# ENVI Tutorial: 3D SurfaceView and Fly-Through


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# 3D SurfaceView and Fly-Through

This tutorial uses Landsat Thematic Mapper (TM) data to demonstrate ENVI's 3D SurfaceView and fly-through capabilities. The 3D SurfaceView function allows you to overlay a gray scale or color-composite image over a digital elevation model (DEM), interactively change the 3D visualization, and create a 3D fly-through. The 3D SurfaceView function also provides limited analysis capabilities.

## Files Used in this Tutorial

ENVI Resource DVD: `Data\bh_3d`

| File | Description |
|---|---|
| `bhtmsat.img (.hdr)` | Landsat TM saturation-enhanced, RGB composite of Bighorn Basin, Wyoming |
| `bhdemsub.img (.hdr)` | USGS DEM at 30 m resolution |
| `bhdemsub.pat` | Fly-through path file |
| `bhdemsub.ann` | Fly-through path annotation file |

## 3D Visualization in ENVI

ENVI provides numerous tools for viewing and analyzing image data in two dimensions. The 3D SurfaceView tool is the first step toward extending data analysis into three dimensions.

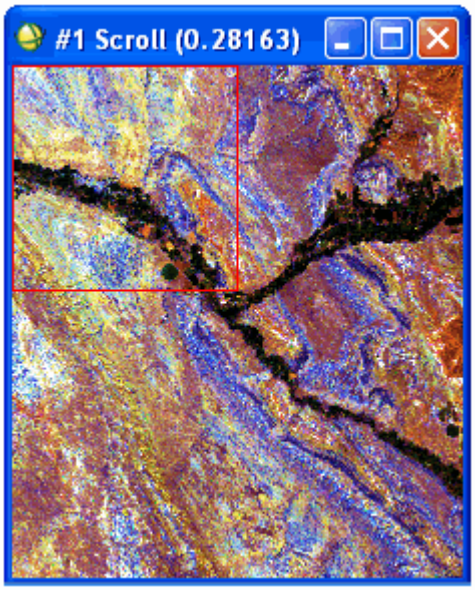
The 3D SurfaceView tool allows you to display a DEM as a wire frame, ruled grid or points, or with a gray scale or color image draped over it. You can rotate, translate, and zoom in or out of the 3D surface in real-time using the mouse. You can add each 3D view to a list to use later for animation. Use saved views, or interactively draw a flight path (using ENVI's annotation tool) to fly through the 3D data. You can set the vertical exaggeration, vertical and horizontal view angles, and altitude. The cursor is linked to the draped 3D image, allowing you to extract profiles in the X, Y, and Z (spectral) directions. You can also use the Cursor Location/Value tool in the 3D image.

# Load a 3D SurfaceView

If you are running ENVI on a Windows system, you must set the display to 24-bit color mode before starting ENVI.

## Open and Display Landsat TM Data

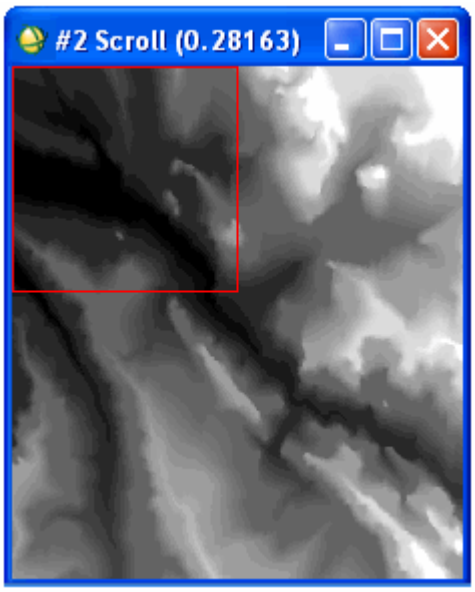
1. From the ENVI main menu bar, select **File > Open Image File**. An Enter Data Filenames dialog appears.
2. Navigate to `Data\bh_3d` and select `bhtmsat.img`. Click **Open**. ENVI automatically loads bands 1, 2, and 3 into a new display group. You can adjust the displayed contrast stretch by selecting **Enhance** from the Display group menu bar.




