Visibility Analysis / 3D Visualization Lab
Lab Guide and Technical notes

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OBJECTIVES

This lab aims to introduce you to basic concepts and techniques associated with visibility analyses and 3D visualization and their applications for those teams whose operations are in Visually Sensitive Areas. Using ArcGis 10.1 you will be able to:

1. Create a **3D TIN** (Triangulated Irregular Network) surface using digital elevation data
2. Create a **3D Raster** or **GRID**
3. Conduct a **Line of Sight** Analysis
4. Conduct a **Viewshed Analysis** from a defined viewpoint
5. Conduct a **Composite Viewshed Analysis** from multiple viewpoints
6. Use **ArcScene** to display and interactively explore the TIN model
7. **Import and Geo-reference** high resolution **Google Earth Pro Image**
8. Assign **Random trees** to surface
9. Determine the visual influence of your proposed harvest plan by visual design (shape, pattern); scale by percent alteration in **Visually Sensitive Units (VSUs)** or landform
10. Learn from visualization results to **improve plan** if required
11. Provide an **easy-to-understand interpretation** of your plan through visualization to **inform and receive response from your client and the general public**.

Build an ArcMap Project using your Team's GIS data:

Start ArcGis ArcMap and Load the 3D Analyst Extension

1. From the ***Start*** menu, go to ***Programs, ArcGis*** (alternatively, ArcGis may be located within the ***Esri*** directory under **Programs**) and open ***ArcMap.***

2. When the ArcGis window opens select ***a new empty map*. Give it a "save-as" name preferably on the "U" drive for permanence and accessibility provided there is not too much demand by multiple users, or a place where all the team can access.**

3. In **ArcCatalogue**, Under the file folder for the project, create a **Geodatabase**. Add all of your data as **Feature Classes** into the same **Geodatabase** for ease of access and consistency in geographic projection in **ArcCatalog**. Right-click on each of your Feature Classes and check properties to see that each have a projection assigned.

4. In ArcMap, use the add data "plus sign" icon and go to your GIS data folder. Select the shapefiles for your ***topography, water bodies, streams, forest cover, and view points (if any)*** files***.*** Click Ok. An ArcMap alert may appear (*one or more layers is missing spatial reference information*). Disregard and click OK. The data will appear in your Map window, and will be listed in **Table of Contents** (TOC). If the TOC isn't visible, it can be opened by finding it listed in the "Windows" dropdown.

5. If you have not already done so, build a clip box (bounding box) polygon giving if sufficient size to cover your Area of Interest (AOI) including surrounding landscape to height of land, and potential viewpoints. Clip all of your data to fit within this box. Use the **Windows | Search** to enable the **Search Box** on the right side of the ArcMap frame. Do a **Local Search** for **Clip Features**. This should allow you to open **Arc Toolbox | Analysis Tools | Extract | Clip** and enter your feature classes one by one. Remember: this Search Utility is the fastest way to open the right tool in the Toolbox for the required purpose.

6. The layer colours and symbols may be changed if desired. **To change layer colours**, place your cursor over the coloured square for the polygon **Feature Class** in the TOC and right click. A colour palette will appear. Choose a colour. Do the same for the contour data. **To change the layer symbol**, place the cursor over the View_points symbol in the TOC and left-click. A dialogue box opens that allows you to change the layer's symbol, colour and size.

7. To create a new **Feature Class** such as your cutblocks or viewpoints, go to **Toolbox | Data Management | Feature Class | Create Feature Class | Name** | and enter location, name, type (use dropdown). Alternatively go to the **Catalog**, right-click the current project folder | **New | Shapefile** and create as before.

8. Ensure the ***3D Analyst Extension*** is enabled by right-click on the empty area of the tool icon bar and check **3D Analyst.** 3D Analyst is now ready for use.

9. Go to **File** / **Save,** name your project and save it to your **FRST424GISVizLab** folder (remember to save your work periodically as the lab progresses).

