WinKarst

Help Contents

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Contents - Getting Started

Creating a New Cave Document

Create a new Cave System Document by selecting **File | New** menu choice or by pressing the new document icon on the tool bar. Once New is selected, WinKarst's survey editor is started. *The editor* contains six pages, *System*, *Caves of the System*, *Surveys of the Caves*, *Properties of the Stations*, *Sketches* and *Maps*. The pages are selected by clicking on the tabs just below the top of the window. All boxes and buttons on the pages have "fly over" hints, just pause the mouse over the object and a message will appear.

Of the six pages, only the first three contain essential, required information to specify a cave survey.

Opening an Existing Cave Document

From the *File* pull down menu, press the "Open..." choice and the Open dialog box will appear. The dialog box can be accessed more quickly by pressing the second button from the left on the Tool Bar. A cave document's name can be typed in the "File Name" box or selected from the list of names in the box below. More than one file may be selected. The "*List of File Types*" drop down box will switch the selection filter to show only cave documents of a particular type. Changing a directory or disk will automatically cause the list of available documents to change. Pressing "OK" or the Enter key or double clicking on a name will select the document.

Alternately, using Window's Explorer or My Computer, locate the name of the cave survey to open. Double click on the file's name or use the right mouse button to open the survey. The file type extension must be recorded by Windows for this method to work. Windows will prompt you to record cave survey file types the first time this method of opening a file type is used. Once the file type has been set, it is also possible to create a shortcut on the desktop to pick a particular cave survey and open it with WinKarst. Through the extension typing, Windows can also open cave surveys with WinKarst from an email or browser application.

Finally, if WinKarst is already open, select the cave survey to open in Window's Explorer or My Computer and drag the icon or file name to WinKarst's window. This will cause WinKarst to open the cave survey. It is possible to select several cave surveys and drag and drop all of them into WinKarst. This also works if the dragged items are placed on a shortcut to WinKarst on the desktop, if WinKarst is not already running.

Main and Locator Map Windows

WinKarst starts with the Main Map window and once a cave survey file is read, the cave is plotted in the window. If the cave survey has geographic coordinates, i.e. latitude and longitude, then it is possible to bring up the Locator Map window. Before User can enable the Locator Map, a *Digital Elevation Model* file (SDTS format) and/or *GeoTiff* image encompassing the coordinates of the cave survey must be loaded. SDTS and GeoTiff files are available for free across the world wide web.

When both windows are open, they are interactively connected. The locator map shows a rectangle corresponding to the area covered by the main map window. The locator map also shows a small circle for each cave entrance in the survey. Resizing or moving the view in the main window causes the rectangle in the locator window to change accordingly. Conversely, redrawing the rectangle with the mouse in the locator window causes the view to change in the main window. When the mouse is moved over the locator map, the coordinates of the mouse are displayed in the status area of the main window.

Views - Multiple Document Interface

WinKarst uses a Multiple Document Interface (MDI) to describe *Cave Survey* information. MDI means the user can simultaneously view several cave surveys at the same time. For example, the user can load two versions of the same cave (would have to exist as different files), one closed and the other not and compare how the closure was performed. The user could load two versions from two different dates and see how the cave survey has changed. Display modes are generally linked to the document and therefore two views would be showing different details about the same cave (different files).

Within the window frame of WinKarst, the document which is active will have its title bar colored by Windows (blue is default). Clicking any menu choices or tool buttons applies the action to the active document. Selection of the active document is either made by clicking on the appropriate title bar or by selecting the name of the document in the **Window** pull down menu.

When the Locator Map window is active, all of the cave entrances from all of the cave documents will be displayed on the map.

Window Controls and Iconing

WinKarst employs all of the standard or typical Windows controls for sizing, moving, focus and ionizing. Your Windows help system, accessed from the program manager or desktop in third party Windows add on products, is a good source of information.

Sizing

Sizing is accomplished by moving the mouse on the edge of the window frame. When the cursor changes from a single to a double headed arrow, press and hold the left mouse button while moving the mouse. Expand or contract the window to the desired size. Alternately, press on the button with the triangle in the upper right hand corner of the window if you want the window to fill all of the available space. In the pull down Window menu, the option Tile will arrange all of children to fill all of the available space among them. All children windows in WinKarst, maps and the edit window are re-sizable.

Iconizing

A window can be iconized by pressing the button with the inverted triangle in the upper right corner of the window. The icons for the window will appear in the lower left corner of WinKarst parent window. Icons can be restored by either double clicking on the icon or by selecting the window's name in the pull down Window menu.

Focus

A window has the focus when its top bar, containing its title, is a color different than the background color of the Windows system. When several caves are loaded and one is on top or maximized, focus can be switched to another cave by picking the window from a list on the Windows pull down menu. Some dialog boxes will retain the focus until either OK, Cancel, Esc or Enter is pressed.

Moving

Window are moved by moving the cursor with the mouse to the top bar and pressing and holding the left button. Moving the mouse with the button depressed will move the window. Map or Edit windows can be moved such that some part of them will be beyond the edge of WinKarst's main or parent window. But in such a case, the part of the child window extending beyond the boundary will not be visible. Pressing Cascade in the *Windows* pull down menu will move all the windows into stacked offset pattern. Creating a new window will also cause any existing windows to cascade. By selecting the a windows name in the Windows pull down menu, it will be brought to the top of any cascaded stack.

Using the Mouse

The operation of the mouse over the cave drawing has different effects, depending upon what is displayed on the map. The mouse behaves in the typical Windows manner in all menus and dialog boxes. The mouse is active when it is shaped as an arrow. When the map is drawing, the mouse is a hour glass and inactive. Should there be a need to interrupt the drawing process, press the "Esc" key. It is not possible to interrupt any of the calculation processes such as loop determination and closure.

When no labels are displayed on the cave drawing, the view will pan to the location pointed to by the mouse when clicked. If both plan and elevation views are present, clicking in the top section will pan to an elevation view and in the bottom to a plan view.

When labels are displayed, clicking once will change to focus of the labeled object type to the nearest object to the mouse's location. The new object of focus will retain the color of the previous object. Double clicking in this case will bring up an information box about the item nearest the clicking point's location. For example, if Survey names are displayed, clicking near the letter "A" will bring up information about the A survey.

By drawing a box, it is possible to zoom in or out in scale. A box is drawn by clicking and holding down the left button and dragging to the opposite corner of box encompassing the desired area. Zooming will occur when the left button is released. If the box is drawn in a left to right manner, the view will zoom in with the display filling the area of the box. If the box is drawn in a the opposite manner, the view will zoom out with the previous display filling the area of the box.

Pressing the mouse's right button will bring up a menu list at the mouse's pointer.

When in the three dimensional mode, the mouse is used to rotate the cave about two axes. Select a point in the window and press and hold the right button. By dragging the mouse to the left or right with the right button depressed, the cave will rotate about its vertical axis. Similarly, by dragging up and down, the cave will rotate about its horizontal axis.

When continuously rotating the cave view, pressing the left mouse button in the view's window will stop the rotation. Pressing the Escape key on the keyboard will also stop the rotation.

Mouse Modifiers

The mouse can assume new functions by pressing one of three buttons on the tool bar. The buttons are **Handgrip**, **Inspector** and **Measure**. When the Handgrip is enabled, pressing and holding the left mouse button grabs the map at the location and moving the mouse pulls the map in the same direction.

The Inspector mouse causes a station name to pop up near its location when the mouse passes near by.

The Measure mouse allows the user to select two stations and determine the distance and direction between them.

Window

Cascade

Use this control to cascade the views of the cave surveys. A cascaded group of windows will appear to be place up top of each other, each one with a slight offset so the the mouse can be use to select and bring a window to the top of the deck.

Tile Horizontally

Use this control to tile the views of the cave surveys. A tiled group of windows will fill all of the main frame of WinKarst horizontally with each of the individual caves.

Tile Vertically

Use this control to tile the views of the cave surveys. A tiled group of windows will fill all of the main frame of WinKarst vertically with each of the individual caves.

Arrange Icons

Use this control to arrange the icons of ionized views of the cave surveys.

Open Caves List

This is a dynamically changing list of caves currently open in WinKarst. Change the focus to any one of the caves in the list by selecting it.

Menu

File

Choose this pull down menu to open, save, rename and close cave survey files, This menu item also contains the controls for printing cave maps.