## Open and Display DEM as a Gray Scale Image

Displaying the associated DEM is not required, but it is recommended to ensure that you have a matched DEM/image pair.

1. From the ENVI main menu bar, select **File > Open Image File**. An Enter Data Filenames dialog appears.
2. Select `bhdemsub.img` and click **Open**. A gray scale image of the Bighorn DEM is automatically loaded to a new display group.




## Start 3D SurfaceView

1. From the ENVI main menu bar, select **Topographic > 3D SurfaceView**. A 3D SurfaceView: Select Input Display dialog appears.
2. Select **Display #1** and click **OK**. An Associated DEM Input File dialog appears.
3. Select **DEM Elevation** under `bhdemsub.img` and click **OK**. A 3D SurfaceView Input Parameters dialog appears.
4. Select the desired **DEM Resolution** (number of pixels) used for the 3D plot. The DEM will be resampled to the selected resolution. Using higher DEM resolutions will significantly slow the visualization and should only be used when sufficient computing power is available. You can select more than one resolution. Typically, you should use the lowest resolution (64) while you are determining the best flight path. Then, use a higher resolution to display your final fly-through sequence.
5. In the **DEM min plot value** field, enter **1219**. In the **DEM max plot value** field, enter **1707**. (You can always experiment with different values later if you find you need to cut out background pixels or limit the elevation range of the DEM.) DEM values lower than the minimum value and higher than the max value will not be plotted in the 3D view.
6. Set the **Vertical Exaggeration** field to **15**.
7. Select the **Full** radio button under **Image Resolution**. (If you select **Other**, the image is resampled to the number of pixels selected for the DEM.)
8. Click **OK** to start the visualization. A 3D SurfaceView dialog appears with the 3D image.

# Interactively Control 3D Visualization

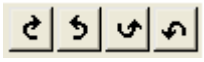
1. Click-and-drag the left mouse button in a horizontal direction to rotate the surface around the z-axis. Click-and-drag in a vertical direction to rotate the surface around the x-axis.
2. Click-and-drag the middle mouse button to translate, or pan, the image in the corresponding direction.
3. Click-and-drag the right mouse button in a horizontal direction to zoom in or out.
4. Double-clicking on a pixel in the 3D SurfaceView moves the Zoom window to that pixel. Double-clicking links the 3D cursor location to selected functions that are active in the display group (see "3D SurfaceView as an Analysis Tool" on page 17 for more information).
5. You can also control the rotation, translation, and zoom factor; and reset the 3D view to its original position, using the SurfaceView Controls dialog described in the following section.

# 3D SurfaceView Controls Dialog

Access the 3D SurfaceView Controls, Position Controls, or Motion Controls dialogs from the Options menu of the 3D SurfaceView dialog. These dialogs determine how the surface is displayed, how the perspective is positioned, and how the surface is animated, respectively.

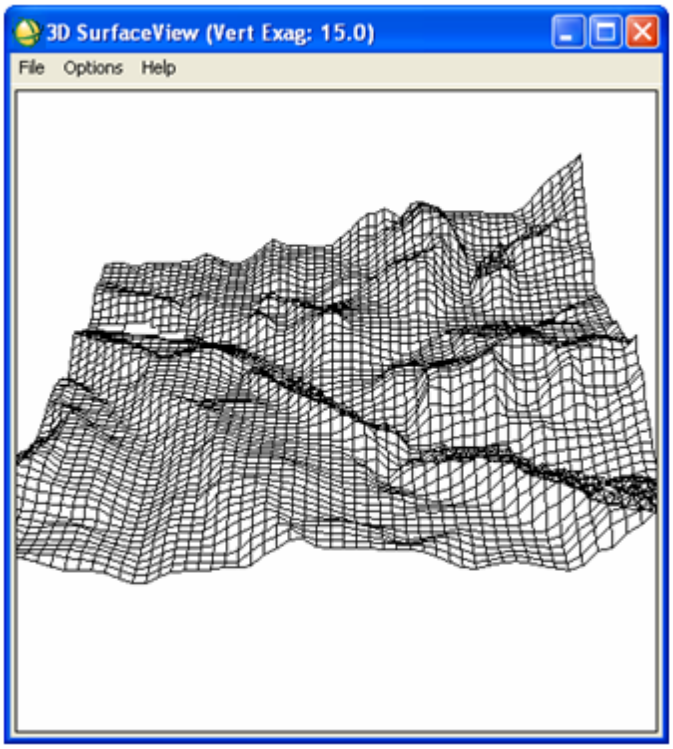
The 3D SurfaceView Controls dialog allows you to make fine adjustments, to edit surface properties, and to rotate the surface around a perspective view.