EXERCISE 1:Create A 3D TIN Model from Contour Information

1. Click on "***3D Analyst Tools" in the ArcToolbox*** . Double-Click on "**Data Management**" then on "**TIN**"

2. Double-click on "**Create TIN**".

3. When the ***Create TIN*** window appears find the **topography** Feature Class. Ensure the ***Height Field*** is set to ***ELEVATION*** and ***Output TIN*** (top of the Window) directs to your **Project Folder. You can create subfolders if you wish to keep organized.** Click OK.

Use the “soft line” **SF Type** in the “SF Type” dropdown box. This surface Feature type allows the hard line breaks of the contours to be softened somewhat during triangulation. **Note:** the preferred method is to use DEM points and break lines instead of contours to produce the TIN, with a more accurate surface, but may not be available,
Coordinate System is Optional, but click on the drop down and click on the coordinate system that you know your contour data to be in by right-clicking the layer name in the TOC and checking **Properties** then **Source**.

The **Catalog** that can be opened from the **Windows** dropdown will also have this information. It may be a good idea to save the most common projections in your database your **Add to Favourites (star)** shown at the top of the shapefile properties.

4. Press OK and your TIN should appear in your map. Check that the elevations appear to be in the correct range.

EXERCISE 2: Define Visible Extent

The purpose of this part of the Lab is to introduce the different 3D analyses and information that can be derived from your 3D surface model. You can construct both Line of Sight (LOS) and Viewshed analyses from different viewpoints.

2.1 Line of Sight (LOS)

A line of sight is a graphic line between two points on a surface illustrating those segments of the line that are visible / not visible as viewed from a specified viewpoint. The Line of Sight Tool is found on the 3D Analyst toolbar in ArcMap. This can be enabled by right-clicking in the open space at the top of the screen adjacent to the other icons and checking 3DAnalyst,

1. In ArcMap click the Line of Sight button on the 3D Analyst toolbar
2. Set an Observer offset (e.g. height of viewer above the surface)
3. Type a Target Offset (e.g. the height of the target above the surface)

4. Click on the viewpoint in your map and then locate and click the target location
5. Create several lines to assess the visible extent of the terrain from the viewpoint

The Graphic LOS's may be difficult to delete once the project is saved, so delete them once you have understood them. LOS is also under the **Visibilit**y tab of the Toolbox under 3D Analyst. That procedure would provide a more formal approach with pre-drawn lines

2.2 Viewshed Analysis

The Viewshed tool allows you to define the visible extent of an area as seen from a defined viewpoint.

To create a Viewshed map first convert your **TIN to a RASTER** in the **toolbox | 3D Analyst Tools | Conversion | From Tin** and double-click to open and select **TIN to Raster** and double-click. Enter your TIN and create an output filename. Under the Sampling Distance dropdown select **CELLSIZE**. The default is 10m resolution. You can try 20m for a coarser but speedier Raster but 10m might be best depending on the size of your AOI. Its handy to use the resolution as part of the filename for the raster. When finished, the raster will appear as a cloud-like black-and-white form on your map. You can change to a colour gradient by right-click on its name in the TOC and selecting **Properties | Stretched** and selecting from the **Color Ramp** dropdown. Elevations can be checked by clicking on the identification button with and "i" inside a blue circle and touching any area of the Raster with your mouse and left-click. The pixel value is the elevation. Identification may pick up other attributes first, so you may have to turn them off.

To create the viewshed:

1. In ArcMap, click ***3D Analyst***, point to ***Visibility*** dropdown and click ***Viewshed***

2. Add the Raster surface you just created

3. Select the viewpoints shapefile that you created. If you already have more than one viewpoint, select just one of them in the attribute table to produce a viewshed from that single point. You will produce a multiple viewpoint composite viewshed after setting viewer height next.