Edit

Choose this menu item to edit a cave survey or other cave characteristics.

Preferences

From the Preferences pull down menu six dialog boxes can be activated. The dialog boxes for caves, surveys, station and loops have push button controls and list for controlling the items included in the cave maps.

Maps

This pull down menu as methods for mapping, view selection, scaling, and sub menus for color usage and labeling.

Calculation

Clicking this choice will activate the Calculation dialog box. In the dialog the parameters for loop closure and adjustment can be modified and data processing can be initiated. See *Determination of Coordinates* to learn how to control the data calculation process.

SDTS

The SDTS pull down menu contains the controls for using *Digital Elevation Model* data. Until a DEM or SDTS file is actually read, only one choice is available on this menu, opening files.

Images

The SDTS pull down menu contains the controls for using *Digital Elevation Model* data. Until a DEM or SDTS file is actually read, only one choice is available on this menu, opening files.

Window

This pull down menu has controls for window management. The menu also has the control for generating addition views of the cave.

Help

Enter the help system from this menu.

File

New

Use New to create a new file for a cave survey. The survey editor is then started, which consists of four pages, for the *Cave System*, *Caves of the System*, *Surveys of the Caves* and *Properties of the Stations*. At least one shot must be completed on the **Surveys of Caves** pages before the cave can be plotted.

Open...

Use Open to select and existing cave survey. Cave surveys can be created by any ascii or text editor or KARST for DOS. There are several types of cave *Survey File Formats*, *KST*, *SUR*, *SEF*, *DAT*, *MAK*, *PLT* and *TXT*. Use the file type drop down list to choose the type of file format.

Save

Save writes any modifications to permanent storage. Currently, it is not possible to modify SUR files. KST and PLT files can be modified by adjusting the loops of the cave survey. SUR files that have been adjusted for loops must be save under a new name so a not to corrupt the original survey data.

Save As...

Use Save As for creating duplicate cave surveys, saving the results of loop adjustments or transposing cave surveys between the file data types. Duplicate file names are prompted for OK before overwrite.

Close

Use this control to exit a cave survey. Note that if multiple views of the cave survey are present, only the view that has the focus will be closed. Use the Close All choice in the Windows pull down menu to simultaneously close all of the views of a cave survey. As the last view is closed, if the cave survey was modified, the user will have the choice to save the modifications.

Close All

Use this control to close all of the views of a particular cave survey. Only the cave survey or system with the focus will be closed.

Import...

The import function allows the user to import any of the file types that can be open as an existing cave survey document. The imported survey is added to the existing document, within the definition of the cave survey file type.

GeoTiff...

GeoTiff refers to TIF files which have geographic (or cartographic) data embedded as tags within the TIFF file. The geographic data can then be used to position the image in the correct location and geometry on the screen of a geographic information display. GeoTiff can be displayed as background maps to cave surveys and sketches or displayed in the *Locator Window* in conjunction with a corresponding DEM. More than one model file can be opened at a time, if they are physically adjacent.

DEM...

Open a Digital Elevation Model file. Two types of file types are supported, the older DEM format and the new SODS format. In the older format, all of the information is contained in a single file. In the SODS format, the information is spread in to a dozen or more files. WinKarst reads the "catalog" SODS file, which contains a list of files that contain all of the model's information. More than one model file can be opened at a time, if they are physically adjacent.

Export...

The export function allows the user to export a representation of the cave survey into other applications. There are seven types of export formats:

DXF AutoCAD version 12, 13 and 14, AutoCAD Lite, Corel Draw, MSWord.

BMP Windows Bitmap, Corel Photo Paint, Front Page, MSWord, PhotoShop.

PNG Portable Network Graphics, Corel Photo Paint, Front Page, MSWord, PhotoShop.

TIF Tagged Image Format, GeoTiFF, Corel Photo Paint, Front Page, MSWord, PhotoShop.

DBF dBaseIV database format, MSAccess, MSFoxPro.

SHP Shapefile, ERSI GIS programs, OziExplorer.

TRK Garmin Track, Garmin's PCX5 format.

WPT Garmin WayPoint, Garmin's PCX5 format.

TXT Comma delimited UTM coordinates, WayPoint+, TOPO!GPS.

SUR WinKarst Survey, export a selected cave, survey, loop or traverse.

SEF SMAPS Survey Exchange Format, export a selected cave, survey, loop or traverse.

DAT COMPASS survey, export a selected cave, survey, loop or traverse.

TXT Comma delimited spread sheet for importing into MSExcel or MSAccess or other database programs.

Pressing this control will bring up the Export Save As dialog box. The format type is selected in the Save File As Type drop down list. The file's name can be selected from the list or typed into the name line. Duplicate file names are prompted for OK before overwrite.

Color coding is encoded with the export file, but the importing software may or may no render the colors as expected. Fonts type is not exported.

Caves without geographic coordinates, latitude and longitude, will not have the TRK and WPT export file types.

The three dimensional export function allows the user to export a complex representation of the cave survey into other applications. *Line plots* are exported as a collection of line segments in three dimensional space. Passage or *Rug* *plots* are exported as a complex collection of "3dface" objects. Each line survey shot will be represented by six 3dface objects.

To export a three dimensional view, WinKarst must be in the three dimensional mode, as indicated by the 3D button on the *Tool bar* or by the check mark next to the three dimensional choice in the *Map* pull down menu. Three dimensional export file type is either BMP or DXF, but DXF is the only true three dimensional object.

Print...

Print activates the print dialog box.

Print Setup...

Making changes from the printer's default setting can be made in the setup dialog box. This dialog is also available from the print dialog box.

Most Recently Used File List

Each time WinKarst is used, the files read during the session are recorded and placed on this portion of the File Menu for easy future access. Up to eight file names are recorded and are saved once the program has terminated.

Exit

Exit WinKarst. If any open cave surveys have been modified, the user is prompted for saving any modifications.

Edit

System Shift+F2

Open the survey editor on the system page.

Cave Shift+F3

Open the survey editor on the cave page.

Survey Shift+F4

Open the survey editor on the survey page.

Properties Shift+F8

Open the survey editor on the property page.

Sketches Shift+F12

Open the survey editor on the sketch page.

Map

Open the survey editor on the map page.

Maps

Plan Cntl+p

Pick this control or press the control and 'p' keys to display the cave in its entire plan view, scaled to fit the window. Only the window with the focus will be redrawn.

Elevation Cntl+v

Pick this control or press the control and 'v' keys to display the cave in it profile or elevation view, scaled to fit the window. Only the window with the focus will be redrawn.

Plan and Profile Ctrl+o

Pick this control or press the control and 'o' keys to display the cave in its plan and elevation views, scaled to fit the window. Only the window with the focus will be redrawn.

3D Unified Alt+o

Pick this control or press the Alt and 'o' keys to display the cave in three dimensional space. Zooming must be accomplished by either the keyboard or Maps pull down menu, see below. Panning must be accomplished with the window scroll bars. In three dimensional display, the *mouse is used* to rotate the cave in two axes Only the window with the focus will be redrawn.

Rose Diagram Alt+c

Pick this control or press Alt and the 'c' keys to display the cave's survey data in a three dimensional histogram. The radial angle in the circular plot represents the bearing angle of the survey data, while the radial distance represents the inclination angle. The color of the intersection of the two angles represents the frequency of occurrence within the survey data, red the highest and violet the least frequent.

Vertical Distribution Alt+l

Pick this control or press Alt and the 'v' keys to display the cave's survey data in a vertical passage distribution histogram. The length of each horizontal segment shows the proportion of passages that exist in one of 256 depth slices. The color by depth sequence is automatically adjusted to give each peak in the distribution a unique color. The new color definition is used when the cave is subsequently displayed with depth coloring.

Scale and Legend **Cntl+i**

The scale and legend dialog box is reached by selecting this item or pressing the control key and 'i'. In this dialog box it is possible to set the drawing's scale and angle of rotation. Symbols indicating the values of these parameters, a scale bar and compass, may each be added or removed from the map. The type of units expressed in WinKarst, English or Metric, is selected in the Scale and Legend. How the mouse's coordinates are expressed, absolute or relative from the cave's origin, is selected in this dialog box. The drawing of either a longitude and latitude or UTM grid is enabled in this dialog.

