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Techniques for Consuming 3D Textured Objects in ArcGlobe™ and ArcScene™

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Overview

ArcGlobe™ and ArcScene™, the two applications provided with the 3D Analyst™ extension, can be used to consume three-dimensional textured objects (like buildings, bridges, etc.) and create realistic-looking 3D scenes. This document lists and explains some of the techniques that can be used for the effective consumption and display of three-dimensional textured objects inside ArcGlobe and ArcScene.

3D Textured Objects

Three-dimensional textured objects are stored as multipatch features inside ArcGIS® and can be used to create realistic-looking 3D scenes. A 3D textured object consists of 3D geometry (multipatch) and texture (image) information for each of its displayed faces. Examples of 3D textured objects include buildings, trees, bridges, and cars.

There are three ways of creating textured multipatch data in ArcGIS:

- Use the Import 3D Files geoprocessing tool (ArcToolbox→3D Analyst Tools→From File) to create a multipatch feature class from 3D Studio Max, SketchUp, VRML, GeoVRML, or OpenFlight files. With ArcGIS 9.3, there will also be the option to import COLLADA files.

- Apply 3D symbology to your point data, then use the Layer 3D to Feature Class geoprocessing tool (ArcToolbox→3D Analyst Tools→Conversion) to create a multipatch feature class.

- Use ArcObjects™ code. The sample code below shows how to create textured multipatch geometry that resembles a vertical polygon:

```
//Prepare the geometry material list
ESRI.ArcGIS.Analyst3D.IGeometryMaterial pTexture = new
ESRI.ArcGIS.Analyst3D.GeometryMaterialClass();
pTexture.TextureImage = "C:\\temp\\theImage.bmp";
ESRI.ArcGIS.Analyst3D.IGeometryMaterialList pMaterialList =
new ESRI.ArcGIS.Analyst3D.GeometryMaterialListClass();
pMaterialList.AddMaterial(pTexture);
//Create textured multipatch
ESRI.ArcGIS.Analyst3D.IGeneralMultiPatchCreator pMPCreator =
new ESRI.ArcGIS.Analyst3D.GeneralMultiPatchCreatorClass();
pMPCreator.Init(4, 1, false, false, false, 4,
pMaterialList);
//Set texture coordinates for a panel
ESRI.ArcGIS.esriSystem.WKSPoint pTxLL, pTxLR, pTxUL, pTxUR;
pTxUL.X = 0;
pTxUL.Y = 0;
pTxUR.X = 1;
```