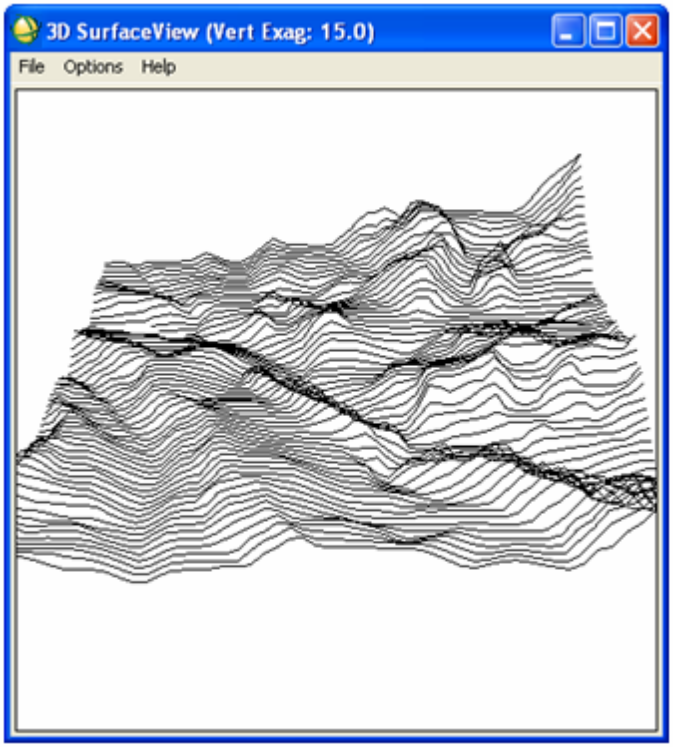
## Rotation/Scale/Translation Controls

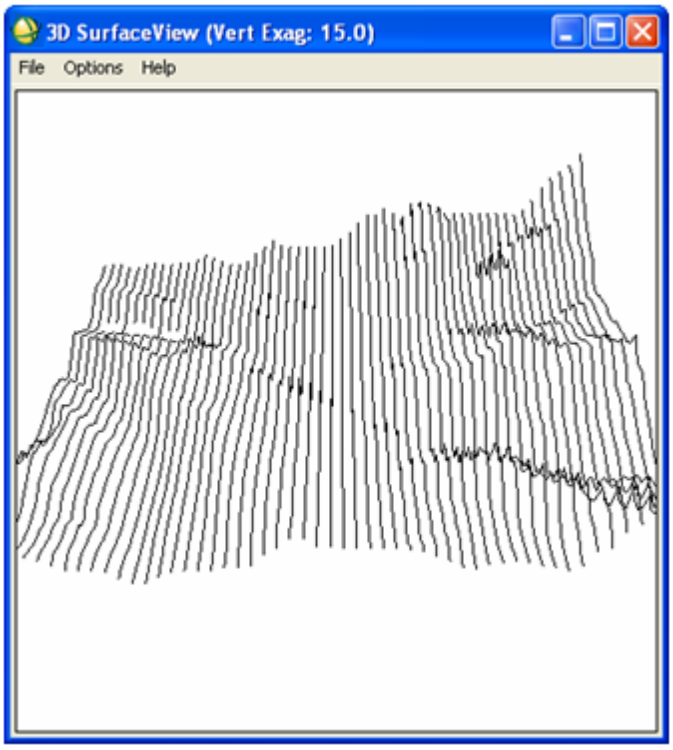
1. From the 3D SurfaceView dialog menu bar, select **Options > Surface Controls**. The 3D SurfaceView Controls dialog appears.
2. Click the  buttons to change the rotation of the surface plot in the desired direction. Use the adjacent **Inc** field to set the rotation increment.
3. Click the  buttons to zoom in or out of the surface plot, respectively. Use the adjacent **Inc** field to set the zoom increment.
4. Click the  buttons to move (translate) the surface plot in the desired direction. Use the adjacent **Inc** field to set the translation increment.

