Caribbean Planning for Adaptation to Global Climate Change
Regional Project Implementation Unit
Inventory of Coastal Resources and Uses Consultancy

Component #3:
Inventory of Coastal Resources and Uses

A GIS-based Data Automation Manual

Alleyne Planning Associates Inc.
BAMP Complex, Spring Garden Highway
St. Michael, Barbados, West Indies

In association with

ESSA Technologies Ltd.
Suite 301, 1595 16th Avenue
Richmond Hill, Ontario, Canada
L4B 3N9

And

Centre for Geospatial Studies
The University of the West Indies
St. Augustine, Trinidad and Tobago

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A MANUAL FOR DATA AUTOMATION

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1.0 SPATIAL DATA AUTOMATION USING ARCVIEW 3.2™

ArcView3.2™ allows one to create spatial data on-screen or from a digitizing tablet through heads-up or heads-down digitizing. After digitizing a theme in ArcView 3.2™, errors may be created and must be edited. This manual will cover the following topics:

1) DIGITIZING IN ARCVIEW 3.2™
   - Heads-up Digitizing
   - Heads-down Digitizing

2) EDITING SAPTIAL DATA IN ARCVIEW 3.2™
3) HOTLINKING IMAGES IN ARCVIEW 3.2™
4) CREATING THEMES IN ARCVIEW 3.2 ™USING GPS DATA
5) AUTOMATING ATTRIBUTE DATA USING MS ACCESS™

At the end of the training, participants should be able to:

- Perform heads-up digitizing and editing of errors in ArcView 3.2™
- Perform heads-down digitizing and editing of errors in ArcView 3.2™
- Hot link images in ArcView 3.2™
- Create themes in ArcView 3.2™ using GPS Data
- Create, join and edit tables for attribute data of an existing theme in ArcView 3.2™

1.1 HEADS-UP DIGITIZING

Heads-up digitizing is the process of creating spatial data on-screen, using scanned and georeferenced images or maps.

1.1.1 Georeferencing of Scanned Maps

Georeferencing is the provision of metric properties to raster imageries so that they can be used as maps. Digital Raster Graphics [DRG] refer to geographically referenced raster images or other graphics generated by scanning source documents.
This requires geometric processing of the scanned raster image.

A properly georeferenced image may be used for the following:

- Distance and area calculations
- Extraction of the coordinates of discrete points
- Vectorization of thematic features
- Overlaying of other digital vectors
- Enhancing cartographic properties of features.

How images are registered to a map in ArcView *(taken from ArcView 3.2™ GIS manual).*
Images are stored as raster data, where each cell in the image has a row and column number. Shapefiles and ARC/INFO coverages are stored in real-world coordinates. In order to display images with coverages or shapefiles, it is necessary to establish an image-to-world transformation that converts the image coordinates to real-world coordinates. This transformation information is typically stored with the image. Some image formats, such as ERDAS, IMAGINE, BSQ, BIL, BIP, GeoTIFF, and grids, store the georeferencing information in the header of the image file. ArcView uses this information if it is present. However, other image formats store this information in a separate ASCII file. This file is generally referred to as the world file, since it contains the real-world transformation information used by the image. World files can be created with any editor. They can also be created using ARC/INFO's REGISTER command.

World file naming conventions
It is easy to identify the world file, which should accompany an image file: world files use the same name as the image, with a "w" appended. For example, the world file for the image file mytown.tiff would be called mytown.tiffw and the world file for redlands.rlc would be redlands.rlcw. For workspaces that must adhere to the 8.3 naming convention, the first and third characters of the image file's suffix and a final "w" are used for the world file suffix. Therefore, if mytown.tif were in a an 8.3 format workspace, the world file would be mytown.tfw. If redlands.rlc was in an 8.3 format workspace, its world file would be redlands.rcw.

For images that lack an extension, or have an extension that is shorter than three characters, the "w" is added to the end of the file name without altering it. Therefore the world file for the image file terrain would be terrainw; the world file for the image file floorpln.rs would be floorpln.rsw.

Affine transformation
Affine transformations involve the conversion of the image coordinate system to the world coordinate system using basic two-dimensional scale, rotation and shift parameters.
·Transformation parameters are obtained for:

- Image and ground coordinates for a known reference point (usually the top left corner of the image).
- Image pixel size and corresponding ground surface pixel size (used as a scalar difference).
- Rotation elements.

How the georeferencing information is accessed
The image-to-world transformation is accessed each time an image is displayed (e.g., when you pan or zoom). The transformation is calculated from one of the following sources, listed in order of priority:

- the world file
- the header file (if the image type supports one)
- from the row/column information of the image (an identity transformation)

Because a world file has higher priority, you can override the header file transformation information by creating your own world file.

World file contents
The contents of the world file will look something like this:
20.17541308822119
0.00000000000000
0.00000000000000
-20.17541308822119
424178.11472601280548
4313415.90726399607956

When this file is present, ArcView performs the image-to-world transformation. The image-to-world transformation is a six-parameter affine transformation, where the ground or real-world coordinates can be given in the form of:

x1 = Ax + By + C
y1 = Dx + Ey + F where:

- x1, y1 are the calculated ground coordinates of the pixel on the *map*
- x, y are the corresponding column and row numbers of the pixels in the *image*
- A, E are the x and y scales respectively; dimensions of a pixel are in map units in the x direction.
- B, D are rotation terms
- C, F are translation terms: x,y map coordinates for the centre of the upper left pixel

1. The scale E is always negative of the y-scale.

Note: The y-scale (E) is negative because the origins of an image and a geographic coordinate system are different. The origin of an image is located in the upper-left corner, whereas the origin of the map coordinate system is located in the lower-left corner. Row values in the image increase from the origin downward, while y-coordinate values in the map increase from the origin upward.

The transformation parameters are stored in the world file in this order:

20.17541308822119 - A
0.00000000000000 - D
0.00000000000000 - B
-20.17541308822119 - E
424178.11472601280548 - C
4313415.90726399607956 - F

Note: ArcView does not rotate, or warp, images. If your world file has non-zero rotation terms (D and B parameters), the image may change its position relative to vector data in the same view when you zoom or pan. Use the ARC/INFO RECTIFY command to properly rotate the image.

1.1.2 ArcView 3.2's interface

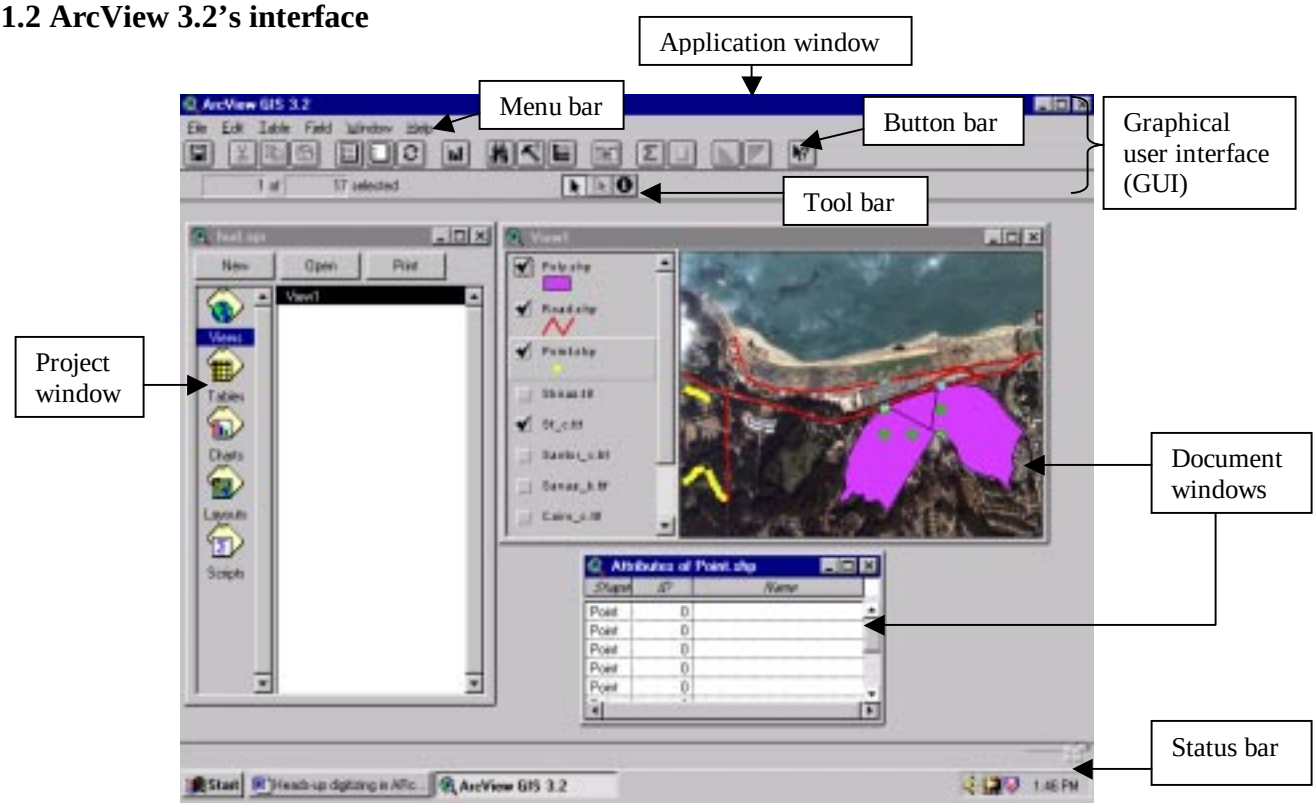


Figure 1. ArcView's interface

ArcView's **application window** contains a graphical interface (GUI) that allows you to move, resize, minimize and maximize the window.

The **Project window** (with a *.apr* extension**)** shows the names of all documents in an ArcView project.

The **Document windows** have their own interface for the information that you may wish to work with.

The **GUI** has all the menus, buttons and tools for accessing the functionalities of ArcView. The *menu bar* has pulldown menus that give you access to ArcView's functionalities. The *button bar* provides quick access to commonly used operations. The *tool bar* contains the tools that perform operations that require you to use the mouse.

The **Status bar** displays on-line description of the operation being performed by the menu, button or tool bars, when you place the cursor over a menu choice. The status bar can also show measurements and a progress bar for lengthy operations.

Tool tips appear over a button or tool when you place the cursor over it.

Heads-up digitizing is done on screen using a scanned map, an aerial photograph or a satellite image that can be read by ArcView.

ArcView reads the following image formats:

- BSQ, BIL and BIP
- ERDAS LAN and GIS
- ERDAS IMAGINE
- JPEG
- BMP
- Run-length compressed files
- Sun raster files
- TIFF, TIFF/LZW compressed, and GeoTIFF
- Grid-cell data in ARC/INFO grid format

1.1.3 Adding a scanned image to a view

- Open a **New View**.
- Click the **Add Theme** button.
- Choose **Image Data Source** from the *Data Source Types* list.
- Navigate to the directory that holds the image you want to add.
- Double-click on the directory name to list the image data sources that the directory contains.
- Double-click on the image you wish to add.
- If there are many images that need to be added, select the first image and while holding the shift key, select the rest of the images to be added. Click **OK**. All the images that make up the composite are added to the view.
- Click the check box next to the theme's name in the view's **Table of Contents** to draw the image.

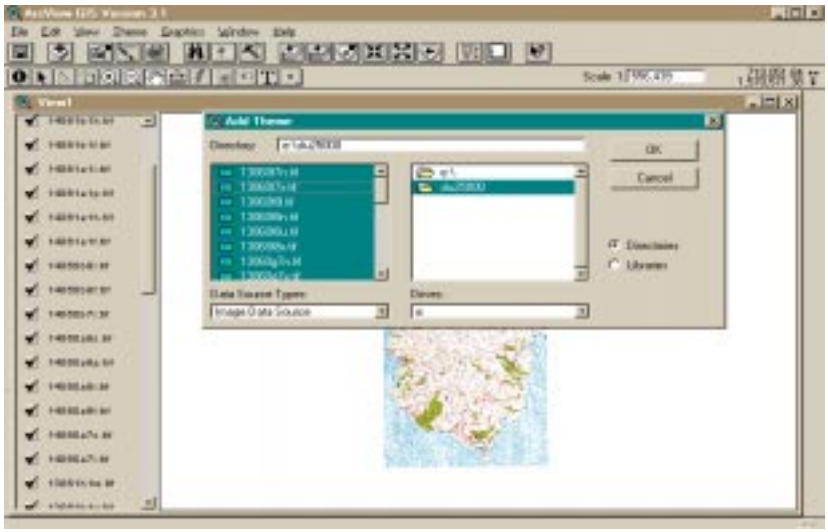


Figure 2. Interface for adding an image to a View

1.1.4. Setting your working directory

- Make the View window active by clicking on the bar at the top of the view window. (The bar goes blue).
- Go to **File**, select **Set Working Directory**.
- A window appears for you to type in the pathname of the location for storing your work.e.g. *c:/temp/yourname*.

This ensures that all work will be saved to this folder as a default.

1.1.5. Setting a scale threshold

Setting a scale threshold, allows you to set a range of scales for displaying a theme. This is necessary when working with raster images, so that you do not zoom in too much to the extent where the grid cells become too large that it is difficult to recognize features.

Should you want to display certain aspects of a theme's properties when you zoom in to a larger scale, you type in that scale value in the **Maximum Scale** input box. The theme will not be displayed when the scale denominator *exceeds* the maximum scale threshold.

To set a scale threshold:

- Go to **Theme Properties.**
- Select the **Display** icon at the left of the window.

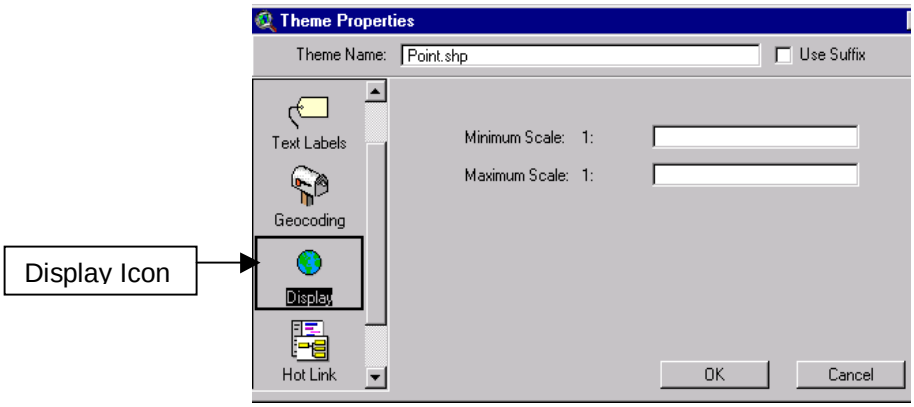


Figure 3. Interface for setting a scale threshold

In the window that appears, for that theme you are working with, type in **denominator values** for the minimum and the maximum scales at which you wish to view the image. For instance, the minimum scale denominator threshold for the image can be 2500 and the maximum can be 25 000. If you try to view the image beyond either of these ranges, it will not be possible to do so.

- Click **OK**

Spatial data in a view is organized as a collection of *themes*. A *theme* is a set of geographic features that represent real-world geographic objects. These geographic features have descriptive information called *attributes*. These attributes are stored in 'Theme Attribute Tables'.

Points, lines and polygons are features that represent real-world geographic objects. These are the features that you may wish to digitize on-screen, as a:

I. Point theme
II. Line theme
III. Polygon theme.

You may wish to create a new theme, or add a feature to an already existing theme.

1.1.6 Digitizing a Point Theme

Digitizing a point theme involves creating a point theme and adding attributes to the attribute table for the point theme created.

Creating a new point theme

- Choose **New Theme** from the **View Menu**.

Figure 4. Creating a New Theme

- Select **Point** as the *Feature type* from the dropdown list in the dialogue box.
- Click **OK**.