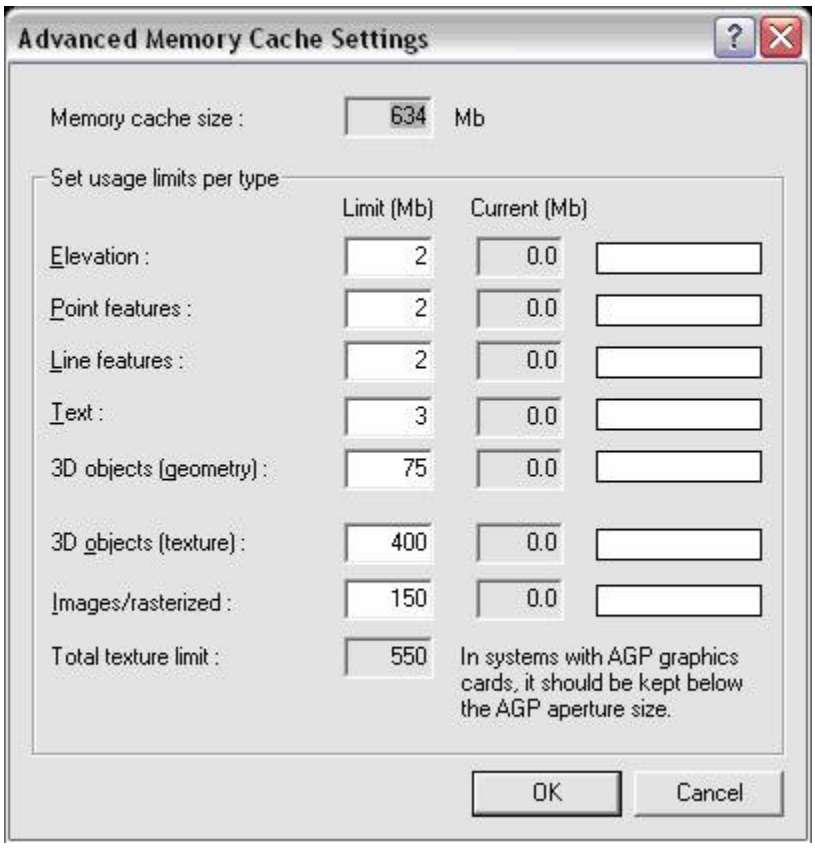
```
pTxUR.Y = 0;
pTxLL.X = 0;
pTxLL.Y = 1;
pTxLR.X = 1;
pTxLR.Y = 1;
ESRI.ArcGIS.esriSystem.WKSPointZ pUL, pUR, pLL, pLR;
pUL.X = 0;
pUL.Y = 0;
pUL.Z = 100;
pUR.X = 200;
pUR.Y = 0;
pUR.Z = 100;
pLL.X = 0;
pLL.Y = 0;
pLL.Z = 0;
pLR.X = 200;
pLR.Y = 0;
pLR.Z = 0;
//Set up part
pMPCreator.SetPatchType(0,
esriPatchType.esriPatchTypeTriangleStrip);
pMPCreator.SetMaterialIndex(0, 0);
pMPCreator.SetPatchPointIndex(0, 0);
pMPCreator.SetPatchTexturePointIndex(0, 0);
//Set real world points
pMPCreator.SetWKSPointZ(0, ref pUR);
pMPCreator.SetWKSPointZ(1, ref pLR);
pMPCreator.SetWKSPointZ(2, ref pUL);
pMPCreator.SetWKSPointZ(3, ref pLL);
//Set texture points
pMPCreator.SetTextureWKSPoint(0, ref pTxUR);
pMPCreator.SetTextureWKSPoint(1, ref pTxLR);
pMPCreator.SetTextureWKSPoint(2, ref pTxUL);
pMPCreator.SetTextureWKSPoint(3, ref pTxLL);
ESRI.ArcGIS.Geometry.IMultiPatch pPatch =
pMPCreator.CreateMultiPatch() as
ESRI.ArcGIS.Geometry.IMultiPatch;
```

Memory Cache Settings in ArcGlobe

One of the first things to check before adding large data to your ArcGlobe document is whether you have appropriate memory cache settings.

Memory caching in ArcGlobe refers to assigning an amount of the computer's RAM for use by ArcGlobe. The memory can be assigned by data type on the Advanced Memory Cache Settings dialog box (figure 1).

Figure 1
Memory Cache Settings in ArcGlobe



The advantage of this per-type memory assignment is that when you have a large number of 3D textured objects in your ArcGlobe document, you can set higher memory limits for the 3D objects (geometry) and 3D objects (texture) fields. This increase in memory allocation can significantly improve the performance of your ArcGlobe document.

So as a general rule, when working with 3D objects in ArcGlobe, make sure that you have allocated enough memory for 3D objects on the Advanced Memory Cache Settings dialog box.

To determine the memory requirements for your multipatch geometry and textures

1. Open ArcGlobe and set high values for the 3D objects (geometry) and 3D objects (texture) fields on the Advanced Memory Cache Settings dialog box (Tools→Options→Cache→Advanced).

2. Add your multipatch data to ArcGlobe and zoom to the layer.

3. Go to the Advanced Memory Cache Settings dialog box and see the current memory usage for 3D object geometry and textures—this should give you a fair idea as to how memory hungry your data is. Please note that this is only an approximate usage

and not the total memory usage for your data. The current memory usage value may increase once you navigate in and around the data.