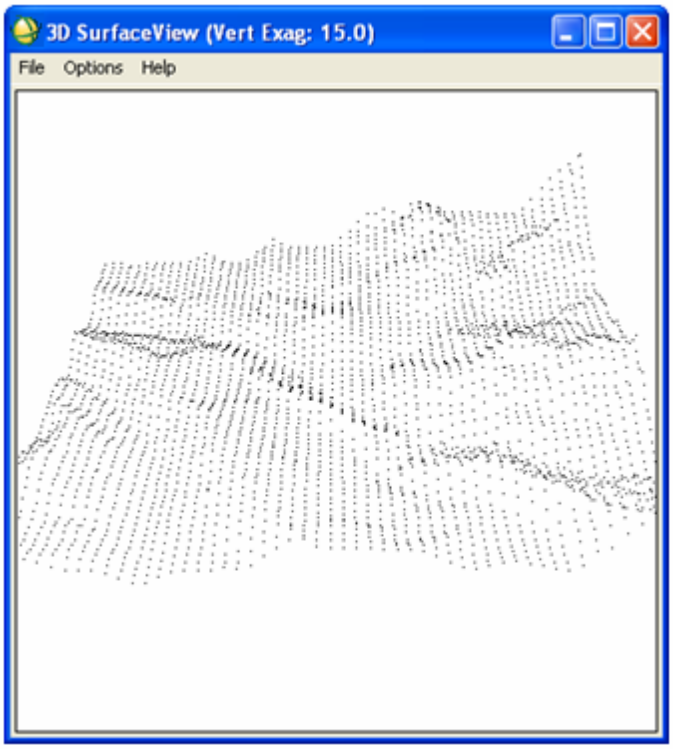
## Surface Properties

1. Click the **Surface Style** drop-down list and select different wireframe options. The figures below show **Wire** (upper-left), **Ruled XZ** (upper-right), **Ruled YZ** (lower-left), and **Points** (lower-right).
2. Experiment with different **Vertical Exaggeration** values. Higher factors increase the vertical exaggeration.


3D SurfaceView (Vert Exag: 15.0)
File Options Help


3D SurfaceView (Vert Exag: 15.0)
File Options Help


3D SurfaceView (Vert Exag: 15.0)
File Options Help


3D SurfaceView (Vert Exag: 15.0)
File Options Help

## Perspective Controls

This section of the 3D SurfaceView Controls dialog allows you to click a point in the 3D SurfaceView plot to specify a perspective origin around which the surface is rotated.

1. Click the  button to toggle the cursor to "select" mode.
2. Move the cursor to the 3D SurfaceView plot and click somewhere in the plot to set the origin of the rotation. The view zooms to the new origin of the perspective, which is set at a height that is 0.05 normalized units (default) above the surface. Rotation begins.
3. You can modify the height of the perspective origin above the surface using the **Translation** controls in the 3D SurfaceView Controls dialog.
4. Click **Stop** to pause the current rotation. If the cursor is in "select" mode, but you did not choose a perspective origin, clicking **Stop** toggles the cursor out of "select" mode.
5. Click **Start** to start a rotation that was stopped; or, if no perspective rotation was started, to begin rotating the surface around its center point.
6. Enter the desired value for **Rotation Delay**, which is the number of seconds to wait between the successive renderings of the rotating surface. The default value is 0.05. Setting the value to 0.0 sets the rotation speed to your computer's limits for calculating the transformation matrix and rendering the surface.
7. You can change the direction of the rotation of the surface by clicking **Direction** and selecting **Left** or **Right**. **Direction** refers to the rotation direction of the surface, not the viewer's perspective.