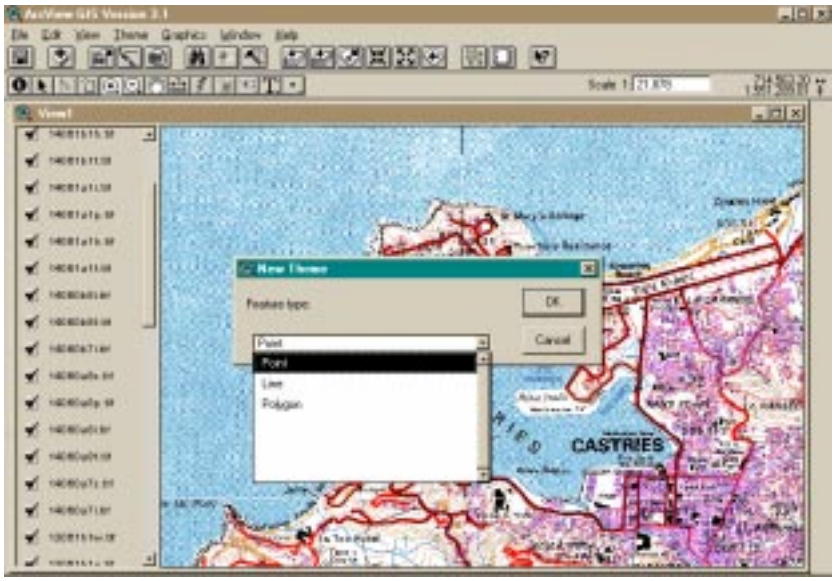


Figure 5. Selecting a feature type for a theme

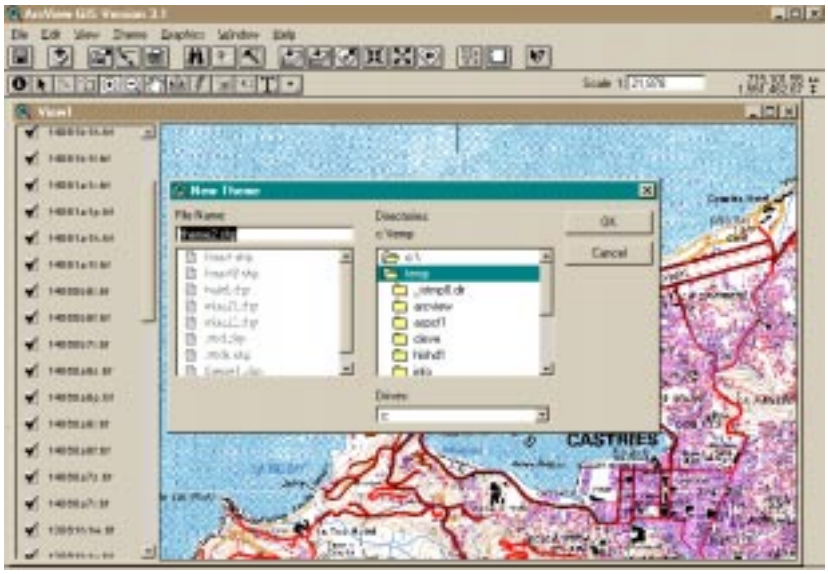


Figure 6. Selecting the directory for storing the new theme.

- Specify the name and location of the new ***shapefile*** in which ArcView will store the data for the theme created, in the dialogue box that appears.

A ***shapefile*** is a simple, non-topological format for storing the geometric location and attribute information of geographic features.

- Click **OK.** A new empty theme for your point features is added to the view.

- Click the **Drawing** tool palette from the Theme menu bar, and select the **Point Tool**.

- Add points to the theme from the image by clicking the left mouse button on a location that you wish to represent as a point. A symbol is drawn to represent the point feature.

- Choose **Stop Editing** from the Theme menu bar when you no longer wish to add points.

- Click **Yes** to save your point features.

Figure 7. Point Theme added to a new view with scanned map.

Adding Attributes to Point Features

When you create a new theme in ArcView, an attribute table is automatically created with it. Each new point adds a new record to the table. The two fields created automatically in the table are the ***Shape*** field for storing the feature type and the ***ID*** number of the feature. New fields can be added to the table to store any additional attribute data for the theme.

- Choose **Start Editing** from the Theme menu bar. A dashed line around the theme's check box indicates that the theme is in edit mode.

- Click the **Open Theme Table** button. The attribute table of the theme you wish to edit appears in the view.

- Choose **Add Field** from the **Edit** menu.

- In the **Field Definition** dialogue box,
  - enter the **Name** of the new field you want to create,
  - choose a field **Type** from ***Number, String, Boolean, Date***
  - enter the field **Width** as a number to accommodate the field name given
  - enter a number for **Decimal places**, if required.

- Click **OK**. The new field is now added to the attribute table.

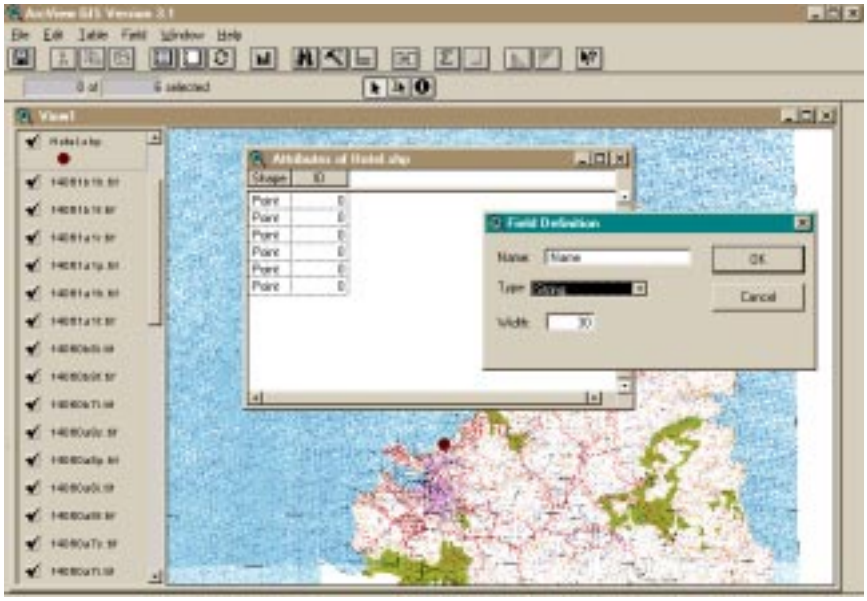


Figure 8. Adding attributes to an attribute table.

- In View, use the **Pointer** tool to select the point for which you wish to add a value. Selection handles appear around the point in the view.
- Click on the bar at the top of the attribute table to make the table active. (The bar turns blue when the table is active.) The selected record in the attribute table is highlighted.
- Click in the **type** field for that record with the **Edit** tool. The cursor appears in that field.
- Type in the value.
- Go to **Table**, from the menu bar and select **Stop Editing**.
- Say **Yes** to the save the edits. The additional fields are stored in the table.

1.1.7 Digitizing a Line theme

Digitizing a line theme involves creating a line theme and adding attributes to the theme table. You must set a snap environment before you start adding lines.

Setting the snapping environment

To ensure that lines meet perfectly at intersections when you digitize, the snapping environment should be set. When the snapping environment is set, ArcView moves the vertices or line segments of the new features you add to align with the vertices or line segments of other features that are within a specified distance, called the snap tolerance.

All line features coming together at an intersection will share the same endpoint. This ensures that there will be no overshoots or undershoots. There are two types of snapping environments:

- The general snapping environment
- The interactive snapping environment

Both types of snapping environments can be set by either typing a value or by using the mouse.

To set the general snapping environment by typing in a tolerance

- Make the theme active in the view's **Table of Contents**
- Click the **Theme Properties** button.
- Click the **Editing** icon in the dialogue box that appears to display the theme's editing properties.
- Click the **General** check box to turn this Snapping on
- Type in a tolerance value in the tolerance field.
- Click **OK**.

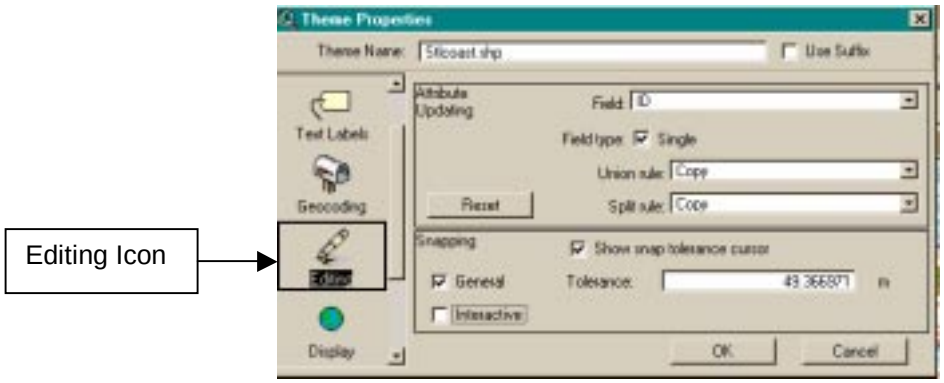


Figure 9. Dialogue box for the snapping environment.

To set the general snapping environment with the mouse

- In the view, hold down the right mouse button to display the popup menu.

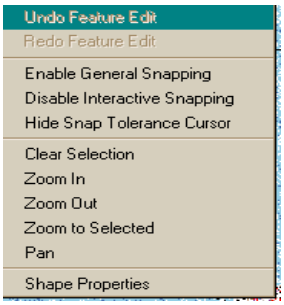


Figure 10. Popup menu for setting the snapping environment with the mouse.

- Choose **Enable General Snapping** from this menu.
- Click the **Snap** tool palette.
- Click the **General Snap** tool.

- In the view, click and drag out a circle to represent the tolerance distance. The status bar shows the radius of the general snap tolerance.

To set the interactive snapping environment by typing in a tolerance

Interactive snapping allows better control of how features are snapped. You can control how each vertex you are adding, is snapped to existing lines in the theme. You can choose one of the following snap rules from the popup menu while you are adding the feature:

Snap to vertex: This snaps the next vertex to the nearest vertex in an existing line.

Snap to boundary: This snaps the next vertex to the nearest line segment in an existing line or polygon boundary.

Snap to Intersection: This snaps the next vertex to the nearest node common to two or more lines or polygons.

Snap to Endpoint: This snaps the next vertex to the nearest endpoint of an existing line.

- Make the edit theme active.
- Click the **Theme Properties** button.
- Click the **Editing** icon in the dialogue box to display the theme's editing properties.
- Click the **Interactive** check box to turn on the Interactive type of snapping.
- Type a tolerance value in the tolerance field.
- Click **OK**.

To set the interactive snapping environment with the mouse.

- In the view, hold down the right mouse button to display the popup menu.
- Choose **Enable Interactive Snapping** from this menu.
- Click the **Snap** tool palette.
- Click the **Interactive Snap** tool.
- In the view, click and drag out a circle to represent the tolerance distance. The status bar shows the radius of the general snap tolerance.

Creating a new line theme.

- Create a new view.
- Choose **New Theme** from the **View Menu**.
- Select **Line** as the *Feature type* from the dropdown list in the dialogue box.
- Click **OK**.
- Specify the name and location of the new *shapefile* in which ArcView will store the data for the theme created, in the dialogue box that appears.
- Click the **Drawing** tool palette.
- Select the **Line** tool.

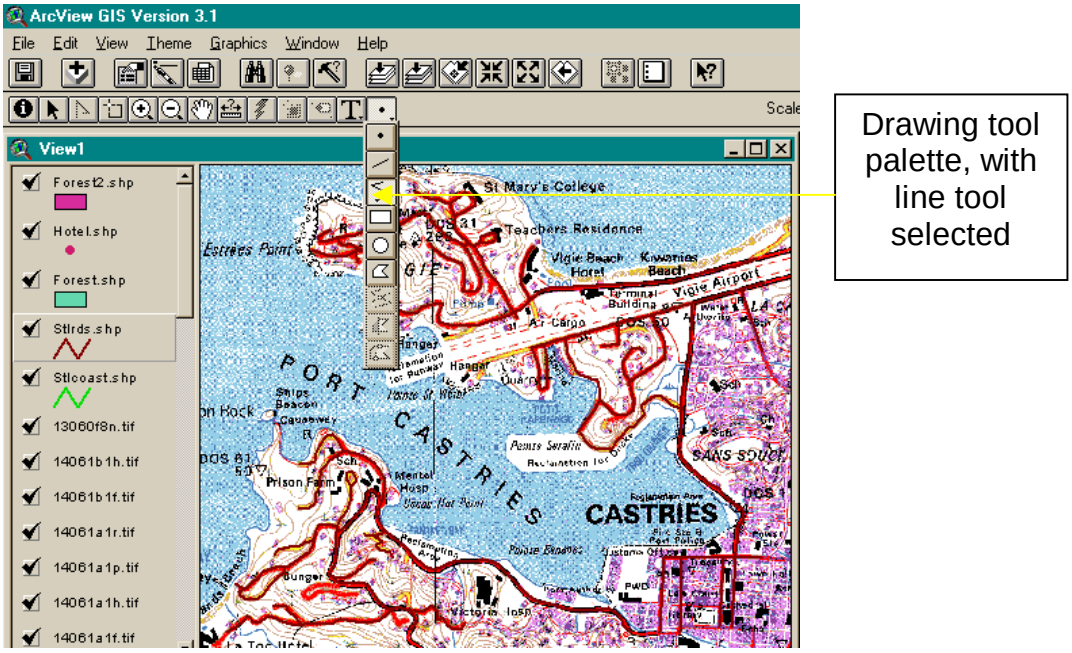


Figure11. Drawing tool palette for creating a line theme.

- Click where you want to start in the view, then click each vertex along the line. Double-click the final vertex

If you are in the Interactive snapping environment, choose one of the snapping options from the popup menu to control how the next vertex you add to the line will be snapped to existing lines in the theme.

While you are creating a line, you can choose the Delete Last Point option from the popup menu to delete the last vertex added. Repeatedly choosing this option allows you to delete all the vertices back to the start point of the line.

When you create a new line feature, a corresponding new record is automatically added to the theme's feature attribute table.

Creating a line feature that splits other lines it crosses.
In drawing a new line that crosses another line, you may need to split the lines so that an intersection is created. To do this:

- Click the **Drawing** palette tool.
- Select the **Line Split** tool from the menu. 
- In the view, click where you want the line to start.
- Click each vertex and double-click the final vertex. The line you draw must cross over another line for any new feature to be created. Both the existing line and the new line are split into separate lines at the point where they cross.

Adding attributes to line features.
When you create a new theme in ArcView, an attribute table is automatically created with it. Each new line adds a new record to the table. The two fields automatically created in the table are the *Shape* field for storing the feature type and the *ID* number of the feature. New fields can be added to the table to store any additional attribute data for the theme.

To add attributes to a line theme, follow the procedure for 'Adding attributes to a point theme' in Section 1.1.5.

To add a length field to a line theme's attribute table.
Open the attribute table of the line theme for which you want to calculate a length.

- Choose **Start Editing** from the **Edit** menu.
- Add a numeric field, *Length*, to the table.
- Click on the *Length* field to select it.
- Click on the **Calculate** button to display the **Field Calculator** dialog.
- In the box labelled [Length] =, type in: [Shape] . ReturnLength
- Click **OK.**

The length field will be automatically calculated in the line theme's attribute table.
The length value calculated will be in the same units as the data source theme.

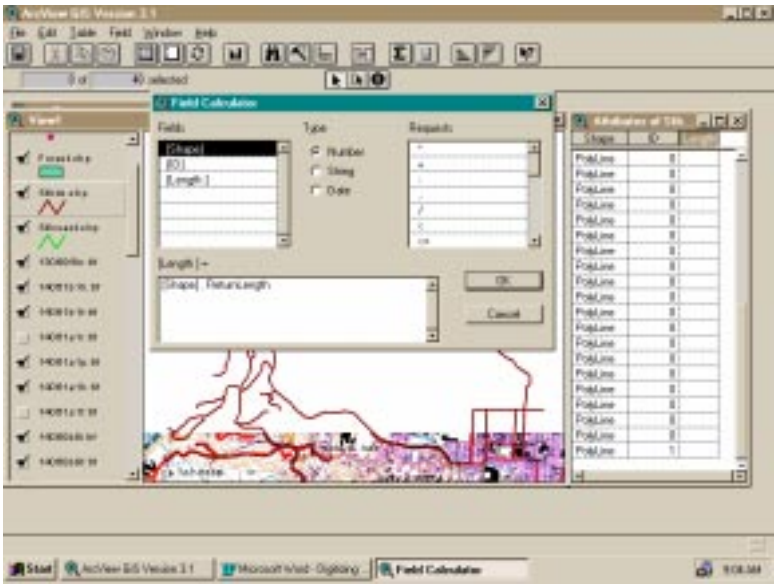


Figure 12. Adding the *Length* field to a line theme.

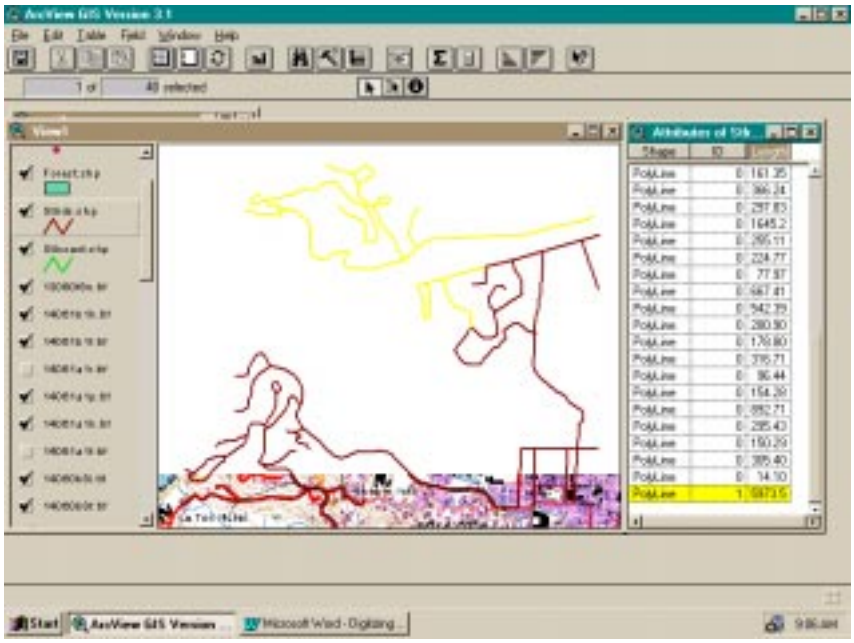


Figure 13. Distances for Length field calculated for each line segment.