Projections **Alt+j**

The Projection Dialog box is reached by selecting this item or pressing the Alt key and 'j'. One of five geographic projections and one of twenty datums may be specified. Each projection must be "described" before it can be used in the *Projection Specification* dialog box. Only cave surveys with Longitude/Latitude control points can be projected. The default projection type upon starting the program is UTM and it requires no specification. The *Geographic Calculator* is reached from this dialog box.

Rotate Left Cntl+r

Use this control or press control and the 'r' keys to rotate the cave counter clock wise about a vertical axis. Both the plan and elevation views will rotate.

Rotate Continuously Alt+c

Use this control or press Alt and the 'c' keys to rotate the cave clock wise continuously about a vertical axis. Press the 'escape' key to halt the rotation. Both the plan and elevation views will rotate.

Rotate in Two Axes Alt+x

Use this control or press Alt and the 'x' keys to rotate the cave clock wise continuously about a vertical axis and horizontal axis. Press the 'escape' key to halt the rotation. Both the plan and elevation views will rotate.

Rotate Right Alt+r

Use this control or press alternate and the 'r' keys to rotate the cave clock wise about a vertical axis. Both the plan and elevation views will rotate.

Zoom In Cntl+z

Use this control or press control and the 'z' keys to zoom the window with the focus in by 10%.

Zoom Out Alt+z

Use this control or press alternate and the 'z' keys to zoom the window with the focus out by 10%.

Focus

Pick this control to bring up the Focus sub menu. The sub menu will enable the choices for focusing on a cave system, a single cave or single survey.

Color

Pick this control to bring up the Coloring sub menu. The sub menu will enable the choices for coloring caves, surveys, loops or by functional relationships.

Label

Pick this control to bring up the Labeling sub menu. The sub menu will enable the choices for labeling caves, surveys, loops and stations.

Fonts

The fonts dialog box is reached with this control. The dialog will allow the user to change the text's point size, style and color that appears on the cave maps. Chosen fonts and their characteristics will be used when printing the cave survey, provided the Windows supplied print driver supports them. If station symbols are shown on the drawing, their size will be proportional to the chosen font's point size.

Calculation

Parameters

Open the loops and survey *calcuation dialog* box. The dialog box allow for changing the varibles that control the loop closure adjustments. The Loop Bunder value is set in this dialog. Different options for calculating the cave survey are also chosen in the dialog.

Find Loops

Find all the loops in the survey.

Close Loops

Find all the loops in the survey and close the loops according to the parameters set in the calculation dialog.

Restore Unclosed

Restore the survey to the unclose form, the condition prior to closing the loops.

Preferences

Save Preferences

Use this control to save the current display options. The display options will be selected the next time the program is started.

System F2+Ctrl

Use this control or press the Control key and F2 to bring up the System Form. The dialog box allows the user to learn about the overall cave system

Cave F3+Ctrl

Use this control or press the Control key and F3 to bring up the Cave Form. The dialog box allows the user to select caves, learn about a cave, color or label caves and edit cave related parameters in the survey.

Survey F4+Ctrl

Use this control or press the Control key and F4 to bring up the Survey Controls dialog box. The dialog box allows the user to select surveys, learn about a survey, color or label surveys and edit an individual survey of the cave survey.

Exceptions F6+Ctrl

An exception survey is a survey that is not connected to the main body of the cave survey. The may have no connecting station to the main body or may have been declared void for documentation purposes. Use this control or press the Control key and F6 to bring up the Exception Controls dialog box. The dialog box allows the user to select surveys, learn about a survey and edit an individual exception.

Stations F7+Ctrl

Use this control or press the Control key and F7 to bring up the Station Controls dialog box. The dialog box allows the user to select a station, learn about a station, label a station, enable labeling options and edit the shots that connect to a station.

Properties F8+Ctrl

The Station List is a grouping of stations than have been independently selected by the user. Use this control or press the Control key and F8 to bring up the Station Lists dialog box. The dialog box allows the user to create or modify the station list, learn about stations in the list, label the stations of the list and edit the shots that connect to a station of the list.

Loops F9+Ctrl

Use this control or press the Control key and F9 to bring up the Loop Controls dialog box. Initially, some of the options of the dialog box are "grayed" until the loops of the caves have either been found or closed. The grayed options will remain so if there are no loops in the cave survey. The user may determine and close the loops of the cave from the dialog box. The user may also learn about a loop, color or label a loop and edit the shots that make up a loop from the dialog box. See *Determination of Coordinates* to learn how to control the loop closure process.

Traverses F10+Ctrl

Use this control or press the Control key and F10 to bring up the Traverse Controls dialog box. Initially, some of the options of the dialog box are "grayed" until the loops of the caves have either been found or closed. The grayed options will remain so if there are no loops in the cave survey. The user may determine and close the loops of the cave from the dialog box. The user may also learn about a traverse, color or label a traverse and edit the shots that make up a traverse from the dialog box. See *Determination of Coordinates* to learn how to control the loop closure process.

Groups F11+Ctrl

Use this control or press the Control key and F11 to bring up the Group Controls dialog box. The assignment of survey to groups is done on the Survey page of the Editor. Once groups are created in the Editor, they are presented in a list in the Groups Dialog. A group can be selected and plotted separately as a unique object. The dialog also can provide information about a survey group.

Sketches F12+Ctrl

Use this control or press the Control key and F12 to bring up the Sketches Controls dialog box. The registering of stations to a sketch is done on the Sketches page of the Editor. Once a sketch as at least two registered stations, it appears in the Sketches dialog. A individual sketch can be plotted with the underlying survey from the dialog. The dialog also can be used to search for sketches that may intersect a survey or contain a station. By typing a survey or station name in the dialog, a list of prospective sketches is determined by calculating the area of the sketch and the location of the survey or station. The dialog can also provide information about a sketch.

If the cave line plot view is not plan, then this menu choice will be greyed and unavailable.

Help

Contents

Use this control or press F1 to enter the help system.

Search for Help On

Start help system in Search Contents dialog box.

How to use Help

General Microsoft instructions about Help.

About

Use this control or press the 'i' tool on the tool bar to learn about the version of WinKarst when no cave survey is open, or about a cave survey after opening a file.

Author

Use this control to learn how to contact the author.

Registration

Use this control to open the Registration form. The username and keycode can be entered or changed in this form.

SDTS Menu

Read SDTS...

Open a *Digital Elevation Model* file. Two types of file types are supported, the older DEM format and the new SDTS format. In the older format, all of the information is contained in a single file. In the SDTS format, the information is spread in to a dozen or more files. WinKarst reads the "catalog" SDTS file, which contains a list of files that contain all of the model's information. More than one model file can be opened at a time, if they are physically adjacent. If a subsequent model is read that does not touch the previous set of models, the previous set is replace with the single new model. File names can be set in the cave survey file on the System page of the survey editor and automatically read when the cave survey is opened.

SDTS Info...

Display information about a particular Digital Elevation Model. The menu choice brings up a dialog box which list the models currently loaded in WinKarst. Select a model name from the drop down list and press the Info button to display the information.

20 Foot/10 Meter Contours

Draw contours with either 20 foot or 10 meter intervals. The selection of English or Metric units is made in the *Scale and Legend* dialog box reached from the *Maps* pull down menu. The displayed map must be the Plan view.

40 Foot/20 Meter Contours

Draw contours with either 40 foot or 20 meter intervals. The selection of English or Metric units is made in the *Scale and Legend* dialog box reached from the *Maps* pull down menu. The displayed map must be the Plan view.

200 Foot/100 Meter Contours

Draw contours with either 200 foot or 100 meter intervals. The selection of English or Metric units is made in the *Scale and Legend* dialog box reached from the *Maps* pull down menu. The displayed map must be the Plan view.

Surface Shadow

Enable drawing of a projection of the cave survey on the surface calculated by the Digital Elevation Model. The surface shadow is always either white or black, depending on the display's background color. The displayed map must be either the Profile, Overall or 3D unified views.

Surface Mesh

Enable drawing of a three dimensional surface mesh based on the Digital Elevation Model. The mesh is only draw above a box enclosing the cave's survey. The mesh is always either white or black, depending on the display's background color. The displayed map must be the 3D unified view.

DLG Transportation

Display DLG roads and trails information if a SDTS Transportation catalog data is loaded. Roads of different quality are displayed with different line weights. The color of the roads is fixed to light green. Roads can only be displayed in the Plan view.