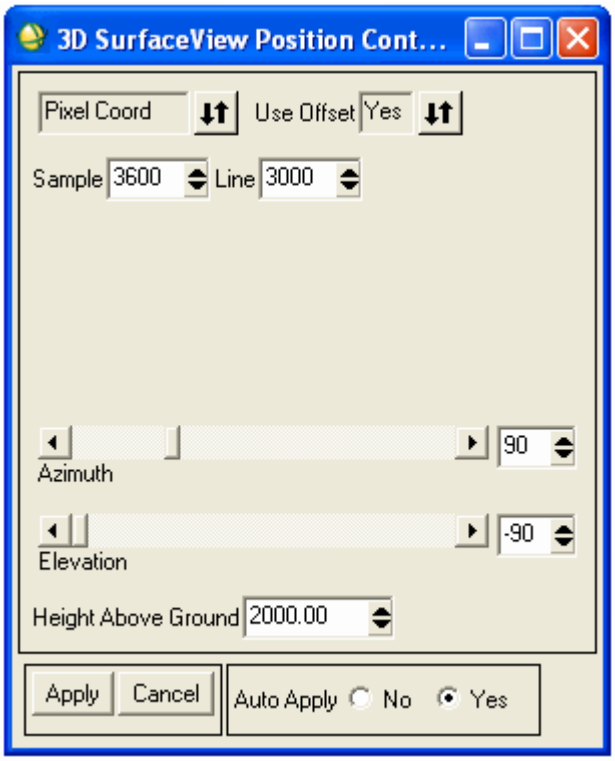
## Other Visualization Controls

1. To change the color of the background in the 3D SurfaceView dialog, select **Options > Change Background Color**.
2. To smooth a surface that appears pixelated, select **Options > Bilinear Interpolation** from the 3D SurfaceView dialog menu bar. To turn off the smoothing effect, reselect this option.
3. To reset the surface view to the default view, select **Options > Reset View** from the 3D SurfaceView dialog menu bar.

# 3D SurfaceView Position Controls Dialog

Use this dialog to view the surface panoramically (as if you are standing in the image), thus setting the view to a specific position and direction.

1. From the 3D SurfaceView dialog menu bar, select **Options > Position Controls**. The SurfaceView Position Controls dialog appears.

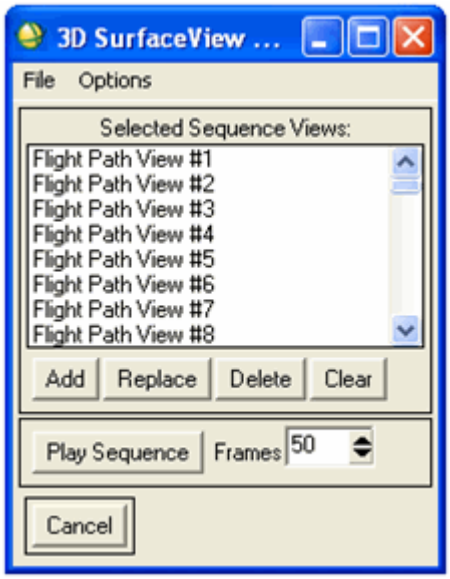



2. Double-click inside the Display #1 Image window to start the Cursor Location/Value tool. Move the cursor to a preferred viewing position and note the corresponding pixel or map coordinates.
3. Click the **Pixel Coord** toggle button to toggle between pixel coordinates and map coordinates. Enter the coordinates from Step 2 into the **Sample/Line** or **E/N** fields. A good starting point is Sample 3600 and Line 3000.
4. Experiment with different **Azimuth**, **Elevation**, and **Height Above Ground** values to see how they change the 3D SurfaceView. Start with an **Azimuth** (look direction) of **90**, an **Elevation** (look angle) of **-90** (looking straight down), and a **Height Above Ground** of **2000** m. Change the height from **2000** to **1000** to **500**. Click **Apply**.
5. Use the interactive rotation and zooming to see the 3D SurfaceView from the selected viewpoint.