To update attributes when lines are spilt or merged

When you split a line, you can specify how the attributes of the two new lines will be derived from the attributes of the original one. This is done by setting attribute update rules.

For a single type field in the attribute table, such as *Length*, depending on whether you split or merge the lines, you can choose one of the split rules, that is, the Merge or Union rules.

Split rules:

Blank: The value in both records will be blank.
Copy: The original value will be assigned to both records (the default).
Proportion: The values will be proportional to the length of the new lines.
Shape Length: The values will be the length of the new lines (the default for fields called *Length*)

Union rules:

Blank: The value in the resulting record will be blank.
Copy: The value in whichever record is first in the table will be assigned (the default).
Proportion: The value will be proportional to the lengths of the merged lines.
Add: The values will be added together in the resulting record.
Average: The values will be averaged in the resulting record.
Shape Length: The value will be the length of the new lines (the default for fields called *Length*).

To set the attribute update rules for a single field in a line theme's attribute table.

- Make the line theme **active**
- Click on the **Theme** Properties button.
- Click the **Editing** icon to the left in the dialogue box that appears to display the theme's editing properties. In the **Attribute Updating** panel, choose the field in the theme's attribute table to which you want the rule to be applied.
- Click the **Single** Field type button.
- Choose either the **Union rule** or **Split rule** you want to be applied to the field
- Click **OK**.

1.1.8 Digitizing a Polygon theme

Polygon features represent areas that have a common characteristic, such as forests, population, land use or soil types.

Setting the snapping environment for polygon themes

If you want to remove any gaps or overlaps created during the digitizing process, you will have to set the snapping environment.

To get all the polygons you are creating to snap to other polygons automatically, within a specified tolerance, set the **General** snapping environment.

However, for better control over how your polygon features get snapped, set the **Interactive** snapping environment. With interactive snapping, you can control how each vertex along the boundary you are adding is snapped to the existing polygons in the theme.

To do this, while you are adding your polygon boundary, click the right mouse button to display the popup menu. Choose from the following options to control how the next vertex you add will be snapped to existing polygons:

Snap to vertex: This snaps the next vertex to the nearest vertex in an existing polygon.

Snap to boundary: This snaps the next vertex to the nearest line segment in an existing polygon.

Snap to intersection: This snaps the next vertex to the nearest node common to two or more polygons.

Refer to Section 1.1.7 for setting the snapping environment.

Creating a new polygon theme

- Create a new view.
- Select **New Theme** for the **View** menu.
- Select **Polygon** as the *Feature* type from the dropdown list in the dialog box that appears.
- Click **OK**.

- Specify the name and location of the new shapefile in which the data for the new theme will be stored. A new empty polygon theme is added to the view.
- Choose **Start Editing** from the **Theme** menu.
- Click the **Drawing** tool palette.

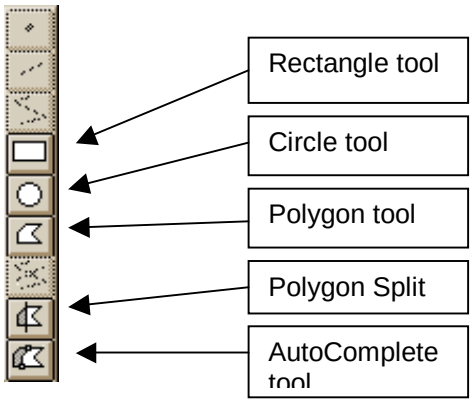


Figure 14. The Drawing palette tool.

- Select the **Polygon** tool.
- Click where you want to start the line for your polygon.
- Click each vertex along the line.
- Double-click the final vertex. A polygon is created in your view.

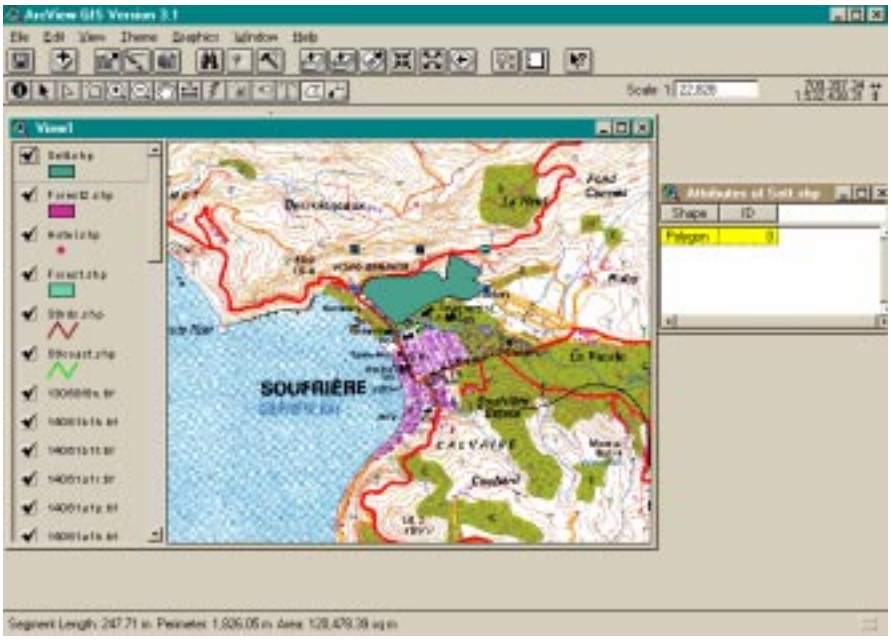


Figure 15. A polygon feature created along with its attribute table.

Adding attributes to polygon features.
An attribute table is created automatically when a new polygon theme is created. The two fields created are *Shape* and *ID*. You can add an area or perimeter field to the table.

To add an area or perimeter field to a polygon theme's attribute table.
Open the attribute table of the polygon theme for which you want to calculate an area or perimeter.

- Choose **Start Editing** from the **Edit** menu.
- Add a numeric field, *Area*, or *Perimeter* to the table.

To calculate the Area field

- Click on the *Area* field to select it.
- Click on the **Calculate** button to display the **Field Calculator** dialog.
- In the box labelled [Area] =, type in:
  [Shape] . ReturnArea
- Click **OK.**

To calculate the Perimeter field

- Click on the *Perimeter* field to select it.
- Click on the **Calculate** button to display the **Field Calculator** dialog.
- In the box labelled [Perimeter] =, type in:
  [Shape] . ReturnLength
- Click **OK.**

The fields *Area* and *Perimeter* are automatically calculated for each record.

1.1.9 Saving and opening your project

From the menu bar,

- Go to **File**, **Save Project As.**

A window appears.

- Name the project (.apr extension), and save it to your working directory.

Opening up your project

To continue working on your project should you exit ArcView,

- Go to **File**, **Open Project**
- Select the name of the project you saved previously from the Open Project window.
- Click **OK**.

1.2 Heads-Down Digitizing

Heads-down digitizing is process of capturing data from paper maps, in digital format. Digitizing of points, lines and polygons is done with the use of a pointing device and a digitizing tablet.

1.2.1 Requirements for digitizing

- *The digitizing tablet* – This is a board with a mesh of wires that define its coordinate system. The density of the wires indicates how close the digitized points may be captured from the hard copy map. The mesh is normally about 0.002 in. apart.
- *The digitizing cursor* - The cursor can be either a pen or a keypad with buttons that control the data input. It is attached to the tablet and captures features from the map. Each time a user presses a button on the keypad, the coordinates of that location are recorded.
- *Digitizer coordinate system* – The tablet has a rectangular coordinate system with the origin in its lower left corner.
- *Spatial data registration* – This is done by the use of known ground control points or 'tics' that are used to register the spatial location of the coverage to the location on the digitizer. A correlation is made between each control point coordinate and its digitizer coordinate.

1.2.2 Establishing coordinates of a coverage

The coordinates of the control points determine the coordinates of the coverage. There are two systems for establishing the coordinates of coverage before digitizing begins. These are the:

Digitizer coordinate system

In the digitizer coordinate system, control points are given coordinate values that are not tied to any real-world origin. Coverages digitized in this system must be transformed into an established real-world coordinate system after the coverage is digitized.

Advantage: a check plot can be created at the scale of the source map and laid over the original map to check for digitizing errors.

Real-world coordinate system

In the real-world coordinate system, control points are given coordinate values in a real-world coordinate system. The control points on the hard copy map are registered to the control points in the coverage. All spatial data digitized are therefore assigned values in a real-world coordinate system (feet or metres). Coordinate transformation takes place automatically as the data are digitized.

Advantages:

- The user has the ability to digitize a new coverage using another coverage as a reference or background coverage in the same coordinate system.

- A master control point coverage can be created for the entire project and the control points copied to each new coverage as they are digitized.

Registration error

Registration error is one that expresses the difference between the relative location of the input control points from source maps and the output control points in real-world coordinates. Control point IDs are used to identify the control points to be compared. The error is given as the Root Mean Square (RMS) error. The input RMS error should be less than 0.003 inches, depending on the accuracy requirements for the project. Four control points should be used to help determine the RMS.

1.2.3 Map Preparation

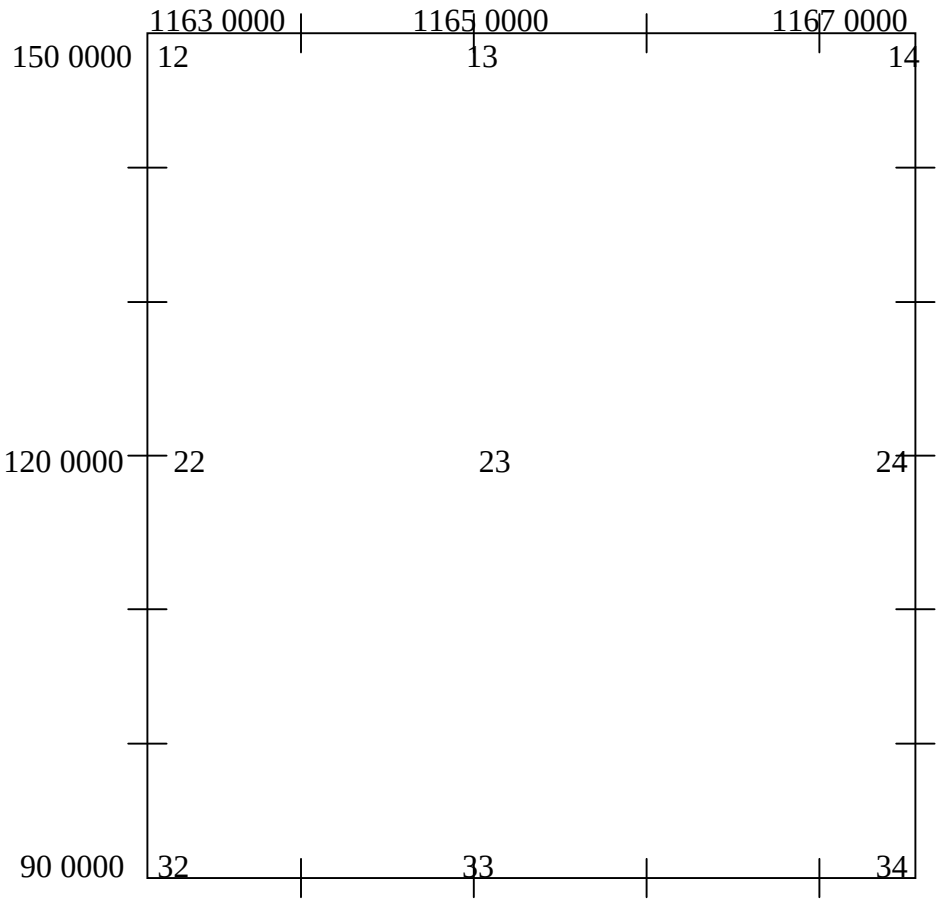
Before digitizing begins, you should prepare the paper map as follows:

- Premark control points
- Extract control point information as a table
- Extend map boundaries
- Extend internal lines beyond the new outer boundaries
- Mark intersection of arcs
- Insert nodes on long arcs
- Indicate starting nodes on island polygon
- Mark label points of polygons
- Record production information of the source map

After preparing the map as stated above, tape the paper map securely to the digitizing tablet.

Exercise

The diagram below shows nine control points and their coordinates. Complete the control point table of the nine control points with their real-world coordinates given in Eastings and Northings.

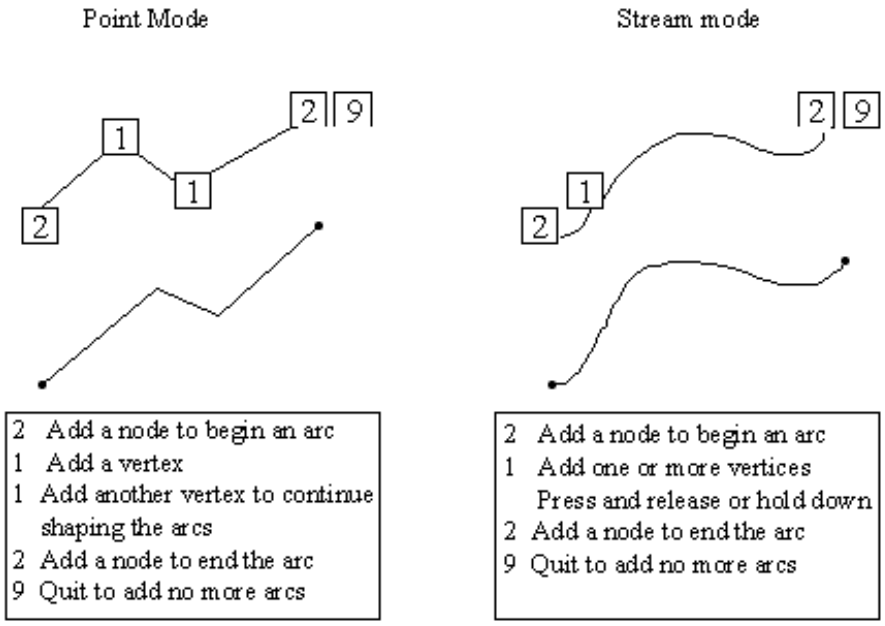


Control point IDs	Easting (X coordinate)	Northing (Y coordinate)
12	11630000	1500000
13		
14		
22		
23		
24		
32		
33		
34		

Control Point Table

1.2.4. The Digitizing Process

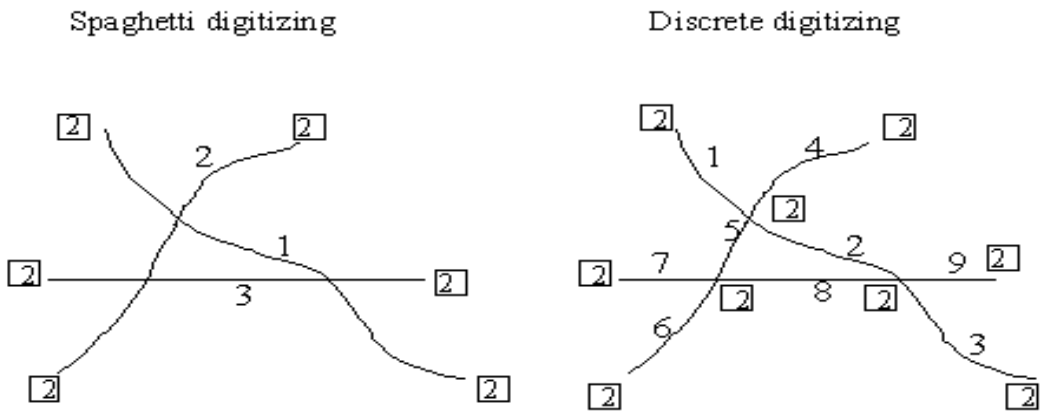
Digitizing Arcs
Drawing an arc is controlled by buttons on the digitizer keypad as shown in the diagram below.



Methods of digitizing
There are two methods of digitizing arcs. These are spaghetti digitizing and discrete digitizing.