DLG Water

Display DLG streams and lakes information if a SDTS Water catalog data is loaded. Intermittent streams are displayed with a different line weight than permanent streams. The color of the water is fixed to blue. Water can only be displayed in the Plan view.

Locator Map

Display the Digital Elevation Model in a separate child window. Once a model's data file is read, its possible to display the locator map without reading any cave surveys. The locator map has its own menu, but its mouse's movement is linked back to a main cave plot display.

Images

Read GeoTiff

Open a *GeoTiff* image file. Only images with a valid set of meta data can be used and the processed projection must be UTM. Adjacent images can be tiled together into a composite image. If subsequent image is read that does not touch the previous set of images, the previous set is replace with the single new image. File names can be set in the cave survey file on the System page of the survey editor and automatically read when the cave survey is opened.

GeoTiff Info

Display information about a particular GeoTiff image. The menu choice brings up a dialog box which lists the images currently loaded in WinKarst. Select an image name from the drop down list and press the Info button to display the information.

Remove Collar

Many GeoTiff images are direct scans of USGS topographical maps with the corresponding location and processing information stored as tags in the image. The scan may or may not include the white boarder around the image and the legend area at the bottom of the sheet. To facilitate the tiling together adjacent topographical maps, WinKarst can optionally remove the boarder with this option enabled.

Rug Cntl+g

This control will toggle all of the views of a cave survey to show either the cave floor (or profile) as calculated from the Left, Right, Up and Down passage dimensions or just a simple line plot. If the map is colored, then the passages will be sorted such that the highest levels will appear on top of the lower passages.

Sketches Cntl+b

Display station registered sketches or background maps on the cave survey lineplot. Images are automatically scaled and rotated to match the registered stations. All images are draw together, transparent in the background color. Sketches can only be displayed in the Plan view.

Single Sketch

Display a single station registered sketch on the cave survey lineplot. Images are automatically scaled and rotated to match the registered stations. Sketch selection is made in the *Sketch Preference* dialog box. Sketches can only be displayed in the Plan view.

Sheet Sketches

Display a specific set of station registered sketches. The entire set is automatically scaled and rotated to match the registered stations. All images are draw together, transparent in the background color. Sketches are placed on a sheet in the Assignment drop down list on the sketch page of the survey editor. Sketches can only be displayed in the Plan view.

Hide Line Plot Cntl+h

If sketches or background images are displayed, the lineplot can be disabled to simulate a completed and hand drawn cave map. The mode is only enabled in the Plan view.

Map Graphics Cntl+f

Draw color maps as a background to the cave survey lineplot. The background color is automatically switched to white for readability. All maps in the system are drawn. The mode is only enabled in the Plan view and can work in conjunction with sketches.

Morph Sketches Cntl+m

The control key and 'm' toggles between raw and morphed sketches. When first selected or after editing the cave survey, the sketches are morphed and a progress meter shows when each sketch is finished. Once morphed, the view can be toggled back and forth between raw and morphed versions to observe the results. Only those sketches in the field of view are morphed and moving the field of view will cause additional sketches to be read and morphed as needed.

Locator Map Menus

File

Choose this pull down menu to export from or close the Locator Map. This menu also contains an exit item to close the entire program.

Options

This pull down menu contains options for setting the Locator Map's size, colors, shading modes and contours.

Locator Map File

Export

The view in the Locator Map window can be exported as a BMP file.

Close

Close the Locator Map window.

Exit

Terminate WinKarst.

Locator Map Options

Rainbow Colors

The color scheme used to represent elevation is based on the rainbow spectrum, violet the lowest and red the highest.

Earth Colors

The color scheme used to represent elevation attempts to display land types, white on the top of mountains, brown midranges and dark green in the lowlands.

B/W Colors

The black and white scheme represent elevation with white the highest and black the lowest.

GeoTiff

The GeoTiff image is drawn in the corresponding geographic region. It DEM data is also present, a Shadow Map or Relief Map will be shaded proportionally from the base GeoTiff image.

Relief Map

The Relief Map darkens the elevation colors based on slope, the steeper the slope the darker the color.

Shadow Map

The Shadow Map illuminates the field with a low to the horizon, bright light source from the west.

Featureless

No Relief or Shadow darkening of the colors.

Contours

Draw contours at 200 foot intervals.

Only Contours

Draw contours at 200 foot intervals, without drawing the underlaying colors.

Tool Bar

The two drop down list on the Tool Bar contain the caves within a survey with multiple caves and surveys within the currently selected cave. Clicking on a cave name will select the cave and cause the survey drop down list to change to the surveys with the cave. Clicking on a survey name will select the survey. If the map focus is one either cave or survey, then selecting either a cave or survey from the drop down lists will cause the display to draw the selected object.

The Tool Bar speed buttons have the following definitions:

New file
Open file
Save file
Save As new file
Edit cave
Print Map
Help
About WinKarst
Color by Depth
Label Station Names
Toggle Line/Rug drawing
Zoom In
Zoom Out

Black background for map
White background for map
Reset color selections
Rotate Counter Clock Wise
Rotate Clock Wise
Autoscale to Plan View
Autoscale to Plan and Profile
Autoscale to Profile View
Continuous Rotation
Two Axis Rotation
Three Dimensional
Rose Diagram
Vertical Passage Distribution
Measure between Stations
Inspect Station Names
Grip Panning
DEM Locator Map
Draw Elevation Contours
Draw Surface Shadow
Draw Surface Mesh
Draw DLG Roads and Trails
Draw DLG Streams and Lakes
Draw a single Sketch
Draw all Sketches
Draw a Sketch Sheet
Hide Survey Line Plot
Draw map background image

Hot Keys

Use Esc key to close any dialog if opened by accident.

Cntl + a	Label station properties
Cntl + b	Draw Sketches
Cntl + c	Color every cave
Cntl + d	Color into Page
Cntl + e	Color every survey
Cntl + f	Map Graphics
Cntl + g	Rug/Line mapping
Cntl + h	Hide Line Plot
Cntl + i	Scale Dialog Box
Cntl + j	Label Junctions
Cntl + k	Label Head of Traverse
Cntl + l	Label stations
Cntl + m	Morph Sketches
Cntl + n	No labels
Cntl + o	Map overall view
Cntl + p	Auto plan view
Cntl + q	Color every loop
Cntl + r	Rotate Counter Clock Wise
Cntl + s	Label surveys
Cntl + t	Color by time
Cntl + u	Label Head of loops
Cntl + v	Auto elevation view
Cntl + w	Color below surface
Cntl + x	Color every loop
Cntl + y	Label head of Group
Cntl + z	Zoom in

Alt + a	Color by Station's Shots
Alt + b	Label sketches
Alt + c	Plot Rose Diagram
Alt + d	Color by Depth
Alt + j	GeoProjection Dialog box
Alt + k	Label with traverses
Alt + l	Vertical Passage Distribution
Alt + o	Three dimensional view
Alt + q	Color every traverse
Alt + r	Rotate Clock Wise
Alt + t	Continuous rotation
Alt + u	Label within Loops
Alt + v	Label every cave
Alt + x	Two axis rotation
Alt + y	Label surveys in Group

Alt + z	Zoom out
F1	Help
F2	Draw cave system
F3	Draw cave
F4	Draw survey
F7	Draw station
F9	Draw Loop
F10	Draw traverse
F11	Draw group
Cntl + F2	Draw overall cave system
Cntl + F3	Cave Dialog box
Cntl + F4	Survey Dialog box
Cntl + F6	Exception Dialog box
Cntl + F7	Station Dialog box
Cntl + F8	Property Dialog box
Cntl + F9	Loop Dialog box
Cntl + F10	Traverse Dialog box
Cntl + F11	Group Dialog box
Cntl + F12	Sketch Dialog box
Shift + F2	Edit System
Shift + F3	Edit Cave
Shift + F4	Edit Survey
Shift + F8	Edit Property
Shift + F12	Edit Sketch
Up arrow	Pan up
Down arrow	Pan down
Left arrow	Pan left
Right arrow	Pan right
Page up	Step up
Page down	Step down
Home	Step left
End	Step right
Escape	Stop a continously rotating drawing

Scroll Bars

When either the bottom or side scroll bar is present, it means the cave's dimensions extend beyond the limits of the display. If the side scroll bar is present, the cave is larger in the North/South direction, East/West direction for the bottom bar. When the cave is plotted in the auto scaling modes, the scale is adjusted such the entire cave fits into the field of view. In this case no scroll bars will appear. The size of the scroll bar tabs represents the area of the window's view relative to the extends of the entire cave system.