4. Select the "Frequency" default analysis type (but this is optional)

5. Specify a name for the output file and save it in your working directory

6. Click OK. The viewshed map will appear on your map. The visible area will show as green and non-visible as red. You can turn off the non-visible area colour by giving it "no colour".

7. For more surface definition, you can easily add a **Hillshade**. Go to **3dAnalyst | Surface Analyst | Hillshade** and use the same input raster.

8. Adjust the observer's height at the viewpoint to consider the observer's height. The current observer height is at surface level. To adjust observer height, proceed through the next set of steps:
    a) Open **ArcCatalog**, go to your current project folder.

    b) Click **File | New | Shapefile** and name a new file Viewpoint_Z or something similar to remind you that it has height values, or "Z" values. Feature Type: Point.

    c) Add Viewpoint_Z to your Map. Before opening the editor, open the Feature Class's attribute table by right clicking on the name. Click on the **Options** dropdown and create a short integer numeric field named "**OFFSETA**". This name must be precise as it triggers a hidden program in 3D Analyst.

d) Click on **Editor | Start Editing**, highlight the folder containing Viewpoint_Z, or right-click on the Feature Class and select **Edit Features**. You will need to open the **Create Features box** with the far right icon **in the upper bar, click on the feature class and click on "point"**

e) With editor still open, open the Viewpoint_Z attribute table by right-clicking on the name, and change the **OFFSETA** for your viewpoint to 2 metres (observer's height is conventionally 2 metres, but, depending on circumstances, it may be greater, such as from the deck of a cruise ship).

f) You can add additional fields as described in the "discussion forum" link in the ArcGIS help. Search for "viewshed observer offset". One of these is "SPOT" if you want the viewpoints to have an actual elevation rather than an offset from the underlying surface. You can assign "OFFSETB" to describe the elevations of objects to be observed from each point, such as transmission towers, smokestacks, or wind turbines. Be sure to name the fields exactly as provided in the discussion.

2.3 Create Viewsheds from Multiple Viewpoints

Viewsheds typically illustrate the visible extent of a landscape as viewed from multiple viewpoints. In this part of the exercise you will repeat the process above but edit the existing Viewpoints theme and add additional viewpoints to produce a **Composite or Cumulative Viewshed**. Once classified, the **Cumulative Viewshed** becomes a **Times Seen Map** that can indicate greater or lesser viewing vulnerability by the number of times an area is seen from the viewpoints.

Edit the Viewpoints Feature Class

To add other viewpoints you must either edit the new viewpoint file that you created or to your original viewpoints shapefile. For this exercise, use the existing feature class:

1. If the Editor is not already on the Toolbar, right click on any empty grey area of the Toolbar and click on **Editor** to load it
2. Right-click on your viewpoints' Feature class in the TOC and Click on **Edit Features | Start Editing**. A **Create Features** box should open. If not, click on the far right **Create Features Icon** in the toolbar.
3. Click on your viewpoints name in the box and then points to start editing. Place as many viewpoints as might be needed to provide sufficient viewing coverage of the area of interest.
4. When finished, click the **Editor | Stop Editing | Save Edits.**

2.4 Create a New Viewshed Based on Multiple Viewpoints

- Repeat the steps above to create a new Viewshed based on your revised Viewpoints feature class with the observer height added.
- Compare the two Viewshed maps you have created.

EXERCISE 3: VISUALIZE AND EXPLORE 3D INFORMATION

Explore 3D Information in ArcScene
Now that you have created a TIN model and the Raster surface, you can load them into **ArcGis ArcScene** to view and interactively explore them from different perspectives. In the following exercises you will learn how to change the viewing properties of a scene, navigate through the scene and add additional data to aid in orientation / analysis.

3.1 Start ArcScene and Loading 3D Terrain Data

1. Start **ArcScene** from **ArcMap** (the icon is situated on the ArcMap toolbar or in the 3DAnalyst toolbar that you may have opened when doing the sightlines).