Spaghetti digitizing
- Digitizing arcs without placing nodes at intersections.
- This method is fast. However, it can lead to arc User-IDs that are not unique.
  Because arcs define polygons, polygon topology cannot be created if arcs cross without nodes at intersections.

Discrete digitizing
- Discrete digitizing involves explicitly placing nodes at intersections as you digitize.
- It is slower than spaghetti because the user must identify and digitize each arc intersection.
- Discrete digitizing produces unique IDs that are important if attributes will be assigned to arcs later.
- If tolerances are properly set, discrete digitizing requires less post-digitizing processing than spaghetti digitizing.



2 Start or end node
Numbers 1 - 9 are arcs.

1.2.5 Setting up the Digitizing tablet

There must be a *Win Tab* compliant digitizer driver software installed in order to use a digitizing tablet with ArcView. The manual that came with the particular digitizer would tell you whether the drivers are present. After installing the driver software, use the *Win tab* manager setup program to configure the buttons of the tablet's puck of pen.

1.2.6 Loading the digitizer extension in ArcView.

Assuming you have successfully configured the digitizing tablet, prepared the map in the manner suggested and taped the map to the tablet, you can now load the Digitizer Extension.

To load the Digitizer extension

- Make the **Project** window active.
- Choose **Extensions** from the **File** menu.
- Click the check box next to the **Digitizer extension**, in the Extensions dialogue box.
- Click **OK**

1.2.7 Preparing the view for digitizing

- Create a new view
- Specify the projection used by the paper map.

1. Choose **Properties**, from the **View** menu.
2. Click the **Projection** button, in the dialogue box that appears.
3. Select, from the options listed, the projection properties to match those of the paper map.
4. Click **OK**.
5. Set the desired Map Units from the dropdown list (e.g. Metres).
6. Click OK.

1.2.8 Registering your map

You need to tell ArcView the ground coordinates for the control points of your paper map.

To register your paper map for the first time.

1. Choose **Digitizer Setup**, from the **View** menu.
2. Specify the level of error you would allow by entering a value in the **Error Limit** field. The default value is 0.004 inches.
3. If your view is projected, use the **Units** list in the **Digitizer Setup** dialogue to specify the units of the ground coordinates for the control points (E.g. Decimal degrees, metres or feet).
4. Click the digitizer puck icon to activate the digitizer.
5. Digitize the control points from the digitizing tablet, in the order of the points from your control point table, placing the crosshairs of the puck over the control points, as accurately as you can. A record appears in the dialogue box for each point you digitize.
6. Type in the actual ground coordinates for the control points in the X and Y Coordinate fields. An asterisk (*) appears next to the record indicating that the control point has been entered and its ground control coordinates are now known.
7. Click **Save** to save the table of the actual ground coordinates.
8. ArcView then generates a RMS error called **Calculated Error**.
9. Click **Register**, if the Calculated Error is smaller than the Error Limit. The paper map is now registered.
10. If the Calculated Error is greater than the Error Limit,
    - Re-digitize the control points on the paper map
    - Re-enter the corresponding ground coordinates
    - Go to File, select Open and navigate to the directory where you saved the actual ground coordinates to bring them back into the coordinate table in **Digitizer Setup**.

- Select the first record, and click the puck icon and digitize the first control point.
- Repeat for the other control points.
- Click **Register**, if the Calculated Error is smaller than the Error Limit.

1.2.9 Digitizing features from a paper map.

Creating new Features in a project

- From the Untitled window, click **New**
- From the **New View**, set the projection of the paper map attached to the digitizer.
- Register the map
- Select **View** from the menu bar.
- Select **Properties**.
- Type in a name for the view e.g. houses.
- Click **OK**

Creating a View for point features

- Select **View** and choose **New Theme**.
- Choose **point** tool from the **Drawing tool** drop-down list.
- Click **OK**
- Navigate to your directory and **Save** the new theme.

The new point will appear in the newly named view, with a default symbol and colour. The new point will also be in editing mode. We are not ready to edit the point.

- Go the **View** menu and select S**top Editing**, from **Theme.**
- You would be prompted to stop editing,
- Click **Yes,** to stop editing.

Note: You can create all of your themes, then begin to digitize or create each theme, digitize it, and then move on to the next theme.

Creating a View for line features

- Select **View** and choose **New Theme**.
- Choose **line** tool from the **Drawing tool** drop-down list.
- Click **OK**.
- Navigate to your directory and **Save** the new theme.
- Go to View from the menu bar and select **Properties**
- Type in a name of the view e.g. Roads.
- Click **OK**
- Navigate to your directory and **Save** the new theme

The new line will appear in the newly named view, with a default symbol and colour. The new line will also be in editing mode. We are not ready to edit the line.

- Go the **View** menu and select S**top Editing**, from **Theme.**
- You would be prompted to stop editing,
- Click **Yes,** to **Stop Editing**.

Creating a View for polygon features

- Select **View** from the menu bar
- Choose **New Theme**
- From the **Drawing tool** drop-down list, choose the Polygon tool.
- Click **OK**
- Navigate to your directory and **Save** the new theme

The new polygon will appear in the newly named view, with a default symbol and colour. The new polygon will also be in editing mode. We are not ready to edit the polygon.

- Go the **View** menu and select S**top Editing**, from **Theme.**
- You would be prompted to stop editing,
- Click **Yes,** to **Stop Editing**.

Digitizing Points

1. Activate the point theme to be digitized
2. Select the theme by checking the box next to the theme
3. Select **Theme** from the **View** menu
4. Choose **Start editing**
5. From the view menu select **Draw point** button, because a point is being edited
6. Activate the digitizer as puck command from the **View** menu view
7. Go to the digitizer tablet, the puck should collaborate with the cursor on the screen and also with the map area.
8. Put points for the features you wish to draw e.g. *Houses*

If you no longer wish to add any more points,

- Select **Stop Editing** from **Theme** menu in the **View**.
- Click Yes to the save edits prompt.

Digitizing Lines

1. Activate the line theme to be digitized.
2. Select the theme by checking the box next to the theme.
3. Select **Theme** from the **View** menu.
4. Choose Start editing.
5. From the view menu select **Draw line** button, because a line is being edited.
6. Activate the digitizer as **puck command** from the **View** menu view.
7. Go to the digitizer tablet. The puck should collaborate with the cursor on the screen and also with the map area.
8. Now trace the line feature you are interested in, by clicking once with the appropriate key on the digitizer puck to start the line and again to change direction.
9. Double click to end the line using the appropriate button on the digitizer puck.
10. Sometimes lines need to be snapped. You then need to use the **general snapping** command or the **snap to vertex** command from the view menu. Before this can be done, the snapping radius must be specified using the required snap tool command.
11. Select **Stop Editing** from **Theme** menu in the **View**, after all lines are digitized and snapped.

12. Click **Yes** to the **save edits** prompt.
13. The line is highlighted after you digitize.
14. Click the **Clear Select** feature button to unselect it.

Digitizing Polygons

1. Activate the Polygon theme to be digitized
2. Select the theme by checking the box next to the theme
3. Select **Theme** from the **View** menu
4. Choose **Start editing**
5. Select the **Draw Polygon** button, from the view menu to edit a polygon.
6. Activate the digitizer as puck command from the **View** menu view
7. Go to the digitizer tablet. The puck should collaborate with the cursor on the screen and also with the map area.
8. Now trace and put points or vertex around the polygon features on the map you are interested in. e.g. *Houses, swamps, etc.*
9. Select **Stop Editing** from **Theme** menu in the **View**, after all lines are digitized and polygons closed.
10. Click **Yes** to the **save edits** prompt.
11. The polygon is highlighted after you digitize. Click the **Clear Select** feature button to unselect it.

Editing/Cleaning data

Usually as the map data is digitized to a project, the data clean up is done simultaneously once you have set the snapping environment.

2.0. EDITING SPATIAL DATA USING ARCVIEW 3.2™

After creating a point, line or polygon feature, you may wish to move, delete or change the feature. Features to be edited must be in a shapefile, ARC/INFO, or CAD format. To edit a theme that is not in any of these formats, you need to convert the theme to a shapefile, add it to your view as a new theme, and then edit this new theme.

To convert a theme to a shapefile

- Make the theme active.
- Choose **Convert to Shapefile** from the Theme menu
- Specify a name and location for the new shapefile.
- Click **OK**.
- Add the shapefile as a theme to the view.

2.1 Editing a point theme

There are many ways to edit a point theme. You can:

- Delete point features
- Cut and paste point features.
- Move point features

Please see Appendix I on how to perform these edits.

2.2 Editing a line theme

You can edit a line theme in many ways. You can:

- Delete line features
- Cut and paste line features.
- Move line features
- Resize line features
- Reshape line features
- Split line features
- Merge line features

Please see Appendix I on how to perform these edits.

Editing attributes when lines are split or unioned

You can:

- Change the ID number for each line segment
- Change or delete text in a record in a field.

2.3. Editing a polygon theme

In editing a polygon theme, you can:

- Delete polygon features
- Cut and paste polygon features.
- Move polygon features
- Resize polygon features
- Reshape polygon features
- Split polygon features
- Merge polygon features
- Create doughnut polygons
- Remove area of overlap between polygons
- Obtain the intersection of polygons.

Please see Appendix I on how to perform these edits.

Editing attributes when polygons are split or unioned

You need to set attribute update rules to specify how data in a polygon attribute table are dealt with when you split polygons using the Polygon Split tool, or merge polygon features using the Union features option.

For each field in a polygon theme's attribute table, you can choose one of the following Split rules:

> **Blank:** The value in both records will be blank.
> **Copy:** The original value will be assigned to both records (the default).
> **Shape Area:** The values will be the area of the new polygons (the default for fields called *Area*)
> **Shape Perimeter:** The values will be the perimeter of the new polygons (the default for fields called *Perimeter*)

For each field in a polygon theme's attribute table, you can choose one of the following Union rules:

Blank: The value in the resulting record will be blank.
Copy: The value in whichever record is first in the table will be assigned (the default).
Proportion: The value will be proportional to the areas of the merged polygons.
Add: The values will be added together in the resulting record.
Average: The values will be averaged in the resulting record.
Shape Area: The value will be the area of the new polygon (the default for fields called *Area*)
Shape Perimeter: The value will be the perimeter of the new polygon (the default for fields called *Perimeter*)

To set the attribute update rules for a field in a polygon theme's attribute table.

- Make the theme active
- Click on the **Theme Properties** button
- Click the **Editing** icon to display the theme's attribute table to which you want to apply the rule.
- Choose the **Union** rule you wish to apply to the field
- Choose the **Split** rule you wish to apply to the field.
- Click **OK**.

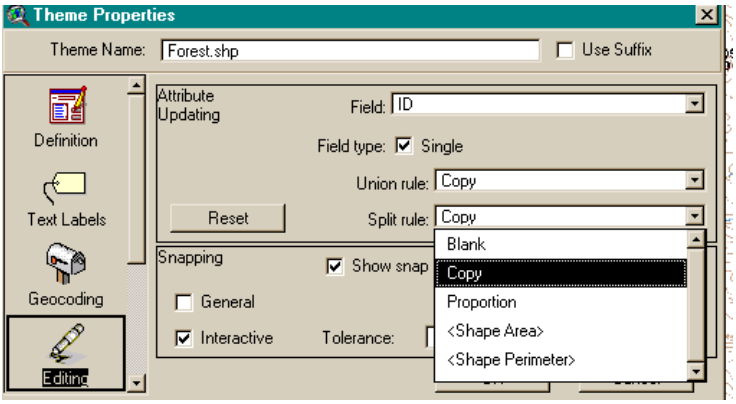


Figure 16. Dialogue box for setting attribute update rules.

- Choose **Start Editing** from the **Theme** menu. A dashed line will appear around a theme's check box in the Table of Contents to indicate the theme is now in edit mode. You can only edit one theme at a time in the view.

To save your edits while you are editing a theme

- Choose **Save Edits** from the **Theme** menu.

To stop editing a theme and save your edits

- Choose **Stop Editing** from the **Theme** menu.
- Click **Yes** to the **Save edit** prompt.

3.0 HOT LINKING IN ARCVIEW 3.2™

A hot link is a functionality in ArcView that allows one to access data directly from a view. The data format can be any of the following:

- Text files
- Images
- Views
- Tables
- Charts
- Layouts
- Video clips
- Scripts

Supported image formats are:

- X-Bitmap
- MacPaint
- Microsoft DIB (Device - Independent Bitmap)
- Sun raster files
- XWD (X Windows Dump Format)
- GIF (Graphic Interchange Format)
- TIFF (Tag Image File Format)
- TIFF/LZW Compressed image data

The Hot Link icon on the menu bar of a view activates the link.  .

When you click on the feature with the Hot Link tool, ArcView opens the linked data source. Each data source name becomes an attribute of a particular record.

- Make the theme for the hot link active.
- Identify the point, line or polygon feature to be hot linked.
- Open the attribute table for that feature.
- Select the record for that feature.
- Create a field to hold the data
    - From the Tables menu, go to **Table**
    - Select **Start editing**
    - From Tables menu, Go to **Edit**
    - Select **Add Field**
    - Set parameters for the new field
        Name: Image
        Type: String
        Width : 30 (to hold the number of characters in the pathname for the image)
    - Click **Close**
    - Click **Yes** to the request to save edits.
    - **Save** edits
    - **Exit** Tables

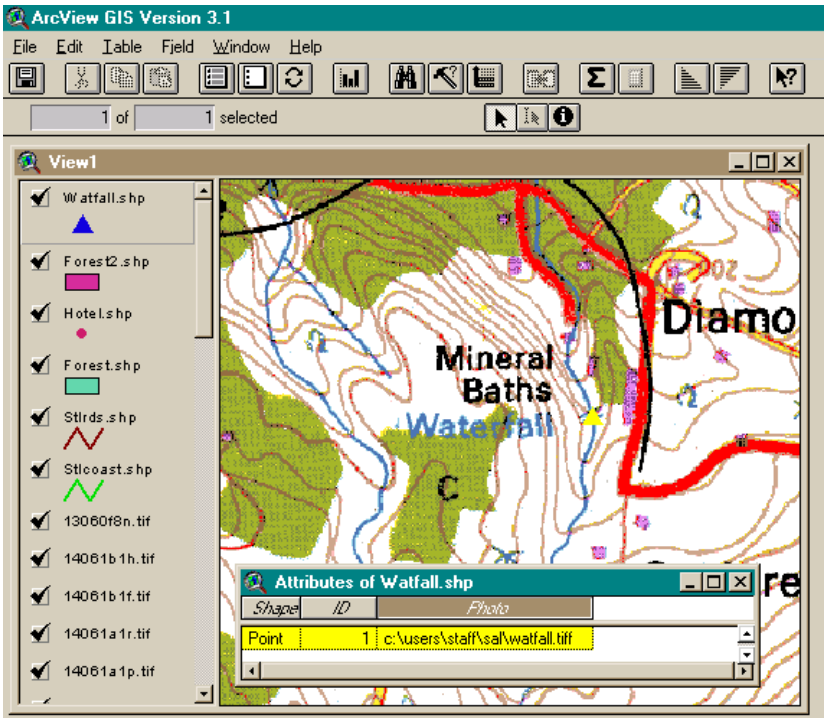


Figure 17. Defining a hot link in a theme's attribute table

- From the attribute table of the feature theme, select the User-Id for the feature to which you wish to link the data.
- On the same row as this User-Id, type in the pathname for the data. The pathname must include the full address of the location on the data on the particular drive. An example of the full path name for hot linking an image is:

  c:\users\sal\watfall.tiff

- If it is an image, type in also the extension for it, such as '.tif' in the pathname.

Since there is no default definition, the computer must find this location for the data every time the hot link is activated.

- Go to **View** and make the theme active.
- Open **Theme** menu
- Select **Properties**
- Choose **Hot Links** as the property.

- The window below appears.

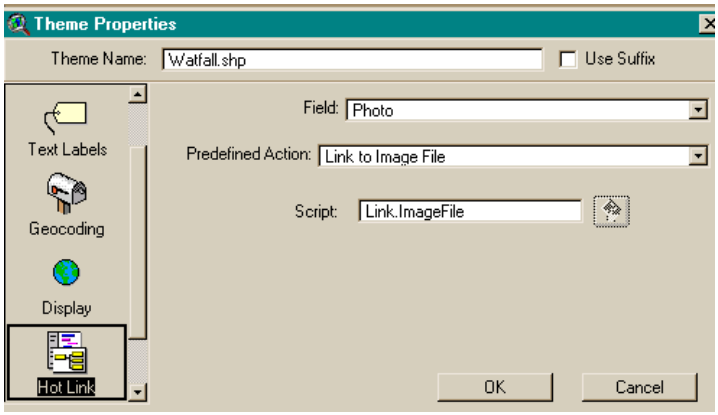


Figure 18. Setting up hot link properties

- Change the field to read the pathname of the data.
- Select **Predefined Action** from the pull-down menu, such as *Link to Image File*
- Click **OK**
- In the view, click on the **Hot Link** icon
- Click on the feature that was linked and the image should be added to the view. For point features make sure that the tip of the hot link icon is ***directly*** over the location of the feature.