When a scroll bar is present, clicking on its arrow or dragging the thumb wheel (the square box between the ending arrows), will pan the view in the indicated direction. Given the selected Scale, the position of the thumb wheel indicates what portion of the cave's extend is in the field of view. For example, if the side thumb wheel is towards the bottom and the bottom wheel is towards the right, then the field of view is of the southeastern section of the cave.

WinKarst as an auto binding feature for scrolling or panning. The view will never pan past the north/south, east/west extents of the cave. In this manner, it is less likely the user will be viewing a blank screen wondering where the cave is. Note, it is possible to zoom out in scale enough to "see" beyond the limits of the cave using the Mouse or Zoom out function.

Status Line

The status line, the part of the window's frame at the bottom, displays information about the current state of the cave view.

The next three fields from the right give the location of the mouse's pointer in cave space. If the view is plan, only the left two fields of the three will be active, representing the x and y coordinates. If the view is elevation, the center field of the three will be inactive and the other two representing x and z coordinates. If both views are present, then either the y or z coordinate will "freeze" as the mouse pass between plan and elevation views. If the cave survey has a geographic location, geographic coordinates, i.e. latitude and longitude, can be displayed once selected in the *Map* | *Scales and Legend* form

The next field from the right, or roughly in the center, is the current scale. The scale may be expressed as a ratio or in English or Metric units. As the view is zoomed in or out, the scale will change to the new value.

The last field, the field on furthest to the left, is the help indicator line. When the mouse passes over a Tool Bar item or a menu item is passed (displayed in inverse video lettering), this line will display a short message to help indicate its function.

When the Locator Map is present, has the focus and the mouse passes over it, the Status Line reports the position in geographic coordinates.

Editing a Cave Survey

Editing a Cave Document

Edit a Cave System Document by selecting **Edit** menu choice or by pressing the edit document icon on the tool bar. The editor contains five pages, *System, Caves of the System*, *Surveys of the Caves*, *Properties of the Stations*, *Sketches* and *Maps*. All boxes and buttons on the pages have "fly over" hints, just pause the mouse over the object and a message will appear. The entire Editor can be resized to match the resolution of the user's computer, however, a minimum resolution of 800 x 600 is recommended.

The editor is integrated with the main mapping window. This means changes made to the survey data in the editor will be reflected immediately in the main window when the editor is closed. It is very important to remember to save the survey data before closing the program, otherwise and changes will be lost. WinKarst keeps track whether a change has been done in the editor and asks the User before closing the survey or the program itself. The title bar of the main window will show the word "modified" once a change has occurred. Save a survey by pressing on the toolbar symbol or in the File drop down menu.

The Editor can also be reached by pressing the **Edit** button on any of the **Preference** forms. When accessed this way, the editor will jump to the page associated with the form. The Editor can also be started after **Double Clicking** on an object displayed on the map and pressing on the **Edit** button that appears on the dialog form that appears. When the editor is started this may, it jumps to the page associated with the object and the specific item in the cave survey. Similarly, when the Editor is closed by pressing the OK button, the drawing's object selections, e.g. cave, survey, etc, will be copied from the last object the Editor was focused upon.

Each of the Editor's pages have either six or eight buttons along the right edge, **OK**, **Cancel**, **Info**, **Help**, **New**, **Delete**, **Cut** and **Add**. The buttons OK and Cancel will always close the Editor, the former applying any edits to the cave survey, the later discarding any changes. The title of the Editor's window will display the word, "Modified", once a change has been made to the cave survey. When the Cancel button is pressed after changes have been made, the user will be prompted to actually verify the changes should be discarded.

The Help button will start this Help browser, jumping to the information pertaining to the editor page in question. The Info button will display a dialog box detailing information about the current object being edited, e.g. cave, survey, etc.

The New and Delete buttons will create or destroy a new object type of the type being edited, e.g. cave, survey, etc.

The Cut and Add buttons will remove or add components to the object being edited, e.g. adding a shot to a survey.

Side Button Page Assignments

System	Cave	Survey	Property	Sketch
Accept edits and close editor	Accept edits and close editor	Accept edits and close editor	Accept edits and close editor	Accept e close edi
Discard edits and close editor	Discard edits and close editor	Discard edits and close editor	Discard edits and close editor	Discard e close edi
Display information about System	Display information about Cave	Display information about Survey	Display information about Property	Display i about Sk
Get help about editing System	Get help about editing Cave	Get help about editing Survey	Get help about editing Property	Get help editing S
Select a new file to include	Create a new Cave	Create a new Survey	Create a new Property	Select a file
Delete a file from the include list	Delete a Cave	Delete a Survey	Delete a Property	Delete a
Add a SDTS file to system	Add a control point station	Add a shot to Survey	Add a station with Property	Add a re station tc
Cut a SDTS file from system	Cut a control point station	Cut a shot from survey	Cut a station with Property	Cut a ref station fr

System Editing Page

The System page contains only a couple of parameters the pertain to the entire cave system survey, the author of the document's name, choice of either English or Metric units, whether or not to automatically calculate magnetic declination, whether the coordinate system is Absolute or Relative, a list of Included files and a list of Geographic Data files.

It is required to select a unit of Measurement, Metric or English. It is required to select a type of Coordinate System, Absolute or Relative. An Absolute coordinate system locates positions on the Earth by longitude and latitude. A Relative coordinate system has an arbitrary origin from which all cave entrances are referenced from by x,y and z numbers.

The magnetic declination calculation is based on the point in time and the location of the cave's entrances on the Earth. WinKarst can calculate the declination for the years 1900 through 2005. The check box for automatic magnetic declination is enabled when the coordinate system is Absolute.

Because the is no method to convert locations from a Relative to an Absolute coordinate system, changing systems will cause the deletion of existing control points. Ensure the correct system is selected before describing any control points of the cave system survey.

The list of included files in the system appears in a drop down list on the page. Create a new file to include by typing its name in the line for included files. After pressing enter, the user is prompted as to whether to create the file by the name provided. If the file already exists, it is simply included as part of the system. Pressing the New button on the right side will invoke a File Open Dialog box to search the file system of the computer. When the file is located in the same or subdirectory of the location of the cave survey data file, then the file name will appear shortened to the relative path to the file.

Note: an existing file that is included is not actually read from a disk until the OK button is pressed and the editor closes. That means the survey data in the include file will not appear in the Survey editor Page until the editor is opened a second time.

When the choice of coordinate system is Absolute, then the list of **Geographic Data Files** is enabled. Pressing the Add button on the right side will invoke a File Open Dialog box to search the computer for SDTS catalog files, DEM files and GeoTiff files. SDTS file set must be previously unpacked and preferably located in a separate directory from the cave survey data files. When the file is located in the same or subdirectory of the location of the cave survey data file, then the file name will appear shortened to the relative path to the file.

Cave Editing Page

The Caves of the System page has a number of data fields to describe properties of the caves in the system and some lists to help find either caves or stations within the system. Each cave can have a Name, Location, Datum (for Absolute coordinates), a list of Control Points and a list of Aliased Stations and their Equivalence.

The Cave List provides for the selection of each cave in the system. A cave is selected by clicking on its name in the list. To change the name of a cave, select it from the list, then type over the name in the cave name box and press enter. The cave's Location is specified by typing the value in the box and pressing the enter key. The location text is optional.

The Station Name and List provides for the selection of a station. Selection is initiated by typing a letter in the Station Name box. For each letter that is typed in the box, the Station List shows all of the stations in the cave with the letter prefix in their name. The final selection can either be made by typing the entire station name and pressing enter or by clicking on a name in the Station List. The Station Name and List is only a tool for finding stations already defined in a Survey. Any Station name can be typed into the Control, Aliased or Equivalent station drop down lists and then later defined in a Survey.

Pressing the Add button on the right side will open a dialog box to type in a Station name, or the one selected from the Station List will be pre-selected. Alternately, the Station name can be typed directly in the Control Station drop down list and accepted after pressing the Enter key. Once a Control Point has been selected, its coordinates will be displayed in the X and Y boxes for Relative or Longitude and Latitude boxes for Absolute coordinate systems, plus the elevation. The elevation can be interpreted has either English or Metric units. Changes to any of these values are accomplished by typing over the value and pressing the Enter key. A Control Point can have an additional text string attached to it by typing the text in the Control Marker Text box. Pressing the Cut button at the right edge will delete the currently selected Control Station from the list. Selecting a Control Station name from the drop down list and pressing the Delete key will remove it and the associated coordinates from the survey.