# 3D SurfaceView Motion Controls Dialog

ENVI's 3D SurfaceView function can be used to build an animation sequence or fly-through of the 3D visualization. Try restoring a previously saved flight path and playing the animation sequence.

1. From the 3D SurfaceView dialog menu bar, select **Options > Motion Controls**. The 3D SurfaceView Motion Controls dialog appears.




2. From the 3D SurfaceView Motion Controls dialog menu bar, select **File > Restore Sequence**. A file selection dialog appears.
3. Select `bhdemsub.pat` and click **Open**.
4. Set the **Frames** field to **500** and click **Play Sequence**. Click **Stop Sequence** to stop the fly-through.

## Define Flight Path and Begin Flying

1. Click **Clear** in the 3D SurfaceView Motion Controls dialog. Use the mouse or arrow buttons (in the 3D SurfaceView Controls dialog) to select the starting viewpoint, and click **Add** in the 3D SurfaceView Motion Controls dialog to add this projection as the starting point of the flight path.
2. Use the mouse or arrow buttons to select another viewpoint, and click **Add** to add this view to the flight path. Repeat this step until you have selected as many visualization steps as desired (at least two are required). When you select the number of frames and play the visualization, the flight path is smoothly interpolated between the different views. A larger number of frames results in a smoother flight path, but it slows down the animation.
    - Select a view number and click **Replace** to replace a projection in the flight path list.
    - Select a view number and click **Delete** to delete a projection in the flight path list.
    - Click **Clear** to clear the flight path list.

- From the 3D SurfaceView dialog menu bar, select **Options > Animate Sequence** to build a full animation and to control the speed and direction of the fly-through.

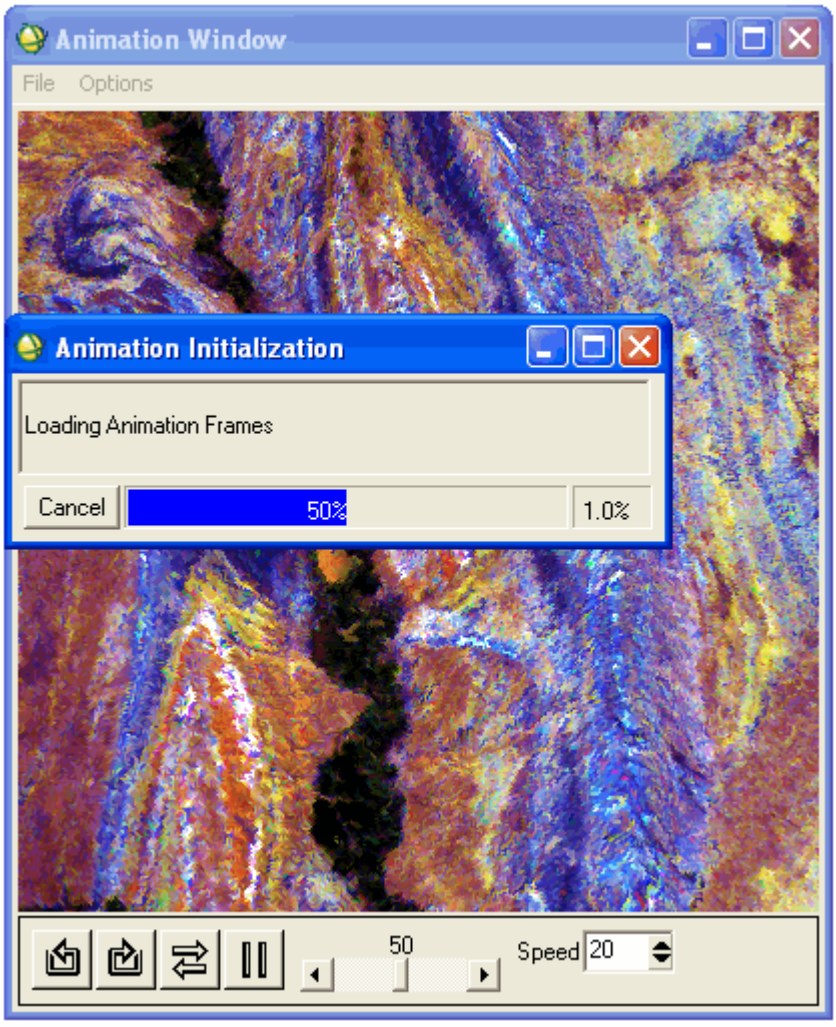
# Build a Visualization Sequence Using Annotation

