display
- Navigation can be sluggish
- Performance degradation depends upon available physical memory as well as memory cache settings
- Three texture-management options are available:
 - Disable textures
 - Apply DXT compression
 - Downscale textures

Texture Management

• Layer Properties → GlobeDisplay



DXT compression

Texture downscaling

Disable textures

Using Multiple Representations

- Feature data in ArcGlobe has only one level of detail
- If you have large number of features then
 - Create multiple representations of your data
 - Use GP tools in ArcToolbox
 - Use texture management techniques
 - Use different visibility ranges

Far
(less detail)



Near
(more detail)



Using Multiple Representations

Example: Multiple representations for buildings

- Aggregated building footprints
- Individual building footprints
- Extruded footprints
- Buildings without textures
- Buildings with downscaled textures
- Buildings with full resolution textures

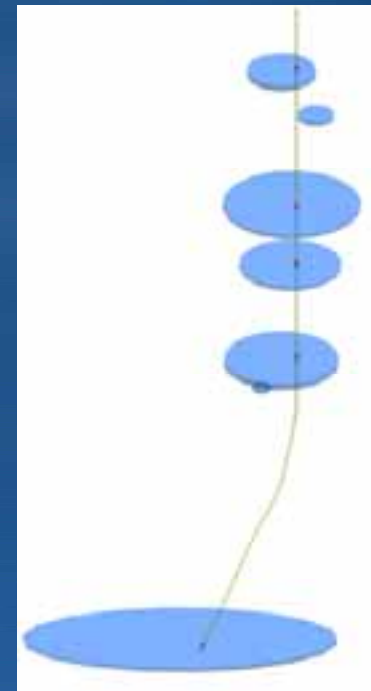
Coarsest



Finest

3D Analysis

- Analysis in 3D space
 - Does a proposed building:
 - Impact the city skyline?
 - Limit views against existing buildings?
 - Enter within a protected 3D zone?
 - Within my buildings, can I:
 - Plan evacuation routes, and direct emergency response?
 - Investigate and optimize my space allocation?
 - For my 3D wells:
 - Where do they intersect underground 3D volumes?
 - How long are they?



Demo 3: 3D Analysis

Serving the 3D View: Publishing to ArcGIS Server

- Publish the ArcGlobe document as a GlobeService
- Supports Local-area (LAN) and Web-based access
- Consume in ArcGIS Explorer, ArcGlobe, Globe Control
- All ArcGlobe supported data types can be served
- Supports Identify and Searching of features
- Animation is also supported

Demo 4: Publishing 3D Content

Demo 5: The Road Ahead

ESRI Technical Papers

- For detailed information on which GP tools to use and how to optimize your ArcGlobe document please see:

<http://support.esri.com/index.cfm?fa=knowledgebase.documentation.viewDoc&PID=54&MetaID=1298>

- The Multipatch Geometry

http://downloads2.esri.com/support/whitepapers/ao_/J9749_MultiPatch_Geometry_Type.pdf

- Source Code and Sample for Virtual City 3D Generator

<http://arcscripts.esri.com/details.asp?dbid=15516>