4. Increase or decrease the settings based on the results from step 3.

5. It is recommended that the total memory usage be kept below the available physical memory, so there is a limit to which the memory settings can be increased. If the memory requirements for your data seem to be more than what your machine has to offer, then specify the maximum settings possible and use the techniques described later in this paper to work with your data.

Also note that the advanced memory cache settings are application-level settings and will affect any future ArcGlobe documents that you work with.

Texture Management

Textures on a three-dimensional object can potentially be very memory intensive and can affect the performance of your ArcGlobe document. If you have a large number of 3D objects with high-resolution textures in your 3D document, then the data can take longer to display and the navigation can be sluggish. This degradation in performance depends on the available physical memory and, for ArcGlobe, also on the memory cache settings.

ArcGlobe and ArcScene provide options via the user interface for texture manipulation of 3D objects. These options allow you to balance display quality and performance.

Disable textures—If your goal is to quickly view the data's extent and geometry, then you can disable the textures for your 3D objects. This will display the multipatch geometry as faces without any image textures, freeing up memory for interactive navigation.

In ArcGlobe, to disable textures for a 3D textured feature layer, check the Disable material textures check box on the Globe Display tab of the Layer Properties dialog box (figure 2).

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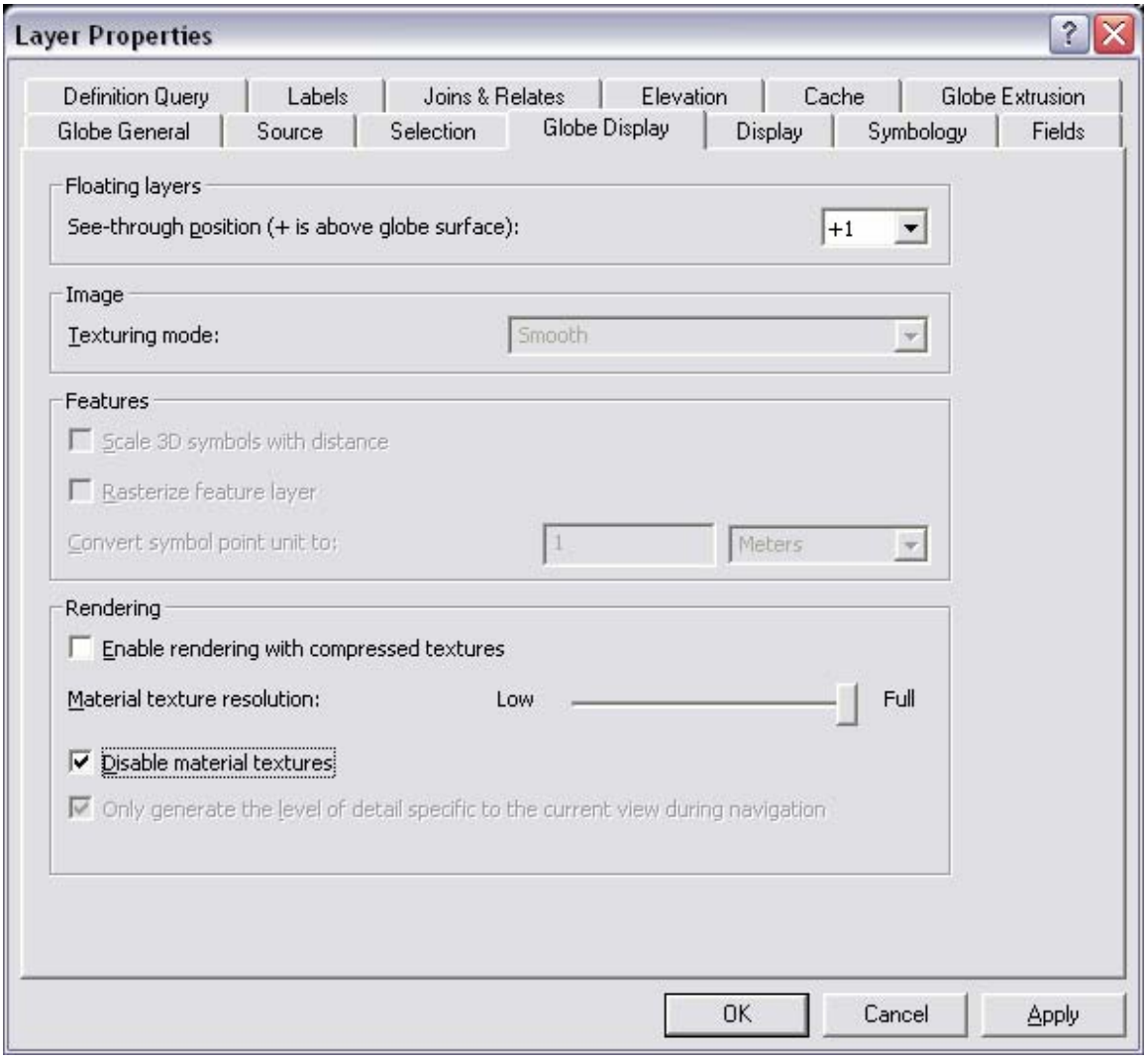
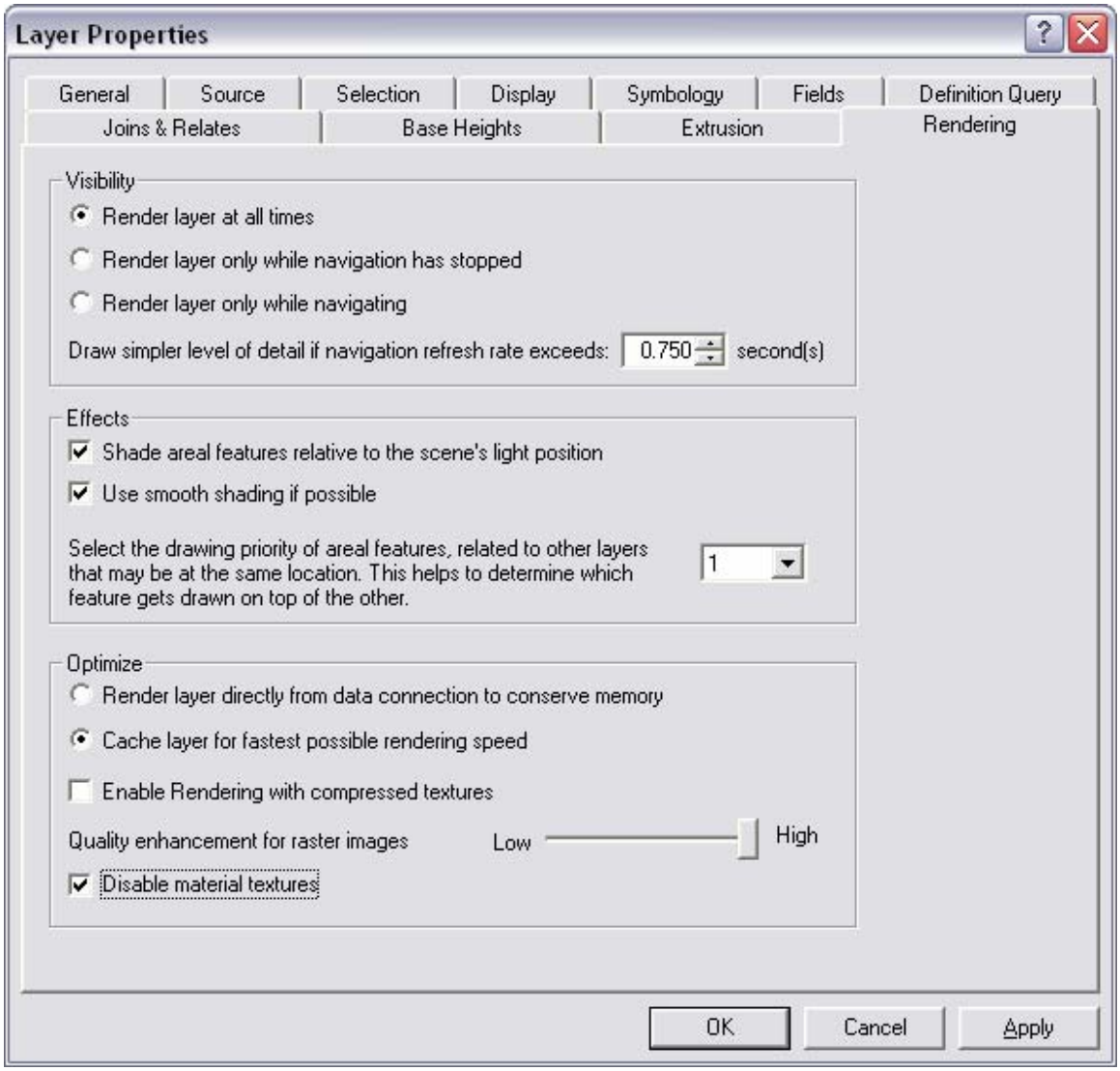
Figure 2
Disabling Material Textures in ArcGlobe