When entering Longitudes, values in the **Western Hemisphere are negative**, the **Eastern Hemisphere positive**. When entering Latitudes, values in the **Northern Hemisphere are positive**, the **Southern Hemisphere negative.** The appropriate Datum must be recorded for any absolute coordinate from the pre-defined list of Datums. If the coordinates come from a GPS unit, consult the manual of the GPS to determine what Datum it is using.

Aliased Stations are typed into the labeled drop down list and pressing the Enter key. Once a Aliased Station has been entered, a corresponding equivalent station name must be typed into the Equivalent Station box. There can be any number of Equivalent Station names to correspond to an Aliased Station. In processing the cave survey data, when any of the Equivalent Station names are encountered, then the Aliased Station name is substituted. This provides a method to connect surveys that are physically connected in the cave but do not share any station names. Selecting an Aliased Station in the drop down list and pressing the Delete key will remove it and the associated Equivalent Station names from the survey.

To create additional caves, press the New button along the right edge of the page. A form will appear to type in the new cave's name. Similarly, pressing the Delete button at the right edge will delete the currently selected cave, after completing a conformation form.

Survey Editing Page

The Surveys of the Caves page has a number of data fields to describe properties of the surveys in the cave and a Survey Shot spread sheet. Each survey can have a Name, Date, Team, Comment and of course, a list of shots. The survey's name can be changed by typing over the value and pressing the Enter key in the Survey Name box. Starting in Version 8.0 of WinKarst, duplicate survey names are not allowed. **Warning:** *Previous surveys with duplicate survey names will be merged into a single survey.* To compensate, Version 8.0 now allows non-contiguous the shots within a single survey.

To create an additional survey to the initial survey, press the **New** button at the right edge of the page. A form will appear to type in the new survey's name. Similarly, pressing the **Delete** button at the right edge will delete the currently selected survey, after completing a conformation form. Survey without any shots will automatically be deleted from the system when the OK button is press to close the editor.

Each survey can have a date, selected from the Year, Day and Month drop down lists. A survey's Team and Comment can be entered by typing in the appropriate boxes and pressing the Enter key. The Team and Comment fields are optional. The magnetic declination is set by typing in the Declination box and pressing the Enter key (the Declination box is absent if Automagnetic Calculation is enabled).

In the lower left corner are three check boxes for survey properties. These properties are Fixed in Loops, True Declination and Do Not Calculate. A fixed survey does not have its shots adjusted during the loop closure process. A True survey uses the declination entered for the survey, despite if Automagnetic Calculation has been enabled. The no calculation option allows for inclusion of a survey for documentation.

The Survey Shot spread sheet can have ten, eleven or twelve columns, Shot Code, From Station, To Station, Length, Bearing, Inclination, Passage Left, Passage Right, Passage Up and Passage Down, Comment, Backsight Bearing, Backsight Inclination and Depth Delta. If Depth Delta or Depth gauge is chosen with backsights, only the bearing has a backsight column. The Depth column replaces the Inclination column in both cases. The choice for backsights and depth gauge is made with the dialog box accessed by pressing the **Ordering** button towards the lower right corner of the page. The column ordering is changed in this dialog box by clicking on a column box and dragging it to the desired position (note, there is no visual feedback of the moving column until the mouse button is released). The choice of survey units is made in another dialog box reached by pressing the **Units** button located next to the Ordering button.

Data entry is accomplished by moving the mouse to the appropriate box, selecting it with a click, typing a value and finally pressing the Enter key.

Pressing the Escape key before the Enter key will restore the original data for the box. Once the data is entered, the box selection is automatically moved to the right. A selected box or focused box is indicated by a slightly darker outline and the selected row by a triangular wedge in the left most column. Navigation about the spread sheet can also be accomplished by using the arrow or page up/down keys.

Each row in the spread sheet has a row number in the left most column. The selected row number is shown at the bottom of the sheet in the VCR button area. Typing a new row number in the Row box will jump the row selection to that row. The VCR button to the right of the box is the **Fast Reverse** button, jumping to the first shot in the survey. The button to the left is used to **Advance** the selection by one row, the next button to the left is the **Fast Forward** to the end of the survey and the last button is the **Play**, which adds a new shot to the end of the survey. If more shots exist than can be shown in the spread sheet at one time, used the scroll button on the right edge to move the rows up and down to the desired shot. The widths of the columns can be adjusted by placing the mouse on the column line in the first row and dragging left or right.

Next to the VCR buttons are two **Search** buttons. The left search button opens a dialog box to type in the characters to search for in the shot spread sheet. The editor will then jump to and focus on the first occurrence of the desired text. The second button is for a **Repeat Search** on the same text.

A new shot can be create in one of three ways. First, by pressing the **Add** button on the right side of the page, which will create a new shot after the selected row. Second, by pressing the **Down Arrow** with a box in the last row selected. Finally, third, by editing and pressing enter in the last column of the table. The **From** station of a new shot is brought forward automatically from the previous line's To station. A predicted **To** station for the new shot is determined by the last character in the **From** station and the current focus is just after the last character of the predicted station name. If the predicted station name is correct, simply press **Enter** to accept the name, otherwise press **Backspace** and type the correct station name. A Station name that does not already exist with in the survey, but exist elsewhere in the cave are assumed to be tie-in stations for the survey. For tie-in stations, the user is asked to confirm the name of the Station.

Finally, a shot can be deleted by pressing the **Delete** key while any box is selected in the row of the shot to be deleted. The **Cut** button on the right edge can also delete a selected Shot. The shot will be deleted once the conformation form has been completed. The deleted shot is place in a buffer and a **Undo** button will appear in the lower right corner of the page. Pressing the **Undo** button will restore the shot to the survey. If a different survey is selected, the **Undo** button changes to a **Paste** button. Pressing the **Paste** button adds the deleted shot to the second survey, thus moving the shot from the first to the second survey. Several shots can be selected for deletion or moving by first clicking on the left most column, the column with the row number, of the first row to be deleted or moved. The entire row will be highlighted, indicating multiple rows can now be selected. By holding down the **Shift** key and pressing either the **Up** or **Down** arrows, additional rows are selected and highlighted.

As data items are entered into the Shot spread sheet, data boundary checking is done and illegal values are not allowed. Shot length must be a positive number, azimuth positive and less than 360.0, inclination greater than or equal to -90.0 and less than or equal to 90.0 and the FROM and TO stations must be different. Shots are also check that enough data items are present to create a complete shot. For backsights, the azimuth and inclination are reported and the difference displayed if the angles differ by more than 5 degrees. Shots and Stations which do not connect to the main body of the cave survey are recorded in the *Exceptions Dialog* and are characterized as Hanging.

Backsights are handled one of two ways. If the survey only records a single pair of azimuth and inclination for each shot, then a Shot Code of 'B' is used to mark the shot as a backsight. This is equivalent to reversing the FROM and TO station names. On the other hand, if the survey records two pair of measurements for each shot, then the backsight is written in the AZM2 and DIP2 columns. In the situation of corrected backsights and two pair of measurements, WinKarst can automatically detect the corrected data and will mark a 'C' in the Shot Code column. The user can also type a 'C' in the column to flip the values in the AZM2 and DIP2 columns. The 'B' character does not apply to the single pair, backsight data model. A warning is given if the back and fore azimuth or inclination differ by more than 5 degrees. A warning is also given for any shot with the same FROM and TO stations that differ by more than 5 degrees. A final warning may appear if another shot with the same FROM and TO stations appears to be a backsight relative to the shot being edited.

The following table describes the values allowed in the Shot Code column

Code	Meaning	Single or pair measurements
N	Normal	Both
X	Length excluded	Both
B	Backsight	Single
R	Length excluded backsight	Single
C	Corrected backsight	Pair
K	Length excluded corrected	Pair
V	Void	Both

The **Group Assignment** drop down list allows the survey to be assoicated with

Group. The user can pick from one of the pre-existing groups in the list, or type a new Group name in the edit box. Group assignments do not change how the survey is processed and is only used for lineplot displays.