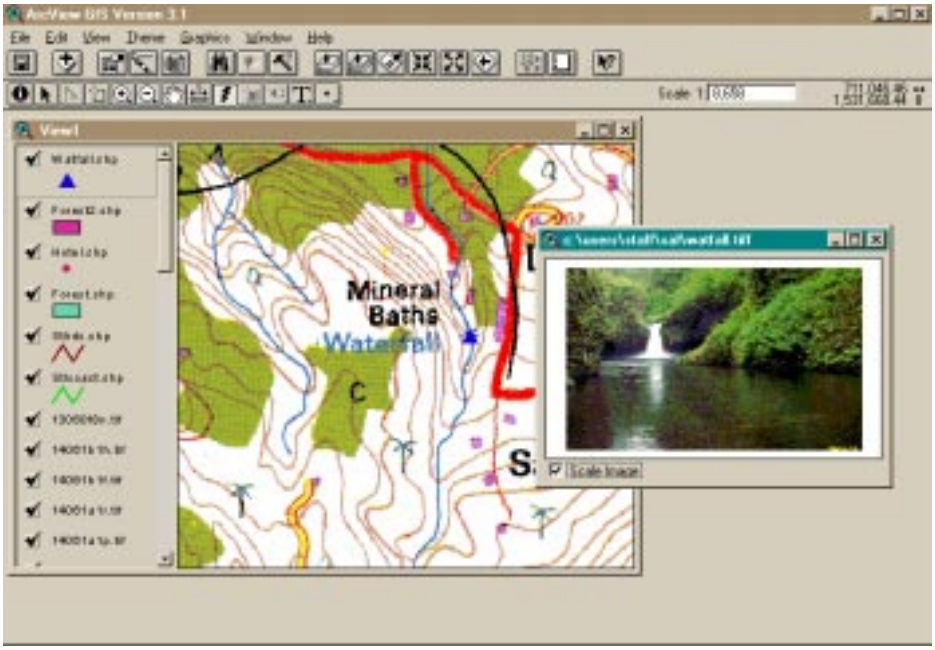


Figure 19. Image linked to location of feature

4.0 CREATING THEMES IN ARCVIEW 3.2 ™ USING GPS DATA.

Positions of objects on the earth's surface are measured in geographic coordinates. Global Positioning Systems (GPS) receivers can capture geographic coordinates. These coordinates can be expressed either as degrees of latitude and longitude, or as pairs of x. y coordinates. When these coordinates are saved in tabular format, ArcView allows you to create themes from such data.

The tabular data format that ArcView supports are dBASE (.dbf), ASCII text files delimited with tabs or commas (.txt), and INFO tables.

Locations stored in a tabular format are referred to as *event locations* or *events.* An *event table* is a table containing these events. Events allow you to map data that have geographic locations that are not in a spatial format, such as addresses and geographic coordinates in a table.

GPS data must be in a Delimited Text '.txt' format so that ArcView can read it.

To add tabular data with x, y coordinates to a map.

- Make the **Project** window active
- Choose **Add Table** from the **Project** menu.
- Choose the type of file that you want to load from the **List Files of Type** dropdown list, in the dialogue box that appears.

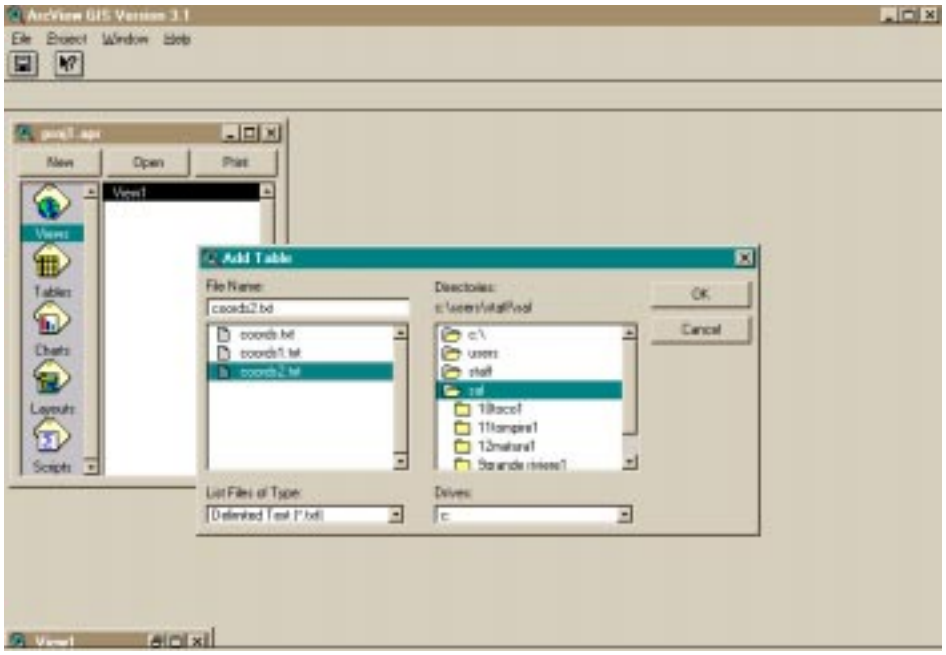


Figure 20. Dialogue box for adding a file to ArcView.

- Navigate to the directory that contains the file you want to add.
- Click on the file you want to add.

- Click **OK**. The file is opened in your project. The name of the file is listed in the Project window.

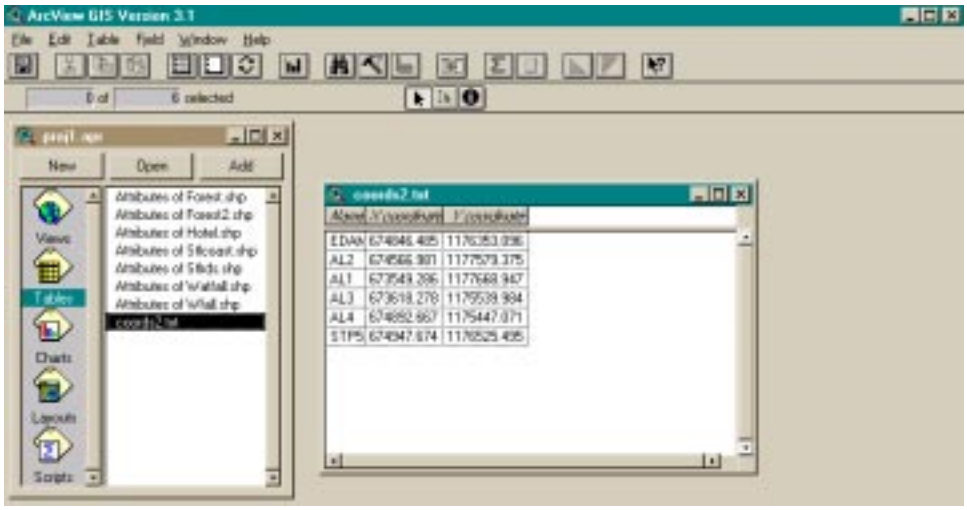


Figure 21. File opened in Project window.

- Open the **View** into which you want the data, or create a new one.
- Go to the **View** menu and select **Properties**, to set the units for the x, y coordinates of the table.
- Choose the units from the **Map Units** dropdown list that appears.
- Click **OK**.
- Choose **Add Event Theme** from the **View** menu.
- Choose the name of your table from the dropdown list that appears in the dialogue box.
- Select the name for the **X field** and **Y field** dropdown lists from your table.
- Click **OK**. A new theme is added to your view containing all the points defined in your table.

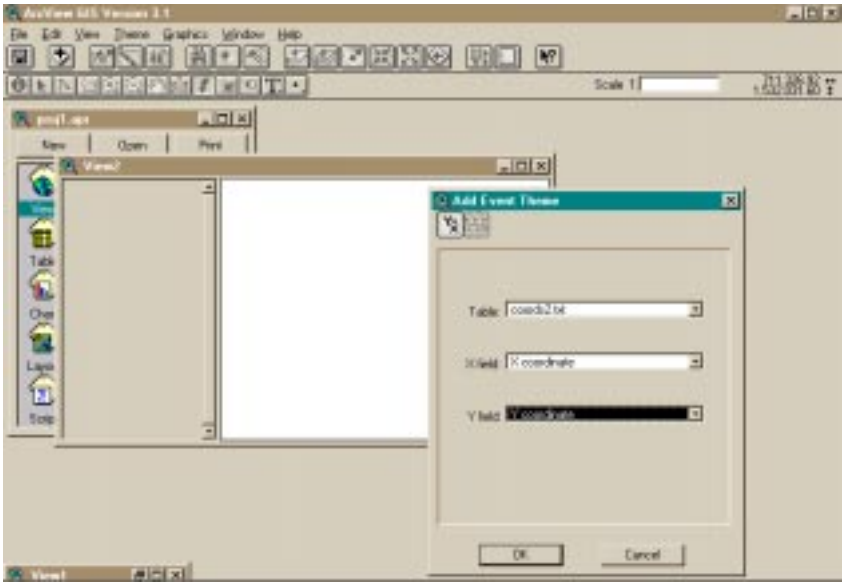


Figure 22. Dialogue box for Add Event Theme.

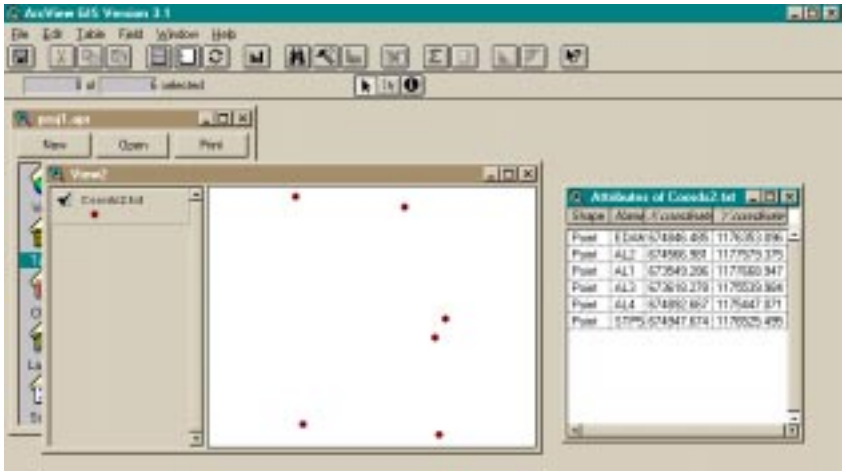


Figure 23. A new theme added from GPS data.

5.0 ATTRIBUTE DATA AUTOMATION USING MS ACCESS™

Attribute data describes the characteristics of spatial features. In order to build a GIS, a digital database of the attributes of the spatial features needs to be collected and automated. For example, the spatial feature, lake, may have the following attributes: Local name, maximum depth, water quality, biotic organisms, date of last water treatment, main uses.

Attribute data are automated into Database Management Systems (DBMS) such as MS Access™, DBASE IV, Oracle, FoxPro, DB2. A DBMS provides the environment for the automation, updating, analysis, integration, and distribution of attribute data. The

integration of a DBMS with the spatial functionalities of GIS enhances the capabilities of GIS as a spatial analysis tool.

Sources of Attribute Data

Attribute data may be newly collected in the field or obtained from existing records, registers, files, forms, cards and reports. Once a spatial feature has been identified, the next step is to identify the attribute data that would be required for effective use of the spatial data in GIS analysis and manipulation. This is followed by the identification of sources of this data. If the data exists in analogue form, then steps should be taken to automate the data. The process of automating the data is described below.

This module will cover the following database topics:

1. Creating a database in MS Access
   Creating a new table
   Adding attribute data to the table
2. Connecting ArcView to an External Table
   Creating an SQL connection
   Joining an external table to a theme table

5.1 CREATING A DATABASE IN MS ACCESS 2000™

MS Access is one of the more popular DBMS that ArcView supports. In order to use MS Access to automate data, a blank database must first be created, using the following procedure:

- Start MS Access
- Click on **Blank Access database**
- Click **OK** (See Figure 24)
- Navigate to the directory in which you wish to save the database.
- In the Filename input box, type in the name of your database, "**Schools**"
- Ensure the database type is Microsoft Access.
- Click **Create.** The new database is created.

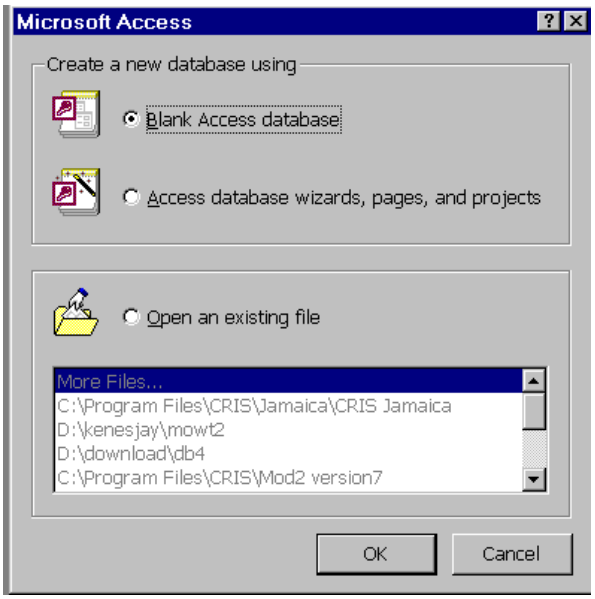


Figure 24. Dialogue Box for creating a new database in MS Access

5.1.1 Creating a Table

Ms Access is an object oriented database and consists of a number of object such as:

- Tables
- Queries
- Forms
- Reports
- Pages
- Macros
- Modules

These objects rely on the data that is stored in tables for their functionality. For a description of each object type, please refer to Ms Access **Help**.

Attribute data is stored in tables. Each table should represent an entity and its attributes should consist of the descriptive elements required.

5.1.2 Creating tables in Design View.

- Double click on **Create table in design view.**
- Using the information in Figure 25, enter the field name, data type and description for each of the five fields.

A table consists of a field name, data type and appropriate description. Data types can be Number, Text, Date and Time. Data types can be selected by clicking on the drop down list indicated by the down arrow in the cell. The description is utilized for the data dictionary. Object oriented databases also have field properties that afford users additional control over data entry. For further information, please see MS Access Help.

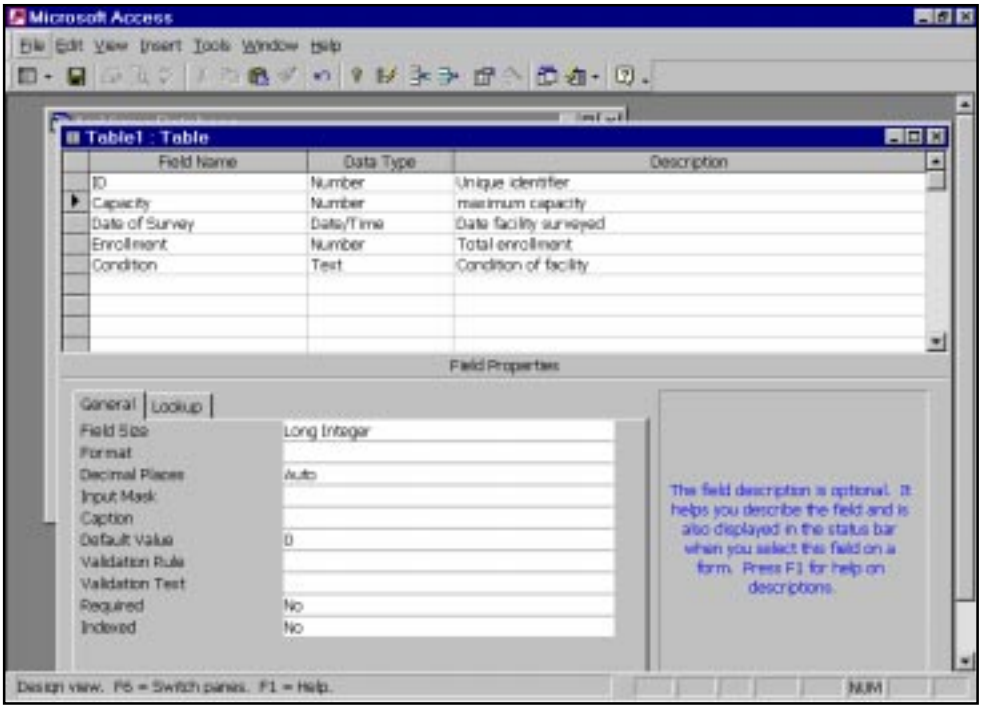


Figure 25. Designing aTable

Data types should be carefully selected as appropriate to the data. Table I shows the data types in MS Access. You should note that any data that will be calculated must be entered as a numeric data type.