In ArcScene, to disable textures for a 3D textured feature layer, check the Disable material textures check box on the Rendering tab of the Layer Properties dialog box (figure 3).

Figure 3
Disabling Material Textures in ArcScene



NOTE: You can still set the color of the 3D objects. For example, when textures are disabled, it can be useful to show buildings with thematic colors.

Texture downscaling—In case you need to see some texturing detail but still need a boost to performance, the solution is to downscale the textures. Texture downscaling improves performance by reducing the resolution of textures, thereby freeing up memory resources. The amount of performance boost you get depends on the amount of downscaling applied.

In ArcGlobe, the downscale textures option is exposed via the Material texture resolution slider on the Globe Display tab of the Layer Properties dialog box (figure 2). To

downscale textures, drag the slider to the left. You can use a trial-and-error approach to determine the downscale level that best suits your requirements.

In ArcScene, use the Quality enhancement for raster images slider (figure 3) to downscale textures.

TIP: In ArcGlobe, you can see how much memory was gained with texture downscaling by comparing the current memory usage on the Advanced Memory Cache Settings dialog box before and after enabling texture downscaling.

Texture compression—You can also apply DirectX Texture (DXT) compression to the textures of a 3D textured object in ArcGlobe and ArcScene. DXT compression will compress the texture image for optimum use with your graphics card. There will be a small drop in texture resolution, but the interactive performance of the application will increase.

In ArcGlobe, DXT compression can be applied by checking the Enable rendering with compressed textures check box on the Globe Display tab of the Layer Properties dialog box (figure 2). In ArcScene, the option is available on the Rendering tab (figure 3).

Using Multiple Representations

If the above-mentioned texture management techniques, or their combination, are not enough to improve performance to an adequate level, then you should also investigate the use of multiple representations of your data. This may occur if your dataset is very large or if your textures have high resolution.

The idea is to create different representations of the data that go from coarse to finest/actual level of detail for your 3D textured objects. When the observer is farther away from the data, then there is no need to burden the system with the task of displaying all the individual features with the highest-resolution textures, because these details won't be visible to the observer. At this distance, a coarser representation of the study area can be used. However, as the observer zooms in closer to the study area, finer representations of the data can be used to show greater detail.

Multiple representations for 3D textured objects are not created automatically by the system but have to be created as a data preprocessing step. Also, the decision to show what details at what distance will vary between datasets and display requirements.

The following section describes, as an example, the process of creating multiple representations of 3D textured buildings for a city and consuming them in ArcGlobe. The steps described in the case study below can be used for other 3D textured objects as well.

Scenario: Creating and displaying multiple representations of 3D textured buildings in ArcGlobe

In this example, assume that you have 3D textured building data for a city and that your dataset is large.

To effectively consume this data inside ArcGlobe, you will create various representations of the data by using the geoprocessing tools available in ArcToolbox™ together with the texture manipulation techniques described earlier in this paper. You will also make use of

visibility distance thresholds to display different representations of the data at different zoom levels.