The **File Assignment** drop down list allows for a survey to be placed in an Included file. Included file names are created or selected on the *System Editing Page*. While it is possible with an text editor to create a survey that spans more than one Include file, WinKarst will always write the a survey to the Include file selected. Generally, all surveys for a single cave in a system of caves should be included in a single file. It is entirely optional to compose the cave survey data into a set of included files or a single file.

Properties Editing Page

The Properties of the Stations in the Surveys page has two functions. One function is for creating Property types and assigning stations to the Property lists. The second function is a Station Shot editing spread sheet.

The main differences between the this spread sheet and the one on the Survey page is that each shot contains as either the **From** or **To** station a selected station in common. Second, no new shots can be added or deleted to or from the spread sheet. The data fields of the spread sheet can be edited, just has on the Survey page. If a station name is changed in the spread sheet that is the selected or common station, then the change is applied to all occurrences of the station. This is how a station is renamed through out the entire cave survey. By pressing the combination of the **Shift** key and the **Enter** key when a station in the spread sheet has the focus, the selected station automatically changes to the focused station. This is how to "walk" through the shot sequences by selecting the following stations.

A new Property is created by clicking the **New** button at the right edge of the page. After completing the property's name in the pop-up form, the name is added to the Property List. A Property's name can be changed by typing over it in the Property Name box and pressing the **Enter** key. Clicking on a name in the Property List will select it and the stations with that property will be displayed in the Stations With Property list to the right. Pressing the **Delete** button to the right of the page will delete the selected Property, after a conformation form is accepted. Each station in a property list can have optional text attached to characterize the quantity of the property. A station can have more than one property.

A station is added to the selected Property by first selecting a station. A station is selected by typing its name in the Station Name box. Has letters are typed, stations with the prefix in the box will appear in the Station List. The final selection is accomplished by either completely typing the name and pressing enter or by clicking on the station's name in the Station List. Once a station has been selected, pressing **Add** button at the right edge of the page will add it to the select Property list. Similarly, pressing the **Cut** button at the right edge of the page will delete the selected station from the selected Property list, if it is a member. A station can also be selected by clicking on its name in the Stations With Property list.

Sketch Page

Sketches are any images that geographically contain a station from the survey. For best results, hand drawings of cave passages done during a survey must be to scale. That means the distance between stations must be scaled with a ruler and account for the shortening of the horizontal distance for shots with a steep inclination angle. The relative angle between two shots sharing a common station must be accurately drawn with a drafting compass or protractor. When the Sketch is reasonably true to scale, then it can be scaled, rotated and drawn over the line plot of the survey to match. When more than two stations are found on the sketch, then the image can also be morphed to exactly cover the lineplot.

For WinKarst to display the images, they must be saved in the PNG format. The PNG format is a public domain format and is superior to the GIF format. PNG is supported by all image editing software and web browsers. WinKarst can read color PNG images, but the images are converted in to a four level gray shaded image. The background of the sketch is treated as transparent, allowing for sketches to overlap in the map view. For hand drawn sketches, converting to a gray scale image usually proceeds without any problems.

Each image must contain at least two stations from the cave survey to be displayed. Once two stations are registered on the image, in terms of their x,y bitmap location, the image can be scaled and rotated to match the orientation of the stations in the line plot. When the hand drawn sketches are to scale, picking two stations will allow for the remaining stations in the Sketch to be properly located. The registered stations should be as far apart in the image to enable the best fit to the line plot.

When more than two stations are registered in a sketch, then sketches can be more accurately placed and morphed. A more accurate placement is achieved by averaging the placement of each pair of shots, creating the best fit scale and rotation of the image. One the best fit is ready, each registered station will be slightly displace from the registered location, this is the error of sketch. By morphing the sketch, the image is stretched and each point in the image is aligned with the exact station location. With a reasonable good sketch, the morphing is not noticeable, but can also provide a working map from sketches of poor quality.

Sketch Sheet assignments are made in the drop down list in the lower left of the page. Pick one of the names from the list or type the name of a new Sheet Name to create a sheet.

The **New** button at the right edge will open an file selection dialog box. Selecting a file from the dialog box will enter the file name in the Sketch File Name drop down list and the image is displayed below. Selecting another file name from the drop down list will display the image. Once the image is displayed, pressing the **Add** button will open a dialog box to enter a Station name. Initially, a new Station will be located at pixels 0,0 in the image, as shown in the Sketch X and Sketch Y boxes. Clicking the mouse on the image will register the selected Station to the location on the image and a symbol is drawn with the Station name. The process must be repeated with another Station to complete the process. The Station Name box and Station Search List are provided as a method to find names in a large cave survey.

Pressing the **Delete** button at the right edge will delete the Sketch selected in the Sketch File Name drop down list. Pressing the **Cut** button will remove the Station from the Sketch Station drop down list.

Sometimes a sketch needs additional touch-up work with an image editing program. Clicking the right mouse button over the sketch opens a pop-up menu. The image name can be sent to and open either Photoshop 6.0 or CorelDraw 8.0. Alternately, the image can be edited by any external image editor while being viewed on the Sketch Page. Once the image changes are saved, a choice on the right click menu is available to refresh the image in WinKarst.

Maps Page

Maps are images that can be referenced to geographic locations. Larger scale maps, locating the cave in the greater field of view, can be scanned and placed as a background image on which the cave survey line plot is drawn. USGS topographical, Forest Service and BLM district maps are good sources for locator maps. Aerial photographs can also serve as background images.

To register these maps, the map needs either a UTM grid or Latitude/Longitude grid points. The grid points become control point stations in the cave survey. For topographical and district maps, two intersecting grid points can be use for registering the map. The grid coordinates are usually printed along the edge of the map. For aerial photographs, stream and road intersections with coordinates can be used as control points.

For WinKarst to display the images, they must be saved in the PNG format. The PNG format is a public domain format and is superior to the GIF format. PNG is supported by all image editing software and web browsers. WinKarst can read and display color PNG images as backgrounds.

Each image must contain two stations from the cave survey to be displayed.

Once two stations are registered on the image, in terms of their x,y bitmap location, the image can be scaled and rotated to match the orientation of the stations in the line plot. If there are more than two stations registered, then WinKarst will calculate the best fit location of the stations in the image. The registered stations should be as far apart in the image to enable the best fit to the line plot.

Begin the registration of a map by pressing the **New** button on the right edge of the page. The Open File dialog is used to pick a PNG image file. The image is place in the center of the page by WinKarst and two more button appear, **Add** and **Cut**. Pressing the Add button opens a dialog in which to type the name of a control point for registration. Type a name and close the dialog. On the left edge, the control point name appears. In the Latitude and Longitude boxes, type the geographic location of the control point. Alternately, the UTM northing and easting can be entered, once the UTM zone is also entered. Hint, by entering a Longitude close to the map, the zone will automatically be calculated by WinKarst. Note that Longitudes in the Western Hemisphere are negative numbers, as are Latitudes in the Southern Hemisphere. Once the location is entered, click the mouse on the map at the location. Adjust the location with the up/down buttons on the X/Y boxes. Repeat for additional registered points.

Contents - Elements of a Cave Survey

Systems

A System is a fundamental object of a *Cave Survey*. A system may be as simple as a single *Survey* in a single *Cave* or as complex as all of the caves in a karst region encompassing hundreds of square miles. A system is the highest level in a hierarchical network that includes systems, caves, surveys and *Shots*. WinKarst can Focus on the first three layers of this hierarchy. This is a physical hierarchy, as opposed to a logical hierarchy base on when or who collected the survey data, aka SMAPS.

The *Stations* names within a cave must be unique with respect to that cave. Station names can be repeated in separate caves of a system.

Currently, a system only consists of a list of caves. Future enhancements might include system name, surface topology features, e.g. benchmarks, rivers and roads and commentary.

Caves

Caves are a fundamental object of a *Cave Survey*. As a minimum, a cave is a single *Survey* with some number of *Shots*. A Cave can contain a number of defining parameters such as, Name, Location, Origin, Control Points and Aliases. The cave Name is a simple text string giving a name to the cave, e.g. "Big Cave." If a cave name is specified, the name will appear on the plot when cave labeling is enabled. The cave Location is also a simple text string giving a place name to where the cave the cave exist, e.g. "Multnomah County, Oregon." The cave Origin gives an offset from the origin in three dimensional space for the first station of the cave, the entrance. The cave Control Points are a list of *Stations* which have x,y and z coordinates pre-specified and permanently fixed. Control Points may specify the locations of other entrances in a multi entrance cave. The cave Aliases are a list of station equates which WinKarst uses to substitute station names and correctly link all of the shots in the cave survey. There is no limit on the number of Surveys, Control Points or Aliases in a cave.