1. From the 3D SurfaceView Motion Controls dialog menu bar, select **Options > Motion:Annotation Flight Path** to use a flight path drawn in the display group using ENVI annotation. An Input Annotation Flight Path dialog appears. You can draw a polyline, polygon, rectangle, or ellipse annotation object to define the flight path, or use a saved file as input instead.
2. Select the **Input Annotation from File** radio button and click **OK**. A file selection dialog appears.
3. Select `bhdemsub.ann` and click **Open**. An Input Annotation Object dialog appears.
4. Select **Ann Object #1: Green** and click **OK**. The selected annotation file and number of nodes are shown in the middle of the 3D SurfaceView Motion Controls dialog, and the flight path is plotted on the surface in the 3D SurfaceView dialog.
5. In the 3D SurfaceView Motion Controls dialog, keep the number of **Frames** at **500**. To smooth the flight path using a running average of points along the line, enter a **Flight Smooth Factor** value of **1000**.
6. Set the **Flight Clearance** field to **1000**.
7. Set the **Up/Down** field to **-60**. A vertical look angle of -90 degrees looks straight down at the surface. A look angle of 0 degrees looks straight ahead (horizontal). Leave the **Left/Right** look angle at **0**. A horizontal look angle of -90 degrees looks to the left, a look angle of 0 degrees looks straight ahead, and a look angle of 90 degrees looks to the right.
8. Click **Play Sequence** to animate the fly-through. Try different values in each of the parameters and observe the effect they have on the visualization. Also, fly over the surface at a constant elevation by clicking the toggle button to select **Flight Elevation**, and enter the desired elevation above sea level.
9. Select the flight path from a saved annotation file by selecting **File > Input Annotation File** from the 3D SurfaceView Motion Controls dialog menu bar. A file selection dialog appears.
10. Select `bhdemsub.ann` and click **OK**. An Input Annotation Object dialog appears.
11. Select **Ann Object #2: Red** and click **OK**.
12. Set the **Frames** value to **100**.
13. Set the **Flight Smooth Factor** field to **10000**.
14. Set the **Flight Clearance** field to **1000**.
15. Set the **Up/Down** field to **-60**, and leave the **Left/Right** value at **0**.
16. Click **Play Sequence** to animate the fly-through. Try different values in each of the parameters and observe the effect they have on the visualization.
17. Try creating your own annotation objects and animating the fly-through by selecting **Overlay > Annotation** from the Display group menu bar, selecting **File > Input Annotation** from the SurfaceView Motion Controls dialog menu bar, and clicking **Play Sequence**.

# Animate Sequence

The Animate Sequence option allows you to control the speed and direction of the 3D SurfaceView animation.

1. Use the same values in Steps 12-15 in "Build a Visualization Sequence Using Annotation" on page 13 for the ellipse flight path, then select **Options > Animate Sequence** from the SurfaceView Motion Controls dialog to load the individual frames into the animation. The 3D SurfaceView Controls dialog changes to show an interactive tool for controlling the animation:




2. Control the speed of the fly-through by increasing the **Speed** value. Higher values result in faster animation.
3. Control the direction of the fly-through by clicking the appropriate button at the bottom of the dialog:

 reverse animation

 forward animation

 continuous animation

 pause animation

When the animation is paused, click-and-drag the slider to step through the animation one or more frames at a time.