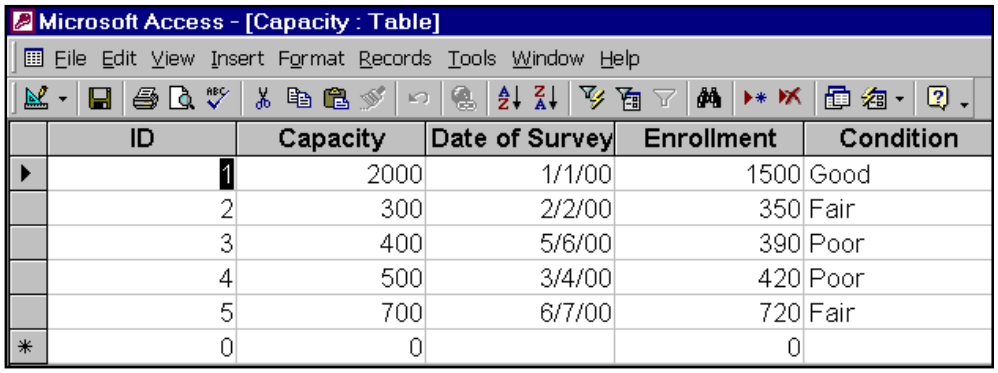
Table 1 – MS Access Data Types

Data Type	**Example**
Text	Default length of 50 characters, maximum 255 e.g.: address of school – **12 Picton Street, Port-of-Spain**
Memo	Maximum length of 64,000 e.g. Notes on special conditions
Number	Numeric field, calculations rounded off e.g. enrollment - **1200**
Currency	Numeric field, highly accurate calculations, no rounding e.g. cost of maintenance - **$100,000.00**
Date / Time	Date of construction – **2000/11/01**
Auto Number	Access automatically assigns a unique sequential number to a field.
Yes / No	Used for a field that only one of two possible responses e.g. Did student pass or fail?
Ole Object	Allows for linking to objects such as pictures and documents
Hyperlink	Creates a field which allows input of a hyperlink address e.g. Web address of supplier
Lookup wizard	Creates a field that allows you to choose a value from another table or from a list of values e.g. **Good, Fair** and **Poor** as options for condition of school.

5.1.3 Adding records to the table

- In the Database window, double click the new table that was created.

- Enter five records as shown in Figure 26 by clicking on each cell and typing in the entry.



	ID	Capacity	Date of Survey	Enrollment	Condition
▶	1	2000	1/1/00	1500	Good
	2	300	2/2/00	350	Fair
	3	400	5/6/00	390	Poor
	4	500	3/4/00	420	Poor
	5	700	6/7/00	720	Fair
*	0	0		0	

Figure 26. Adding Records to an Access table

Columns may be resized by dragging for convenient viewing.

- Close the table
- Select **File, Exit**

Figure 27 shows commonly used data entry shortcut keys.

Data Entry Shortcut Keys

Action	Keystroke
insert current date	Crtl + semicolon (;)
insert current time	Crtl + colon (:)
insert value from the same field in the previous record	Crtl + apostrophe (‘)
add a new record	Crtl + plus sign (+)
delete the current record	Crtl + minus sign (-)

Figure 27. Commonly used Data Entry Shortcut Keys

5.2 Connecting ArcView to an External Database

GIS data analysis often requires that non-spatial data be added to a project. The data may reside in a table or a query of another database. This requires that ArcView connect to the database and its specific tables or queries.

An ‘**ID**’ field is generated by default when a new shape theme is created in ArcView. It is always defined as numeric. The ‘**ID**’ field is the field that is common to both tables and is used as the join field. To facilitate connecting to another table, it is critical that the ‘**ID**’ field of the external table be defined and named exactly as the ‘**ID**’ field in the ArcView theme table to which it will be joined.

- Make the ‘**ID**’ field the primary key of the table.
- Right Click on the ‘**ID**’ cell.

- Select **'Primary Key'.**
- Select **File, Save** and name the table "**Capacity**"
- Click **OK** and close the table. A new table is listed in the database window.

ArcView can connect in two ways:

- The Project / Add Table Menu option
- The Project / SQL Connect Menu option

5.2.1 The Project / Add Table Menu Option

This option allows the addition of *.dbf , text delimited* and *INFO* files to an ArcView project. MS Excel spreadsheets may be exported as either *.dbf* or *text delimited* files and imported into ArcView. Figure 28 illustrates the **Project/Add Table** dialogue box.

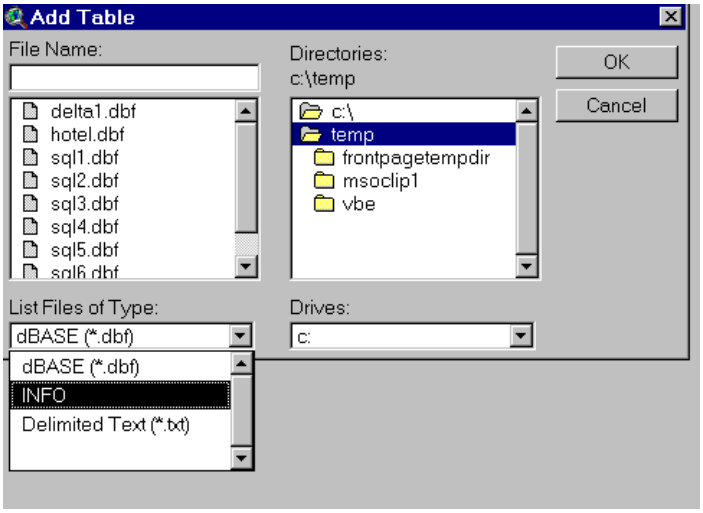


Figure 28. Project/Add Table Dialogue Box

5.2.2 SQL Connect Menu Option

The SQL Connect function connects an ArcView project to a database utilizing Microsoft's Open Database Connectivity (ODBC) standard. The ODBC driver for the database must be installed. The source name is setup in the ODBC Data sources manager in the Control Panel by the system administrator. ArcView should work with any database with an ODBC driver and database client software. Please refer to your operating system manual for instructions on installing an ODBC driver.

SQL connect utilizes the ODBC source name for the database. SQL Connect allows external data to be accessed via SQL. The returned records are stored in an ArcView table. Records can be manipulated but not modified.

5.2.3 Creating a Theme Table For Joining

- Create a new point shapefile theme using the instructions from Section 1.1 in the Head –up digitizing module.
- Name the new theme "**Schools**"

- Add five points to your theme
- Enter the ID numbers 1,2,3,4,and 5 in the Theme table.

Figure 29 indicates an example of this theme.

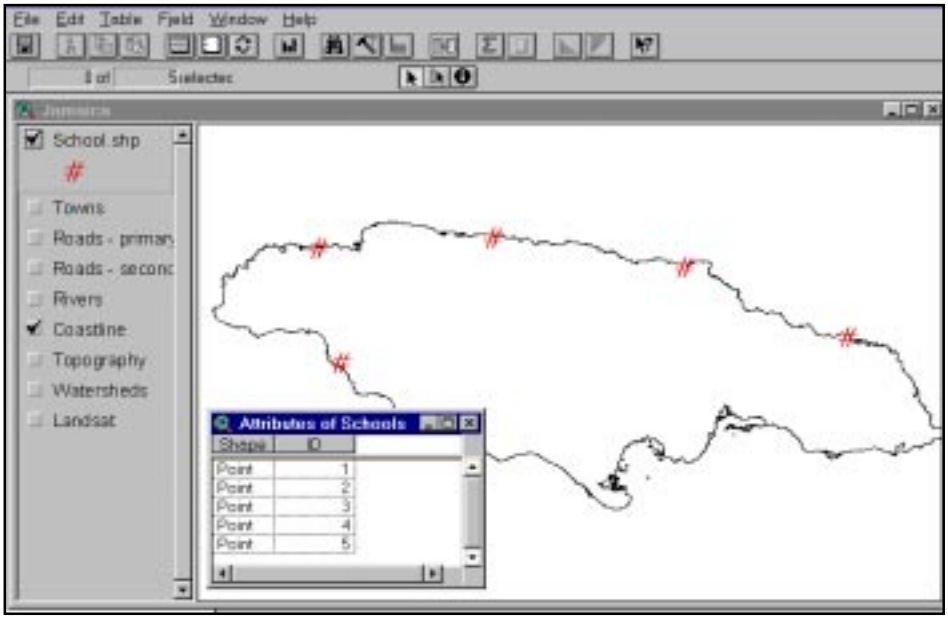


Figure 29. An Example of a Point Theme and Table

5.2.4 Creating an SQL Connection

- Select **Project: SQL Connect**
- Navigate to the location of the MS Access database "**Schools.mdb**".
- Click **OK**

As indicated in Figure30, tables available to ArcView will be listed in the **Tables** box.

- Click on "**Capacity**" table created
- Click on **All Columns**
- Name output table in **'Output Table:'** box
- Click on '**From:**' Box. Double click the name of your table in the Tables Box.
- Click on **Query**.

Figure 30. SQL Query Dialogue Box

5.2.5 Joining Tables

The new table is added under **Tables** in the project window. There are now two tables listed in the Project window.

- Open both tables in the table window.
- Click on the '**ID**' Field name on both tables.
- Click on the Theme table to make it the active table.
- Go to **Table** from the menu. Select **Join.**

Figure 31 shows the two tables to be joined using the **Join** selection.

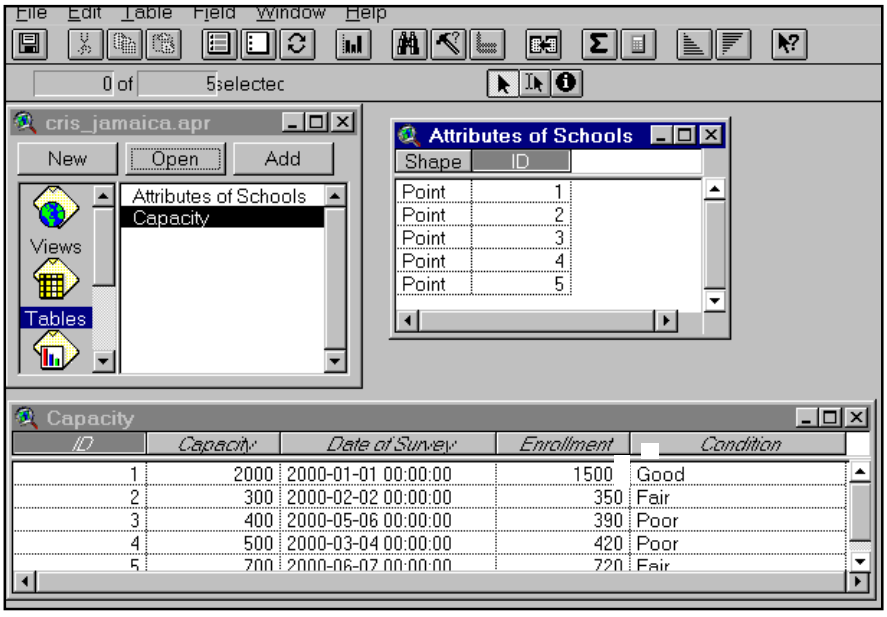


Figure 31. Joining Tables

Figure 32 indicates the Theme table (Attributes of **Schools**) joined to the **Capacity** table.

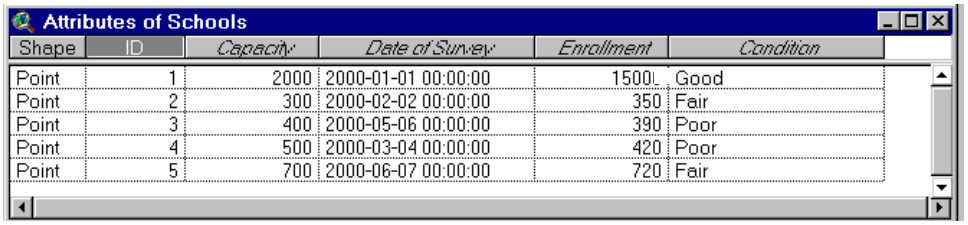


Figure32. Joined Tables

The joining of the **Capacity** table to the Theme table, **Schools**, now allows for the spatial querying of the data that was in the external table.

6.0 Data Management Requirements in GIS

The development of a GIS involves the design and population of a database, which meets specific user requirements. It includes the transformation of data from existing formats to the formats required by specific GIS products and often requires the integration of different data. A successful GIS is one that will be utilized and expected to evolve over time. This requires a robust plan and database management system to support this development

Figure 33 indicates that data management is one of the central elements of a GIS. It is an integral part of the information system that not only manages internal data manipulation but also the management of data input.

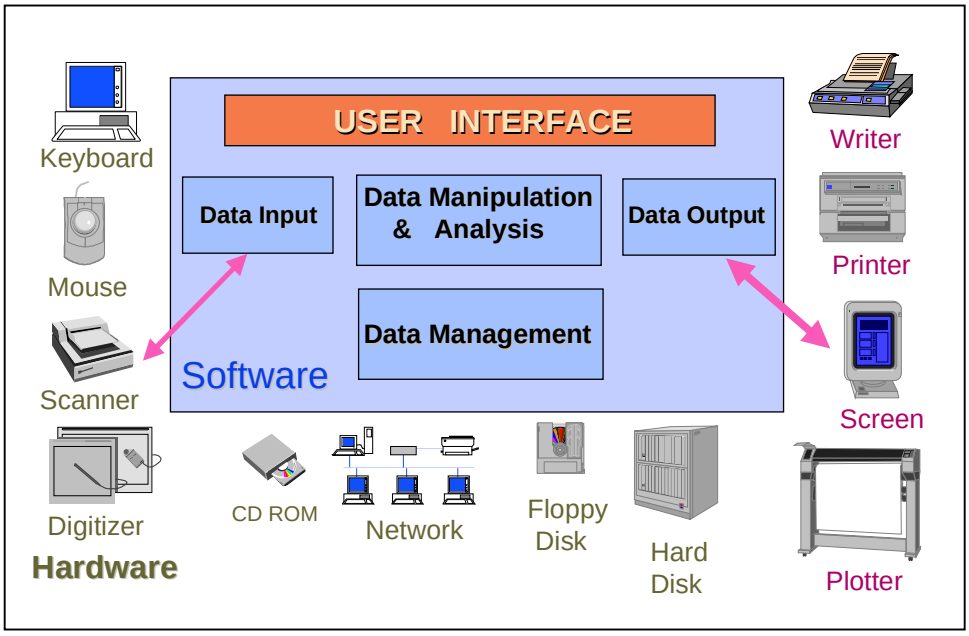


Figure 33. Components of a GIS

The success of a GIS is often measured by how accurately the design meets the requirements that were specified. However, users define a successful system as one which produces accurate and timely data in the formats required. To achieve this data management requirements must be considered and met. These include data identification and evaluation, classification and coding, data entry and validation, storage and access control, data maintenance and dissemination. These issues are part of a comprehensive database development plan, as shown in Figure 34. The management of data is not a single task but part of the continuous cyclic development of the database. These tasks themselves may be expected to evolve with the database and technology.

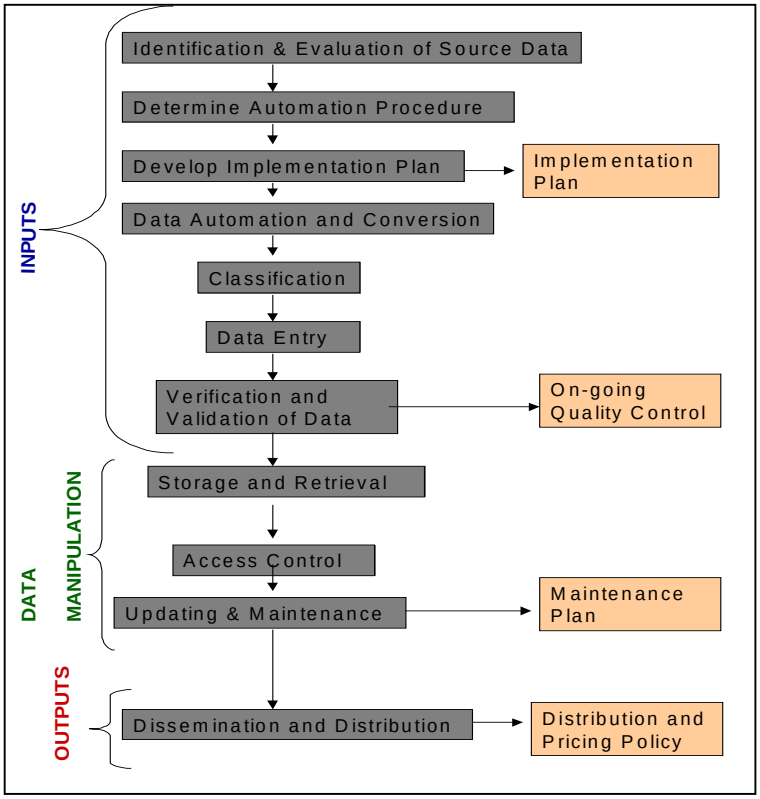


Figure 34. Database Development Plan

6.1 Data Identification and Evaluation

The identification and evaluation of system data is the primary stage in system development. Requirement analysis will identify data needs but the data sources must then be identified and evaluated. Key, reliable and current data sources that can form the foundation of the GIS must be identified.