Step 1. Decide the number of representations to support—Before creating multiple representations for your data, you need to determine how many different levels of detail you require. In our example of 3D buildings, we have decided to support the following six representations (from coarsest to finest):

1. Aggregated building footprints (coarsest)
2. Individual building footprints
3. Building footprints extruded to their true heights
4. Buildings without textures
5. Buildings with downscaled textures
6. Buildings with full-resolution textures (finest)

The number of representations depends mainly on the range of distance where you want the data to be visible. You should choose the representations such that your scene looks realistic. For example, if you don't want the data to be visible beyond a distance of 3 km, then your coarsest representation should probably be Buildings without textures.

Also keep in mind that you will need to maintain each representation as data, layer properties, or both, so keep the number at a manageable level. For example, more than 10 representations may be too many.

Step 2. Create derivative data from the multipatch features—To support the level 2 and 3 representations, we need the 2D footprints of our multipatch buildings. Calculate these by using the Multipatch Footprint geoprocessing tool (this tool can be found in ArcToolbox under 3D Analyst Tools→Conversion→From Feature Class).

The tool takes as input your multipatch (3D textured objects) feature class and outputs a feature class containing the footprints (polygons) of the individual multipatch features.

When you are zoomed out far from your study area, the buildings will be visible to you only as a blob, and you won't be able to distinguish between individual features. At this zoom level, you can safely show just the aggregated building footprint polygons, which we have identified as our level 1 representation.

To support this representation, use the Aggregate Polygons geoprocessing tool (this tool can be found in ArcToolbox under Data Management Tools→Generalization). Use the building footprints created above as the input and specify how you want the aggregation to be done.

Step 3. Define the ArcGlobe document properties—Before you start adding data to the ArcGlobe document

1. You should have appropriate memory cache settings as described earlier in this paper.

2. Choose the option to make newly added layers invisible by default (Tools→Options→General) as the layers have to be configured so that they don't overwhelm the system.

Step 4. Add data into ArcGlobe—As you begin adding layers to the globe document, you will be prompted via the Add Data wizard to set the following two properties for each layer:

1. Typical Scale—Choose the optimum level of detail for the layer. You should use the same level-of-detail setting for all the layers so that the tile sizes match between the layers representing your buildings.

2. Visibility Range—Specify the visibility distance range for each layer with the coarser representations visible at larger distances and more detailed representations becoming visible as you move closer to the study area. Please note that the visibility range settings specified for the layers in this example do not represent the ranges that you need to set for your data. Your values can be different.

If you don't have the Add Data wizard enabled, you can do so via the Tools→Options→Messages tab.

NOTE: You can also turn on the option to Check visibility based on each tile distance for a layer so as to not render the features in the layer that are farther away from the observer. This option is available on the Globe General tab of the Layer Properties dialog box.

In our example, we would add the data as follows:

- **Aggregated building footprints—**Add the Aggregated building footprints feature class (created in step 2) to ArcGlobe. In our example, the level of detail selected is Buildings and the Visibility range is 7 km to 25 km.

- **Individual building footprints—**Add the Individual building footprints feature class (created in step 2) to ArcGlobe. In our example, the level of detail selected is Buildings and the Visibility range is 5 km to 7 km.

- **Building footprints extruded to their true heights—**Again add the Individual building footprints feature class to ArcGlobe. In our example, the level of detail selected is Buildings and the Visibility range is 3 km to 5 km.

  Next, extrude the features in this layer to their true heights (Layer Properties→Globe Extrusion). Also, check the option to not draw the bottom face of the extruded polygons.

- **Buildings without textures—**Add your 3D textured buildings feature layer. In our example, the level of detail selected is Buildings and the Visibility range is 2 km to 3 km.

For this layer, disable the textures so that you only have the true building geometry (as opposed to the simple extrusion applied to the building footprints in the above step). Refer to the Texture Management section to see how you can disable textures.

- **Buildings with downscaled textures—**Add your 3D textured buildings feature layer. In our example, the level of detail selected is Buildings and the Visibility range is 1 km to 2 km.

  Apply a combination of both texture downscaling and texture compression to this representation. Refer to the Texture Management section to see how you can apply texture compression and texture downscaling.