4. From the Animation Window menu bar, select **File > Cancel** to return to the 3D SurfaceView Motion Controls dialog.

# Save Visualizations

The ENVI 3D SurfaceView function also offers several options to save the visualization results and/or path. Select the following from the SurfaceView Motion Controls dialog:

- Select **File > Save Sequence to File** from the SurfaceView Motion Controls dialog menu bar to save the current path to an ENVI path (`.pat`) file that can be restored to a 3D visualization session.
- Select **File > Restore Sequence Path from File** from the SurfaceView Motion Controls dialog menu bar to restore a saved flight path when the visualization is in the User Defined mode.
- Select **File > Input Annotation from Display** from the SurfaceView Motion Controls dialog menu bar to get annotation from the current display group when the visualization is in the Annotation mode.
- Select **File > Input Annotation from File** from the SurfaceView Motion Controls dialog menu bar to get annotation from an ENVI annotation file when the visualization is in the Annotation mode.
- Select **File > Save Surface As > Image File** from the 3D SurfaceView menu bar to output the currently displayed view to an ENVI image.
- Select **File > Print** from the 3D SurfaceView menu bar to perform direct printing of the currently displayed view.
- Select **File > Save Surface As > VRML** from the 3D SurfaceView menu bar to output the 3D visualization to a VRML file that can be viewed in a web browser.

# 3D SurfaceView as an Analysis Tool

ENVI's 3D SurfaceView tool provides powerful visualization capabilities for viewing images draped on DEMs. Because of the way you can dynamically link ENVI display groups and dialogs, this function also allows you to perform DEM analysis using the 3D SurfaceView tool. Analysis tools are described below.

1. Start the 3D SurfaceView tool and display the desired 3D surface.
2. Cursor Location/Value: Double-click in the Image window to start the Cursor Location/Value tool. Read the cursor location (pixel and map coordinates) and value by moving the cursor in the 3D SurfaceView window.
3. Spatial and Spectral Pixel Editors: From the Display group menu bar, select **Tools > Spatial Pixel Editor** or **Tools > Spectral Pixel Editor**. Double-click on a pixel in the 3D SurfaceView window to position the cursor in the ENVI display group to the appropriate location. Edit the desired pixel values.
4. X and Y Profiles: From the Display group menu bar, select **Tools > Profiles > X Profile** or **Tools > Profiles > Y Profile**. Double-click on a pixel in the 3D SurfaceView window to position the cursor in the ENVI display group to the appropriate location. The X or Y Profiles are updated to match the selected cursor location, and the location is marked with a red vertical line in the selected profile.
5. Z Profile (Spectral Profile): From the Display group menu bar, select **Tools > Z Profile** or **Tools > Profiles > Additional Z Profile**. Double-click on a pixel in the 3D SurfaceView window to position the cursor in the ENVI display group to the appropriate location. The Z Profile spectrum is extracted from the data to match the selected cursor location.
6. Spectral Analyst: Display a Z Profile, then select **Spectral > Spectral Analyst** from the ENVI main menu bar. A Spectral Analyst Input Spectral Library dialog appears. Open the desired spectral library by clicking **Open > Spectral Library**. The Edit Identify Methods Weighting dialog appears. Click **OK**. From the Spectral Analyst dialog menu bar, select **Options > Auto Input via Z-Profile** to link the Spectral Analyst to a specific spectral profile. Once the Spectral Analyst is set up, double-click on a pixel in the 3D SurfaceView window to position the cursor in the ENVI display group to the appropriate location. The Z Profile spectrum is extracted from the data to match the selected cursor location, and the Spectral Analyst calculates a match to the library spectrum.
7. When you are finished, select **File > Exit** from the ENVI main menu bar.