2. An empty **ArcScene** view will appear on your screen. Click the Add data icon on the upper toolbar, select your TIN and/or Raster file and click OK. You will find the Raster to be more useful when adding forest cover heights for a truer representation of a forested surface or when adding a major water body as a terrain feature with an assigned elevation (topo usually only goes down to 20m elevation on the coast).

3. A legend for the surface model will appear in the margin on the left side of your screen. The TIN and/or Raster will appear in your viewer. If they appear flat they need the **Base Heights** to be directed to each of their file names. Right-click the **filename | Properties | Base Heights** and enter.

3.2 Change 3D View / Scene Properties

Change the appearance of the 3D scene in several ways.

1. Change the colour of the TIN or Raster by right-click on either filename in the **legend | Layer Properties | Symbology**

2. Disable the contour lines in the TIN by right-clicking on the **TIN name**, opening **Properties** and unchecking **Edge Type**.

3. Change the viewing angle, observer position and elevation by navigating to the **View | View Settings** on the upper **ArcScene Toolbar**. If you get lost, just press the **Full Extent** button.

4. Add a **North Directional Arrow** to keep you oriented.

5. Change to **orthographic** (map view) from **perspective** (camera) **view**.

6. Interactively change the **illumination of the scene** by opening **View | Scene Properties** and changing the **azimuth** and angle of the **illumination source**. This will change "on the fly" in the 3D scene as you change the settings.

Spend some time experimenting with these and explore how they influence the legibility / appearance of the scene.

3.3 Interactively Explore the 3D Model

View the 3D scene through as through a camera which is represented by the **bird** which can either be **flying with wings open or settled with wings closed**. The location of the bird is a function of the **observer position**. The point where a "camera" is aimed is referenced as the **target**.

2. Vary the camera / observer settings using the ***Navigate***, ***Fly, Zoom to Target, Centre on Target, Set Observer, Narrow / Expand Field of View*** tools on the ArcScene / 3D Analyst Toolbar.

2. Use the Navigate button to move and spin the model along its horizontal and vertical axes while clicking and holding the left mouse button (When using Navigate, you can zoom in or out by holding the right mouse button down while moving the mouse forward or backward). You can change the pivot point about which the model rotates by using the Centre on Target tool.

3. Flying Tips: Fine-tune the **fly speed** In between mouse clicks, press arrow up or down to increase or decrease speed, respectively.

4. **Look up or down while flying.** Press Shift while flying to maintain a constant elevation. You can then point the mouse up or down to look in those directions without changing the direction of travel.

5. Zoom in or out of the model in small increments by using the ***Narrow/ Expand Field of View*** arrows on your keyboard. The **Full Extent (Earth Icon) will return you to a full view of the model.**

6. Use the **Fly** button to interactively explore the model. You can fly the bird in any direction and move backward or forwards at different speeds. Click the left mouse button to move forward – Right click to reverse (the number of "clicks" incrementally increases / decreases the speed of travel). If you get lost, click the ***Full Extent*** **Icon** on the ArcScene Toolbar to restore the 3D scene. If you wish to stop and settle the bird, click the "***ESC***" button on your keyboard. You might quickly tire of this and want to settle permanently on a viewpoint (see 7).

7. **Use the Set Observer** and **Centre on Target** tools to view the model from a specified point. This is the more useful mode for analysis and assessment. Use the **Centre on Target** tool first to define where you want the camera to aim then, use **Set Observer** to define the camera position. The camera will then move to your selected viewpoint and point towards the target (you can change the elevation of the camera by modifying the Z value in ***View Settings***).

3.4 Visualize and Explore 2D Information in 3D Models

Add the Viewpoints to the Scene

1. In **ArcScene**, click the **Add Data Icon**, highlight your viewpoints layer, and click **Add**.

2. You won't be able to see the viewpoints because their current elevation are set to 0 metres. To bring the viewpoints into the scene, you will need to drape them onto the TIN or Raster surface. **Right click** on the layer in the ArcScene legend, to open the **Layer Properties,** select **Base Heights** tab. In **Elevation from Surfaces**, select **Floating on a custom surface**, click **the "Obtain heights for layer from surface"** button, and locate the appropriate surface in the dropdown.