6.1.1 Data Identification

In order to identify data requirements several questions must be considered:

- What will the GIS be used for?
- Who will the users be?
- What information will be required and in what format will they be required?

The data format currently being used should be identified and their usability examined. The evaluation of the existing data is aimed at determining their currency, quality, format, resolution and other restrictions to its use.

6.1.2 Database Content and Structure

At the conceptual stage it is important that all potential users come to a consensus on the features and attributes that should be included in the database. Data characteristics and the degree of intelligence required should be thoroughly evaluated and the maintenance

responsibility for database features should be clearly identified. Database needs should be prioritized and development phased.

A principal task of GIS development is the determination of the database content. There is a need to establish:

- Data features and attributes of interest to most or all users.
- The most adequate data sources.
- Data to be contributed by each participant.
- The data to be shared by the GIS products.
- The database design that will satisfy requirements.

6.1.3 Data Sources

Data may be collected from a variety of sources. The objective of the plan is to prevent surprises and avoid cost overruns. A thorough analysis of source data is required to prepare initial data conversion costs. The plan should include the matching of data needs to database design. The following issues should be considered:

- Whether the source is primary or secondary.
- The availability and reliability of metadata.
- The format of the data.
- The physical condition and location of hardcopy data.

Source data must be evaluated in terms of their quality and completeness. Source data that has to be created must be identified and it is important to consider alternate sources of data such as aerial photography or satellite imagery. The prioritization of new data items and source decisions is essentially an economic decision.

6.1.4 Data Collection Strategies

The data collection strategy adopted is a function of data availability, cost and efficiency.
The assembling of the data required by a GIS can be a significant exercise. The format and location of the data determine the degree of effort required. Data may be available in primary or secondary forms and in raw or compiled forms. Care should be taken when working with report formats to ensure that the tabulation details coincide with the detail level required of the GIS.

6.1.5 Source Preparation

Scrub is the manual preparation, edit verification and correction of a map or drawing prior to digitizing. Sources requiring scrub need to be identified and prepared appropriately for data conversion. A manual that addresses the details of the scrub plan should be prepared and scrub procedures should be driven by the database requirements.

6.2 Data Integration

The nature of a GIS requires that data be integrated from a number of different sources. The success of this integration affects the richness and accuracy of the data in the GIS.

Several integration issues must be recognized and successfully managed to achieve efficient and effective integration.

Existing data may have varying characteristics such as scales, projections, datums, currency, levels of accuracy and resolution. Metadata should be provided with each data collected to ensure that accurate information can be generated for the interpretation process.

Data of different formats can be integrated into a GIS. These include vector files, attribute database files, text files, raster, video and scanned images, digital photographs, sound and Global Positioning Systems (GPS) data.

The integration of multimedia data has served to increase the depth of GIS analysis. Multimedia Image Data include aerial and landscape photographs, infra-red images, satellite data and video based images. Theses images have the specific characteristics of Image_ID, Format (e.g. '.bmp', '.tiff ', '.avi'), Resolution (e.g. 300 dpi, 600dpi), Capture date, X and Y co-ordinates and Colour.

Picture elements are identified by rows (X) and columns (Y) and the content of each picture element is represented by a colour, or a grey scale value. The easiest physical encoding technique is the bitmap (.bmp). Sound and video images are stored digitally in ".avi" format. The limitation to widespread use of image data is the large amount of physical storage required.

6.3 Data Classification and Codification

Database attributes represent real world features. In order to efficiently create a database, it is necessary to classify and code data. A unique numbering system that supports classification and a unique identifier is assigned to each class. Features are tagged with these numbers during the data automation process and it is on the basis of classification that features can be selected and manipulated. Classification facilitates the queries and reports required of the system. The efficient design of classification and coding relates directly to the level of efficiency of query and report generation. Coding should be determined in the context of system requirements.

6.4 Data Entry Management

Data entry management is an important element in the maintenance of data quality. It is also an important time and cost consideration that should not be underestimated. The time and cost of data entry relates to data source quality and the mode of data entry selected. The format, condition and location of data sources must be carefully considered. The mode of data entry employed must be appropriate to the data source and the availability of trained staff.

6.4.1 Spatial Data Entry Modes

A variety of data entry modes exist. Each mode has its strength and weakness and is particularly applicable to certain types of source data. The most cost efficient mode of

data entry should be chosen. Cost efficiency must include time and staffing considerations. The choice of data entry options are listed below:

a) Direct keyboard data entry is well suited to textual attribute data and map annotations in small to moderate volumes. Scanning with Optical Character Recognition (OCR) should be considered with large data volumes.
b) The digitizing of hardcopy maps may be required in instances where digital maps are not available. It is applicable to small and moderate map conversion when skilled staff is readily available and time is not a constraint.
c) Scanning and automated vectorization of maps, textual and image documents can be an extremely efficient method of data entry. It may be costly depending on the volume being scanned. The condition of the source map is a critical factor, which will relate directly to the amount of checking and cleaning required of the scanned document.
d) The conversion of existing digital data is also an option, if it is necessary to convert digital data to another format. Care must be taken to note the formats of sources and the conversion methodologies required for software compatibility.

6.4.2 Attribute Data Entry Forms

Data forms are utilized for the entry and retrieval of attribute data. Data Entry Forms should exist in both hardcopy and digital format. Raw data should be collated, coded and entered onto hardcopy forms that should then be verified and checked before digital entry. Digital data entry should be done from these forms to facilitate speed, efficiency and accuracy.

Digital data entry forms can integrate controls at the attribute level, which serve as a screening and data quality device. These controls relate directly to the classification and coding of the data. The degree of control exerted by the data form will be a factor of the software being utilized.

6.5 Data Verification

Data verification consists of the processes of data quality control and quality assurance. It is dependent on the anticipated applications and output products. Data quality is a significant requirement in any automation project. It is an indication of how well the GIS data matches reality. It impacts on the data conversion method selected, cost and the confidence users will ultimately have in the GIS.

Data quality is often a balancing act between user needs and cost. The realities of data conversion economics must be considered and the positional accuracy of source documents is a key issue, which must be examined. It is always desirable to improve the accuracy of source documents. A reduction in the allowable positional error can increase costs exponentially.

6.6 Standards

The establishment and implementation of standards is critical to successful technical implementation. Standards are a statement of quality. They facilitate cost effective use of the GIS. The more heavily used and complex a GIS is, the more critical the issue of standards. They form the basis for data exchange and communication. The development of standards requires extensive evaluation efforts and should be applied to the following:

- Database design
- Accuracy levels
- Graphic presentation

6.7 Quality Control

Quality control ensures that the data standard determined for the GIS is applied and maintained. The type and extent of control will depend on the functionality of the software being utilized. It should include the following elements:

- Data checks before, during and after data entry.
- Data entry form controls.
- Data table design controls.
- DBMS controls such as referential integrity.

6.8 Quality Assurance

The client should be able to determine the acceptability of data acquired. This process of data acquisition and automation must be documented and agreed to by all parties. In order to determine the acceptability of data, random sampling techniques are often utilized. Sampling may also be conducted by a neutral third party on the basis of established acceptance criteria.

Quality assurance may be conducted using both manual and automated validation approaches. Manual quality assurance is designed to verify the accuracy and completeness of output products. Automated quality assurance utilises custom software designed to test the integrity of converted data. Quality assurance may also include field verification of data.

6.8.1 Manual Validation

Manual validation of source documents may consist of the following:

- Absolute/relative positions must be within acceptable tolerances.
- Feature annotation must correspond to the information provided on the source document and be in accordance with the graphic specifications.
- Text offsets and orientations must be correct and be in accordance with the graphic specifications.
- Feature annotation must be converted, formatted, and displayed in accordance with the GIS data conversion specifications.
- Default attribute values must only be used in feature annotation when an acceptable value does not exist on the source documents.
- Features depicted on the source documents and specified for conversion must be included on the check plot.
- Graphical connectivity must be maintained in accordance with specifications.

- Feature representations must correspond to the source document representations and all must be present.
- Features spanning multiple plots must be correctly edge matched.
- Obsolete source record symbology must be correctly translated into GIS standard symbology in accordance with GIS data conversion specifications**.**

6.8.2 Automated Validation

Automated validation checks may consist of the following:

- Each database record must represent a feature as specified in the GIS data conversion specifications documents
- Each feature record must contain values for all required attributes.
- Feature attributes must contain acceptable values.
- Attributes containing calculated values must correspond to the values resulting from appropriate formula or algorithm.
- All attributes for features requiring network connectivity must be logically consistent e.g. a 4-inch pipe cannot be connected to a 3-inch pipe without a reducer.
- Each graphic element requiring connectivity must be connected e.g. in a soil coverage each boundary line between soil types should close to form a polygon.

6.8.3 Field Verification

Field verification is required to ensure the accuracy of the data. Features located in the field and specified for data conversion must be included on a GIS check plot. This check plot is the basis for field verification. Field verification checks that the digital data is positioned on the GIS check plot within acceptable tolerances for relative and absolute accuracy. Field observation ensures that features are classified correctly and feature displayable attribute values correspond to values observed or measured in the field**.**

6.8.4 Assessing Data Quality

The quality of data in a GIS may be assessed in general and specific terms as they relate to the cartographic and graphic elements. The measures listed below are used to assess the general quality of the GIS:

a) Completeness is the degree to which all features are included in the database. This is applied to graphic objects, attributes, annotation, connectivity and topology. It is more related to the source maps and records.

b) Correctness consists of locational object information. It considers the representation of object, attribute information and database relationship.

c) Timeliness is a measure of the temporal correctness of the database. All data must be current or of a specified vintage.

d) Integrity demonstrates and confirms the usability of the database. Graphic integrity examines the connection of lines, topology and connectivity of objects and attributes. It considers that records are correctly built and that there is no missing or duplicated data.

Cartographic data quality is assessed in terms of relative and absolute accuracy. Relative accuracy is a measure of an object's position relative to another in terms of the maximum deviation between the two objects. Absolute accuracy considers how closely objects are positioned within an absolute reference frame. It is the maximum deviation of an object on a map vs. its true location on the earth's surface.

Graphic quality is assessed in terms of the legibility of data, consistency of graphic representation, aesthetics and the adherence to graphic standards such as symbols, line style, font size and placement.

6.9 Data Storage and Retrieval

A GIS database can be stored in a number of configurations and on a variety of storage media. The database can be centralized or distributed. A GIS consists of thematic layers and coverages, which may be stored as a single entity or tiled to reflect a chosen administrative boundary. Similarly the data media for storage can be massive for bulk storage or form smaller units for convenient dissemination.

Retrieval mechanisms are a function of the database design and storage choice. They rely on database queries and their functionality and robustness will depend on the GIS software, database management systems and operating systems being utilised.

6.9.1 Storage Structure

The storage structure is related to structural design of the database. A centralised database design lends itself to bulk storage with massive hard drives, backup mechanisms and disk imaging. Distributed databases pose significant challenges to GIS databases because of their cartographic size. Data can be centrally stored and distributed over local or wide area networks but high data transfer speeds are critical to maintaining performance levels. Another option may be to distribute spatial data databases via CD-ROM and provide distributed network access to current attribute databases.

The data may also be compressed to facilitate storage and transfer. Compression Techniques are utilized such as CCITT Group IV (an international compression standard), the use of Tag image file format (.tiff) and Run length Encoded (.rle) for line work.

6.9.2 Storage Media

A number of storage options exist such as hard drives, optical disks, magnetic tapes and removable disks. The increasing size, retrieval speeds and reduced cost of hard drives have reduced the need to resort to other means of permanent data storage because of space constraints. Optical disks may be more convenient because of their mobility and relative stability. The increasing size of other removable disks such as zip disks offer an interesting option for smaller GIS databases because of their speed of access and 're-writeability'.

6.9.3 Data Retrieval

The linking of spatial and attribute tables expands the functionality of a GIS and facilitates efficient data storage and sharing. Spatial and attribute data are virtually linked to facilitate GIS analysis. This allows for attribute data to be maintained and distributed separately to the spatial data and accessed only when required. This has significant impact on permanent data storage requirements and is ideally suited to distributed systems. This type of design is supported by the development of Client Server architecture, the Internet and Active server pages (ASP). Server side processing greatly reduces the processing and storage demands on client machines.

Data retrieval is based on the creation and execution of queries. The query language will vary with the software being utilised. In some cases the attribute data may be externally stored within a separate database management system and an interface connection will have to be created. Most GIS will support the creation of permanent database connections and in particular SQL connections.

6.10 Access Methods and Control

Access control is required to protect information from unauthorized or accidental modification, destruction, disclosure and use. Data collection is an investment and the need for security increases as the value of information is recognized by the organization. This is particularly true in the present IT environment with the need for daily virus protection. In order to implement access control it is necessary determine the following data access issues:

- The levels of data access required.
- The allocation of users to access levels.
- The identification of restricted data and the method of distribution that will apply.
- The identification of potential threats
- The mechanisms available for access control
- A determination of data access costs.

The risk management view of security evaluates access control and the need for security in terms of the following:

Confidentiality	- level of access
Integrity	- wholeness, completeness
Availability	- back ups
Utility	- usefulness
Authenticity	- accuracy, correctness of information

There are two dimensions to security, system security and data security. System security relies on technology and is a function of software capabilities. Data security is established through data access policy.

Several security mechanisms can be employed. Username, passwords, fingerprints or voice can be used to determine authorization to a specified level of access, data or

services. Access Audits should be run on a regular basis as a security measure and to monitor usage of the database.

6.11 Updating and Maintenance Procedures

The updating and maintenance of a GIS is a critical issue. The currency of data will ensure the value and continued use of the system. Updating and maintenance procedures should be designed in a feasible manner that take into consideration the resources of participating agencies. It should be practical and applicable. The interest of participants in database maintenance will vary and it is impossible to maintain a central database at different rates. The simplest solution is the sharing of a centrally maintained land (LAN?) base with participants maintaining their own database layers.

Updating and maintenance procedures should consider which participants have specific responsibility for maintenance, data currency and updates. The procedures should consider if responsibilities relate to all data or to a specified subset of data. If so, it must clearly identify the subsets and participants that are responsible for maintaining the portions of the database. The issue of a participant abandoning this responsibility must be examined and a consensus of opinion reached as to procedures in this instance. The procedures must be clearly determined, agreed to and documented.

6.12 Data Dissemination and Distribution

The dissemination and distribution of data incurs legal liability and data rights on the part of the distributing agency. GIS data is an asset to organizations and has come to be considered a property, since a property data can be owned, held or kept from others.

The design of the GIS having a number of participating agencies requires that rights and liabilities be determined. It is possible in a distributed system to have a number of agencies each responsible for its own database, which it shares with the larger entity. In such scenarios liabilities and rights must be clearly determined by all parties prior to the implementation of the system. The management of these activities requires that these liabilities and rights are considered and an appropriate dissemination policy determined. A data dissemination policy should determine the following:

- The distributing agency or unit.
- The data items that should be distributed.
- The medium of distribution.
- A pricing policy (if necessary)

6.13 Data Distribution Options

Data distribution may be undertaken as a public service or for commercial purposes. The private sector may act as a distribution or value added agent. There are a number of distribution options, some of which are listed below:

- Each department distributes own data to customers
- A single value-added agency - one-stop shopping
- Multiple value-added agencies for specific markets

- Multiple value-added agencies for specific data

6.14 Liability

The provision of land-related data exposes the provider to liability for losses incurred by the user as a result of inaccuracies in the data. Data management must consider accuracy and quality issues inherent in data collection and update, data entry, data model and scale, the accuracy of software and hardware, paper and plotting accuracy. The provider may be liable for breach of contract, delivery timetables and negligence. The provider may also be liable for accuracy and non-performance and it is therefore necessary to include an accuracy disclaimer with data provided (where necessary).

In order to effectively manage data liability the following issues must be considered:

- Definition of public records and access issues
- Policy on freedom of information, costs of public information and data resale
- Copyright laws
- Digital data security issues
- Map maintenance liabilities

6.15 Data Ownership

Data is an asset that can be owned. However, because of the digital nature of data special care must be taken to specify and protect this ownership. The data dissemination policy should address ownership concerns. An organization may hold data on behalf of the wider community or may also hold data in a custodianship.

Copyright may be used to protect the investment of organizations in the database. It assures that the creators retain the sole right to its use. An external copyright can prevent distribution among participants. Licensing can establish a contractual relationship between participants and the purchasers of data.