  For this layer, apply maximum texture downscaling (move the slider to the far left).

- **Buildings with full-resolution textures—**Add your 3D textured buildings feature layer. In our example, the level of detail selected is Buildings and the Visibility range is 0 km to 1 km.

  This is going to be your highest-resolution representation. Note that in some cases, you may again apply texture compression and texture downscaling if your data is particularly memory intensive. The amount of texture downscaling that you apply should be less than what was applied for the layer in the above step.

Step 5. Generate full data caches—Generate full data caches for all your vector feature layers (the layers added in step 4) by right-clicking each layer in the table of contents and clicking the Generate Data Cache option. Having a cache prebuilt for a layer will improve its interactive performance.

Step 6. Group the representations together—Select all the representation layers of your 3D textured buildings, right-click the selection, then create a group layer. Having a group layer gives you the ability to turn on/off your 3D textured buildings as a single unit, regardless of the current representation being displayed.

Step 7. Test the display—Turn on all the child layers of the group layer and navigate around.

Once you start interacting with the data, if the performance or display quality is not what you require, you may have to tweak the settings you made. For example, you may have to increase the memory allocations for the 3D objects, apply more texture downscaling to your highest level-of-detail representation, or move the visibility ranges.

Conversely, if the globe document is performing well with your initial settings, you might consider decreasing the amount of texture downscaling applied to your high level-of-detail representations to get better display quality.

In either case, with some experimentation, you can find the optimum settings for displaying your data with the best display quality and performance.

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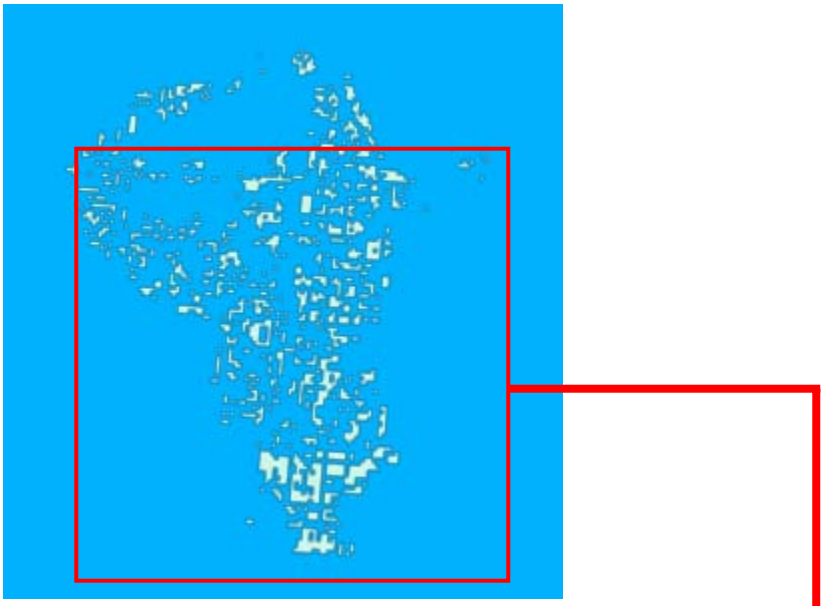

Representation 1—Aggregated Building Footprints

Representation 2—Individual Building Footprints

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Representation 3—Building Footprints Extruded to Their True Heights