3. **Click OK** -- The Viewpoints should now appear in your 3D scene.

4. Follow the same procedures to bring in a **water body** that may have important viewpoints, roads, **planned cutblocks.**

5. **Shapes don't show well on steep and varied terrain. You might just bring them in as outlines. Or Use the Extrude tab in the properties and raise them slightly above ground level. Another option is go to Arc Toolbox | Functional Surface | Interpolate Shape to interpolate z-values based on elevation from the terrain.**
6. You can also set **Layer Properties** | **Rendering** | **drawing priority** for your features - the higher number (1-10) will be drawn on top of lower numbers**.**

EXERCISE 4: Obtain and Geo-Reference High Resolution Google Pro Image

4.1 Select Corners in your GIS Model

1. **Enable the Clip Box that you made for your AOI in ArcMap**
2. **Create a Point Feature Class and place a point at all 4 corners.**

4.2 Open Google Earth Pro and locate your AOI (Approximately)

3. Assign A projection of UTM93-10 or other zone as required
4. **Upload your corner points to Google Earth Pro**
5. Change the **Resolution to Maximum**
6. Press the **save image box** and save the image to your project file

7. Right-click the file name in **Arc Catalog** and assign the correct **spatial reference** in Properties
8. Open it in your ArcMap and **Zoom to Layer. Note your 4 corner points.**
9. Open to Geo-referencing toolbar: **Customize | Toolbars | Geo-referencing**
10. Choose the layer that all the geo-referencing will apply to in the box.
11. Have both the **Google image with the uploaded corner points and the Arcmap Corner points that you made at each corner of the clip box ready.** Only one layer will be visible at a time so you will have to click back and forth and zoom to the layer.
12. Zoom to the Image
13. Press the add **Control Points icon in the Geo-referencing toolbar** and touch the upper left corner in the image. Each point will be assigned a number then a line showing the link in progress.
14. Zoom to the corner points file and click on the upper left corner point.
15. Proceed with all four corners
16. Open the link box with the link box icon to see all 4 points**.** Check that the newly Geo-registered Google Earth image is now in alignment with the rest of your data in your ArcMap project.

EXERCISE 5: Geo-Referenced High Resolution Google Pro Image into ArcScene

1. **Add the Geo-Ref. image to your ArcScene project**
2. **Base Heights**
3. **Examine your model from a ground viewpoint with Set Observer and target**
4. **Add your cutblocks**
5. **Bookmark the view and give it a name**

EXERCISE 6: Add Trees to Cutblock Edges in ArcScene

1. In **ArcScene**, Open 3D Graphics in **Customize | Toobars | 3D Graphics**
2. **Place points** around your cutblocks
3. Open **Symbol Selector**
4. Locate Type: **3D Marker Symbol**
5. **Style Reference Box**: - check **3D Trees**
6. **Select** (for example) Colorado Spruce 1
7. **Enter Size** (Z) to 30m, Colour: Bright Green
8. **OK**. Your trees will appear around each cutblock that you have added points to.
9. You can also assign random points along lines and within polygons back in ArcMap, Import to ArcScene and select the trees. This could apply to all of your forest cover polygons, for example, assigning 100 points per polygon, or 100 points along lines. To make points around a cutblock you would have to convert polygon to polyline. If applying to forest polygons, you would have to clear points away from you cutblock. **More details forthcoming**.

Using Exercise 6 to add trees of a given height allows you to consider the effect of tree screening in your model and determine the amount each block will be visible from each viewpoint. This will be beneficial when determining scale of openings relative to the VSU / landform. Save views from each viewpoint as jpegs.