The nature of some projects requires ownership and operation of a common data centre. Asset ownership should be clearly specified and if payments are required they should be fully scheduled. Data ownership and maintenance issues must be carefully detailed.

6.16 Pricing

The pricing of data is an economic issue, which often takes on political overtones if the data agency is a public agency. The core issue sometimes border on cost recovery. Pricing strategies are often a trade-off that balances public opinion and some measure of cost recovery. The legal issue of the right to freedom of information must be considered. It may be that the only costs that can legally be recovered are costs incidental to the supply of the data to the end user. Cost can be determined on the basis of a number of parameters. These may include the following:

- Volume of data supplied
- Extent of Coverage: Parish / County / Country

- Form of product: list / print / plot / chart
- Use of information: public benefit / profit making
- Market value
- Reciprocity arrangements
- Legislative or statutory requirements
- Precedent

A number of cost recovery options exist and are listed below:

- Direct cost recovery (labour & material only)
- Incremental cost recovery
- Partial cost recovery
- Costs of system development / data maintenance / data distribution
- Market value pricing (supply/demand)
- Full cost recovery (HW/SW, data, training, salary)

References

Environmental Systems Research Institute. 1996. **ArcView GIS**. Environmental Systems Research Institute , Redlands, CA, USA.

Montgomery, G.E., and Schuch, H. 1993. **GIS Data Conversion Handbook**. GIS World Books.

APPENDIX 1

The notes in Appendix I are taken from the on-line Help function of *ArcView 3.2.* ™

TABLE OF CONTENTS

1. OVERVIEW OF EDITING THEMES

ArcView allows you to edit a theme that is based on an ArcView shapefile if you have file write permission on the shapefile.

To make a shapefile theme editable

- Make the shapefile theme active.
- Choose Start Editing from the View's Theme menu. ArcView allows you to edit only one theme in a view at a time. If you choose Start Editing on a theme while you are editing another theme, you will be prompted to save your edits on the theme you were previously editing before editing on the second theme is enabled.

A dashed line around the theme's check box in the Table of Contents indicates that you can edit that theme.

To undo and redo edits

Choose Undo Feature Edit from the Edit menu to undo the last edit you made to the shapefile. Choosing this option repeatedly enables you to successively undo all the edits you made since you started editing. Undo Feature Edit undoes changes to the feature geometry in the shapefile and the corresponding changes to the feature attribute table. The Redo Feature Edit option let you re-apply the changes.

To save your edits and continue editing

Choose Save Edits from the Theme menu to save all edits made to the theme during the current edit session. Once you save the edits, you can continue to edit the theme but you are not able to undo or redo any edits that were made prior to choosing Save Edits.

To save your edits out to a new theme

Choose the Save Edits As option from the Theme menu if you want to save your edits out to a new shapefile rather than changing the original shapefile. The edited version of the original theme will be written out to the new shapefile, editing will be disabled on the original theme, and the edits will not be written to the original shapefile. The new shapefile will be added to the view as a theme, the same editing environment and legend will be set up for this theme, and editing will be started on the new theme automatically. Now any edits you do will be to the new theme.

To stop editing a theme and commit your edits

Choose Stop Editing from the View's Theme menu to disable editing on the theme. You will be prompted to save your edits.

Note: *You cannot edit the features of a multipoint shapefile theme. Start Editing is disabled if the theme you want to edit contains multipoint features. To check if a theme is a multipoint theme, see the Shape field in the theme's attribute table. However, you can edit the values in its attribute table.*

2. EDITING SHAPES USING SHAPE PROPERTIES

The Shape Properties dialog allows you to view or edit the properties of the selected graphic or feature in your view.

To view or edit the properties of a shape:

1. Select a feature or a graphic in your view
2. Right-click on the shape and select Shape Properties from the pop-up menu
3. Select the Vertex in the list you want to change, or add a new vertex after.
4. Click Add, Edit, or Delete.
5. Click OK to commit the changes to the shape.

3. EDITING POINT THEMES

There are many ways to edit point themes. What do you want to do?

- Delete point features
- Cut and paste point features
- Move point features

Deleting features

To delete features

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to delete.
3. Press the DELETE key.

The features are removed from the theme, and the corresponding records in the feature attribute table are automatically removed.

Cutting and pasting features

You can cut features from one theme and paste them into another theme.
To cut and paste features

1. If the theme you want to cut features from is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the features you want to cut.
3. From the Edit menu, choose Cut Features to cut the features to the clipboard..
4. Start Editing on the theme you want to paste the features into. You will be prompted to save edits on the first theme.
5. From the Edit menu, choose Paste.

It is not advisable to cut from a theme in one view and paste into a theme in a different view because the two views may have different projections or map units. ArcView places features based on their coordinates and in the above case, the coordinate spaces for the two views may not be the same.

Moving features

To move features with the mouse

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to move.
3. Press and hold the mouse button within a selected feature or features, then drag to a new location. A faint outline of the selection follows the mouse movement; the feature re-draws in the new location once the mouse button is released.

4. EDITING LINE THEMES

There are many ways to edit line themes. What do you want to do?

- Create new line features
- Delete line features
- Cut and paste line features
- Move line features
- Resize line features
- Reshape line features
- Split line features
- Merge line features

Deleting features

To delete features

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to delete.
3. Press the DELETE key.

The features are removed from the theme, and the corresponding records in the feature attribute table are automatically removed.

Cutting and pasting features

You can cut features from one theme and paste them into another theme.

To cut and paste features

1. If the theme you want to cut features from is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the features you want to cut.
3. From the Edit menu, choose Cut Features to cut the features to the clipboard..
4. Start Editing on the theme you want to paste the features into. You will be prompted to save edits on the first theme.
5. From the Edit menu, choose Paste.

It is not advisable to cut from a theme in one view and paste into a theme in a different view because the two views may have different projections or map units. ArcView places

features based on their coordinates and in the above case, the coordinate spaces for the two views may not be the same.

Moving features

To move features with the mouse

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to move.
3. Press and hold the mouse button within a selected feature or features, then drag to a new location. A faint outline of the selection follows the mouse movement; the feature re-draws in the new location once the mouse button is released.

Resizing features

To resize a feature with the mouse

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature you want to resize.
3. Click the mouse on a handle and drag. The corner handles provide stretching that will maintain the aspect ratio (i.e. if you stretch a square from one of its corner handles it will still be a square when you are done). The side handles allow you to resize in the horizontal or vertical directions. A faint outline of the feature being stretched follows the mouse movement, and the feature is redrawn when the mouse button is released.

Reshaping lines

You can use the Vertex Edit tool to reshape a line by moving, adding, or deleting vertices. When you edit a line, you can choose to preserve topology, or not, by the way in which you select the feature:

When you select a single line, any edits you make to the vertices will affect only that line.

When you select a line segment common to two lines, any edits you make to the vertices will affect both lines.

When you select a node common to two or more lines, any edits to that node will affect all the lines that contain that node.

To move a vertex with the Vertex Edit tool

Place the cursor on the vertex you want to move. When the cursor appears as a crosshair, hold down the left mouse button and drag the vertex to the new position.

To add a new vertex with the Vertex Edit tool

Move the cursor to the position on the line where you want the new vertex. When the cursor appears as a target, click the left mouse button.

To delete a vertex with the Vertex Edit tool

Place the cursor on the vertex you want to delete. When the cursor appears as a crosshair, press the DELETE key on the keyboard.

To reshape a single line

1. Click the Vertex Edit tool.
2. Click on the line. A hollow, square vertex handle appears at each vertex of the line.
3. Now when you move, add, or delete vertices, only the single line will change.

To reshape a segment common to two lines

1. Click the Vertex Edit tool.
2. Click on the common line segment. Square vertex handles will appear at each vertex of the shared segment, and round anchors will appear at the vertices at each end of the common segment.
3. Now when you move, add or delete a vertex, both lines will change.

To move a node that is common to a number of lines

1. Choose the Vertex Edit tool.
2. Click on the node that's common to two or more lines. A square vertex handle will appear at this node and round anchors will appear on the next closest vertex on each line.
3. Now when you move the common node, all lines, which share this node, will change.

Splitting line features

In ArcView, you can use the Line Split tool to create a line that gets split wherever it crosses another line, and also splits all lines it crosses.

To split line features

If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.

1. Click the Drawing tool palette and in the list of tools that pops down, click the Line Split tool.
2. In the view, click the left mouse button where you want the line to start, click each vertex, and then double-click the final vertex. The line you draw with the Line Split tool must cross over at least one other line for any new features to be created. Both the existing line and the new line are split into two separate lines at the point where they cross. (The same new line can cross more than one existing line if you want to split a number of lines at once).

When a feature is split with the Line Split tool, the record of that feature is removed from the theme's feature attribute table and two new records are added to the table to represent the new features. If you want to specify how the data in the original record is handled when you split line features, you can set attribute update rules for each field in the table.

Merging line features

If you have a group of lines that you want to merge into one line, use the Union Features option. Union Features returns the union of the selected features to create a single feature. If two lines meet at exactly the same point, one continuous line will result. Otherwise, the result is one feature with multiple parts. If the line features overlap, the overlapping segment is not removed.

To merge lines

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the lines you want to merge.
3. From the Edit menu, choose Union Features.

When a set of features is merged with Union Features option, the records of those features are erased from the feature attribute table and one new record is added to the table to represent the new feature. If you want to specify how the data in the original records is handled when you merge line features, you can set attribute update rules for each field in the table.

5. EDITING POLYGON THEMES

There are many ways to edit polygon themes. What do you want to do?

- Delete polygon features
- Cut and paste polygon features
- Move polygon features
- Resize polygon features
- Reshape polygon features
- Split polygon features
- Merge polygon features
- Create doughnut polygons
- Remove area of overlap between polygons
- Obtain the intersection of polygons

Deleting features

To delete features

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to delete.
3. Press the DELETE key.

The features are removed from the theme, and the corresponding records in the feature attribute table are automatically removed.

Cutting and pasting features

You can cut features from one theme and paste them into another theme.

To cut and paste features

1. If the theme you want to cut features from is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the features you want to cut.
3. From the Edit menu, choose Cut Features to cut the features to the clipboard.
4. Start Editing on the theme you want to paste the features into. You will be prompted to save edits on the first theme.
5. From the Edit menu, choose Paste.

It is not advisable to cut from a theme in one view and paste into a theme in a different view because the two views may have different projections or map units. ArcView places features based on their coordinates and in the above case, the coordinate spaces for the two views may not be the same.

Moving features

To move features with the mouse

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature or features you want to move.
3. Press and hold the mouse button within a selected feature or features, then drag to a new location. A faint outline of the selection follows the mouse movement; the feature re-draws in the new location once the mouse button is released.

Resizing features

To resize a feature with the mouse

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the feature you want to resize.
3. Click the mouse on a handle and drag. The corner handles provide stretching that will maintain the aspect ratio (i.e. if you stretch a square from one of its corner handles it will still be a square when you are done). The side handles allow you to resize in the horizontal or vertical directions. A faint outline of the feature being stretched follows the mouse movement, and the feature is redrawn when the mouse button is released.

Reshaping polygons

You can use the Vertex Edit tool to reshape a polygon by moving, adding, or deleting vertices. When you edit a polygon, you can choose to preserve topology, or not, by the way in which you select the feature:

When you select a single polygon, any edits you make to the vertices will affect only that polygon.

When you select a shared boundary between two polygons, any edits you make to the vertices will affect both polygons.

When you select a node common to two or more polygons, any edits to that node will affect all the polygons that contain that node.

To move a vertex with the Vertex Edit tool

Place the cursor on the vertex you want to move. When the cursor appears as a crosshair, hold down the left mouse button and drag the vertex to the new position.

To add a new vertex with the Vertex Edit tool

Move the cursor to the position on the line where you want the new vertex. When the cursor appears as a target, click the left mouse button.

To delete a vertex with the Vertex Edit tool
Place the cursor on the vertex you want to delete. When the cursor appears as a crosshair, press the DELETE key on the keyboard.

To reshape a single polygon
1. Click the Vertex Edit tool.
2. Click inside the polygon. A hollow, square vertex handle appears at each vertex of the polygon's boundary.
3. Now when you move, add or delete vertices, only the single polygon will change.

To reshape a common boundary between two polygons
1. Click the Vertex Edit tool.
2. Click on the common boundary. Square vertex handles will appear at each vertex of the shared boundary and round anchors will appear at the vertices at each end of the common boundary.
3. Now when you move, add or delete a vertex, both polygons will change.

To move a node that is common to a number of polygons
1. Click the Vertex Edit tool.
2. Click on the node that is common to two or more polygon features. A square vertex handle will appear at this node, and round anchors will appear on the next closest vertex on each polygon.
3. Now when you move the common node, all polygons, which share this node, will change.

Splitting polygon features
When you are editing polygons, you can use the Polygon Split tool to draw a line across a polygon to split it into separate polygons. For example, to create 10 adjacent land parcels, you can create one polygon that represents the outer boundary of all the parcels, and then use the Polygon Split tool to draw the boundary lines between them to split the polygon into 10 separate polygons. This capability also makes it easy to modify existing polygons. For example, to make a polygon smaller you can use the Polygon Split tool to simply split off the unwanted part, select it, and then delete it.

To split polygon features
1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Click the Drawing tool palette and in the list of tools that pops down, click the Polygon Split tool. (If this tool is dimmed out, your theme is not currently in edit mode. Choose Start Editing from the Theme menu).
3. Draw a line across the polygon you want to split. To draw the line, click where you want the line to start, click each vertex along the line, then double-click the final vertex. You can overshoot the boundary of the polygon you are splitting. (The same line can continue through more than one polygon if you want to split a number of polygons at once).

When you have finished drawing the line, ArcView automatically splits the polygon along the line your drew, and removes any overshoots from the line
When a feature is split with the Polygon Split tool, the record of that feature is removed from the theme's feature attribute table and two new records are added to the table to represent the new features. If you want to specify how the data in the original record is handled when you split polygon features, you can set attribute update rules for each field in the table.

Merging polygons
If you have a group of polygons that you want to merge into one polygon, use the Union Features option. Union Features option returns the union of the selected features to create a single feature. If the selected polygons share a common boundary, the common boundary is removed to create a single polygon. If the selected polygons overlap, the boundaries of the overlap are removed to create one polygon. If the polygons are not adjacent or overlapping, the result is one feature with multiple parts.

To merge polygons
1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the polygons you want to merge.
3. From the Edit menu, choose Union Features.

When a set of features is merged with the Union Features option, the records of those features are removed from the theme's feature attribute table and one new record is added to the table to represent the new feature. If you want to specify how the data in the original records is handled when you merge polygon features, you can set attribute update rules for each field in the table.

Creating doughnut polygons
If you have a polygon and want to create a hole inside it (make it into a doughnut polygon) use the Combine Features option. With this option, the polygons you select are merged, but any overlap between the polygons is removed from the resulting polygon.

To create doughnut polygons
1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. On top of the polygon that you want to make into a doughnut, use the Polygon, Circle, or Rectangle tool to draw a smaller polygon representing the area you want to cut out.
3. Use the Pointer tool to select both of the polygons.
4. From the Edit menu, choose Combine Features.

Note: If your selected polygons do not overlap, Combine Features option behaves the same way as Union Features.

Removing area of overlap between polygons

If you have two overlapping polygons and want to remove the area of overlap, you can subtract one polygon from the other using the Subtract Features option. The polygon on top gets subtracted from the polygon on the bottom, so the portion of the bottom polygon that is overlapped by the top polygon is removed, and the top polygon remains unchanged.

Suppose you are adding a new polygon to your theme and one of the existing polygons extends into the area where the new polygon should be. You can draw the new polygon, extending on top of the existing polygon, and then use Subtract Features to remove the area of overlap from the existing polygon.

To remove an area of overlap between polygons

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Draw the new polygon, partly overlapping an existing polygon.
3. Use the Pointer tool to select the new polygon and the existing polygon containing the area you want to subtract. (Subtract Features only works on two selected polygons at a time).
4. From the Edit menu choose Subtract Features.

Note: If you want to reverse the order of the operation, that is, subtract the bottom feature from the top feature, hold down the SHIFT key as you choose Subtract Features from the menu.

You can also use the Subtract Features option to create an island polygon (a polygon that is totally surrounded by another polygon but which does not overlap the polygon it is surrounded by). To create an island polygon, draw the polygon on top of the polygon that it is surrounded by, select both polygons, and choose Subtract Features.

Obtaining the intersection of polygons

Use the Intersect Features option if your theme contains several polygons that overlap and you are only interested in the area that is shared by the overlapping polygons. This creates a new polygon from the area common to the overlapping polygons, and removes all the original polygons.

To obtain the intersection between polygons

1. If the theme is not already in edit mode, make the theme active and from the Theme menu, choose Start Editing.
2. Use the Pointer tool to select the polygons you want find the intersection of. In this example, two polygons have been selected.
3. From the Edit menu choose Intersect Features.