Representation 4—Buildings without Textures

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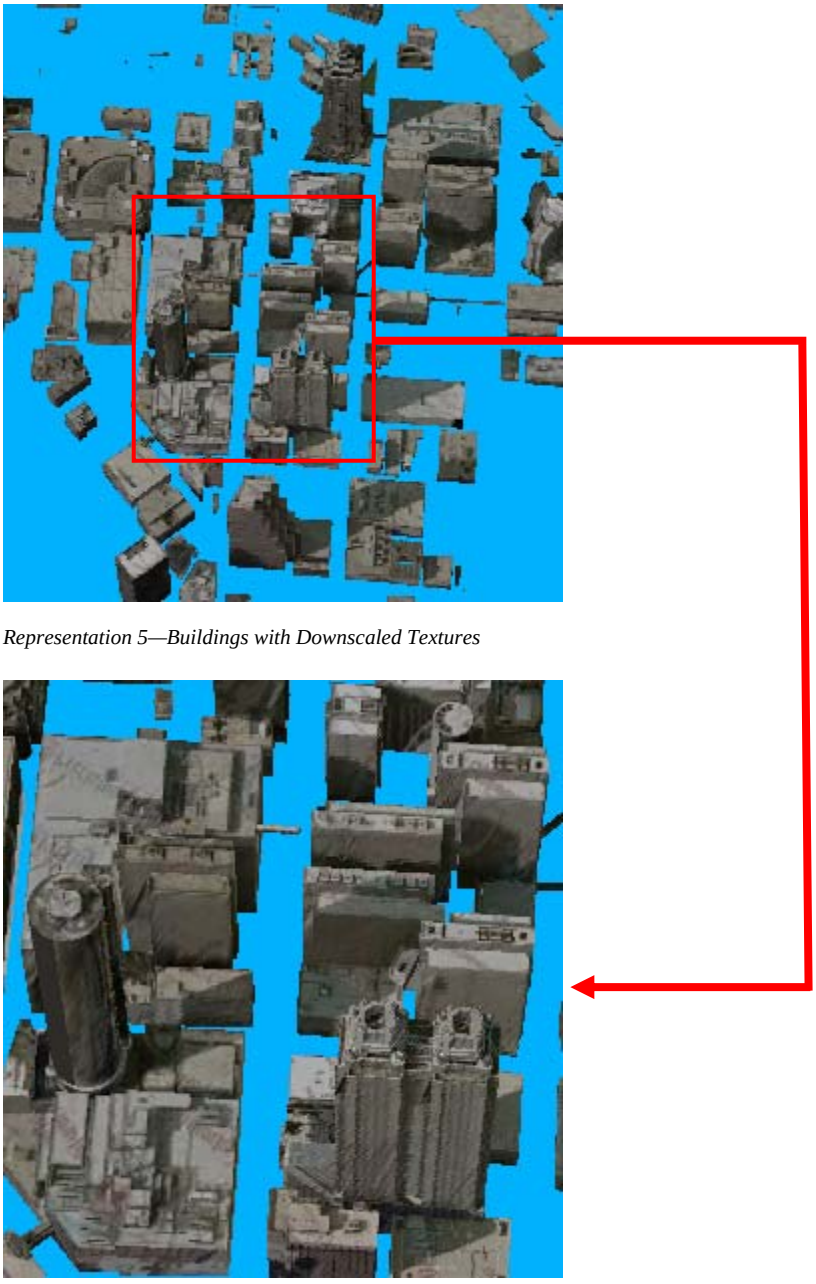

Representation 5—Buildings with Downscaled Textures

Representation 6—Buildings with Full-Resolution Textures

Summary

- Specify appropriate memory cache settings before consuming 3D textured objects inside ArcGlobe.
- Remember that memory cache settings are application-level settings and will affect any future ArcGlobe documents that you work with.

- Since textures on 3D objects can be very memory intensive, make use of the texture manipulation techniques like disabling textures, texture compression, and texture downscaling, as needed.

- You can use geoprocessing tools along with the texture manipulation options and visibility distance thresholds to create multiple representations for your 3D textured objects.

- The number of representations you create for your 3D textured objects feature layer depends on the range of distance in which you want your data to be visible and also on how memory intensive the geometry and textures are.

- Consuming the same 3D object feature layer (with different texture options) *n* times means that the total geometry memory requirement would be *n* times the geometry memory requirement for a single layer. So if the geometry is complex, you may have to reduce the number of representations because of memory constraints.

- For texture downscaling, start with the highest downscale level (far left on the slider bar), then move to the right to determine the best settings for your data.

- In ArcGlobe, generate full data cache for your vector feature layers before turning on the layers.

- Group the layers depicting multiple representations.