The Focus of WinKarst's plot can be set to the current Cave by pressing F3 or by pressing Map in the Cave Dialog box. The current cave can be selected in Cave Dialog box. If there is only one cave in the system, the cave map will appear exactly the same as the system map.

When cave labeling is enabled, double clicking near a cave's name or entrance symbol will bring up dialog information about that cave. This action will also set the current cave to this selected cave. If the view of the system was zoomed in to a particular area when a cave was selected through double clicking, the view will zoom into an area around the cave. This will also occur when a cave is selected through the Cave Dialog box.

Cave Form

The Cave Dialog box is used for selecting caves and enabling or running the functions associated with Caves. The **Ok**, **Help**, **Cancel**, **Info**, **Map** and **Edit** are the major actions that can be applied to the selected Cave. A cave can be selected by either typing its name in the Cave Name line or by **Clicking** or **Double Clicking** on its name in the Cave List. The **Color**, **Reset** and **Auto** buttons will apply colors to the caves in the survey. The **Label** and **Control** check boxes specify cave labeling modes for the map.

Cave Surveys

The first stage of producing a cave map is to collect the raw data. This involves entering the cave and establishing points along the length of each passage. Each point, called a *Station*, is visible from at least two adjacent points. Usually, horizontal angles between the stations, bearings, are measured with a magnetic compass and vertical angles, inclination, are measured with a clinometer. The distances between the stations are measured with a graduated tape, while passage dimensions are normally estimated. The stations, bearing, inclination and distance constitute a survey *Shot*.

Obviously, the job pattern of cave surveying can be broken down in any manner the surveyors see fit and the traditional sequences of the the mapping Team, Tape, Instrument and Book persons, can be rearranged if efficiency, expediency, or mood so dictates. Three of four people are ideal for most surveying teams. Increasingly, a four person records Cave Inventory in a separate note book at each station.

The cave survey usually begins at the cave entrance or at a known survey station or benchmark within or near the cave. On a typical three person survey, one caver walks down the passage, unreeling the tape at the same time. This caver, the Tape Person, locates a point in sight of the original station, and from which the continuing passage can also be viewed. The second caver, the Instrument Person, assists by warning the Tape Person when they are almost out of sight. The point chosen by the Tape Person can be anywhere, rock, wall, floor, etc. This new station is called the TO station, the original station is the FROM station.

The Tape Person and the Instrument Person pull the tape tight and after checking for knots or bending, the Tape Person reads the distance. This number is shouted to the Book Person, who records it in the survey book and repeats it aloud for a check.

While the Instrument Person is readying the compass and clinometer, the Tape Person marks and letters the station, if the station needs to be marked. The the Tape Person places a light on the TO station, pointing towards the the FROM station and shouts, "Light on station!" The Instrument Person reads both the compass and clinometer and tells the Book Person the readings, who records the numbers on the *Data Page* of a survey book.

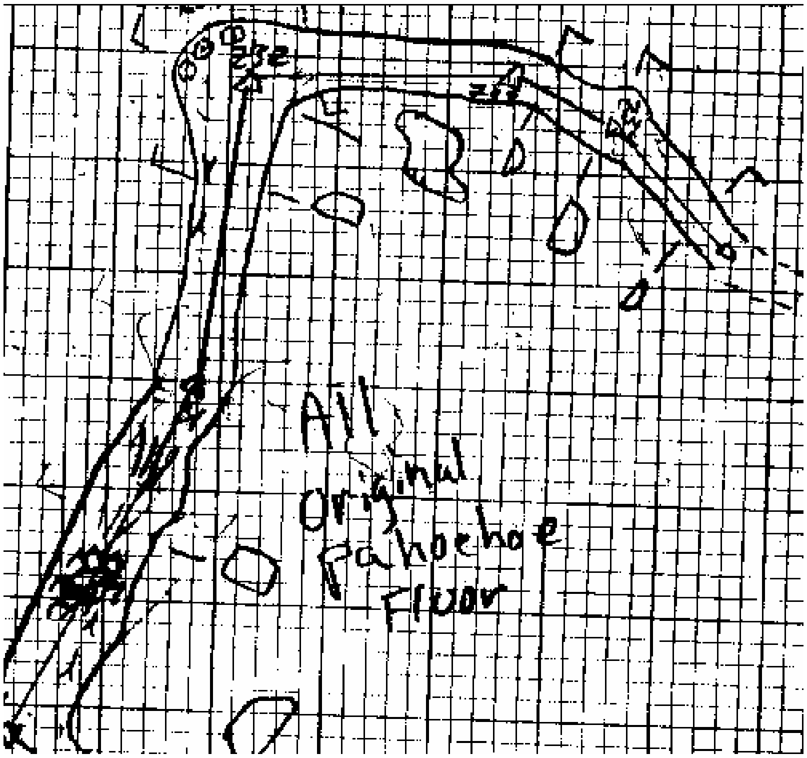
As all of the is occurring, the Book Person estimates or measures the height and width of the passages, the Left, Right, Up and Down dimensions and draws the shape, features, profile and cross sections of the passage on the *Sketch Page* of a survey book.

The day's work is an individual *Survey* and the measurements are recorded in the computer for processing by WinKarst. WinKarst is ideally suited to create line plots which will form the backbone of a drawn cave map. Once in the computer, the data can be studied to reveal characteristics of the survey itself or of the cave in general.

On another day, the Survey Team return to the cave to check leads unexplored from the previous visit. Surveying continues from an existing station down these unexplored leads. As the individual surveys accumulate, the form the complete Cave Survey. The cave surveying continues until the entire cave is explored, measured and mapped. In some cases, the cave is never fully explored or mapped.

Occasionally, as the Survey Teams walks to and from the cave entrance, a second cave entrance is discovered. The second cave may or may not be connected to the first, but is closeness means the two *Caves* constitute a *Cave System*. Often, the system will encompass a Karst Region, e.g. The Marble Mountains or the Black Hills. In a system, all of the caves have unique locations, determined either by surface surveys or GPS. WinKarst allows for any number of caves in a system.

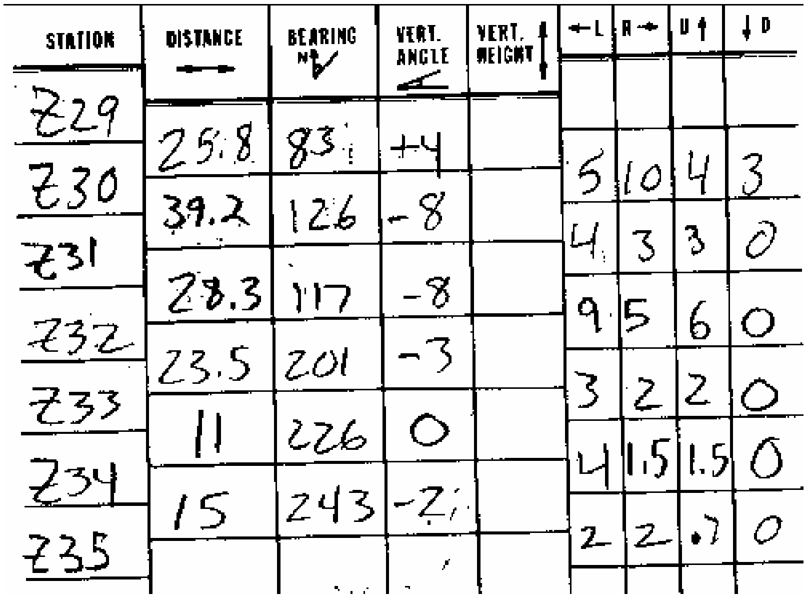
Sketch Page



Typical survey sketch. The note, "All Original Pahoehoe Floor," is a note describing the cave in the area of the sketch. This information is recorded as attributes of the Stations. The station Z32, at the elbow in the cave passage, is a Station in the sketch. Stations should be marked with a symbol, a triangle, circle or heavy dot. The line between stations Z33 and Z34, towards the right end of the cave passage, is a survey shot. Some surveyors connect the Stations with a line, which makes it easier to find all of the stations in the sketch.

WinKarst allows for sketch pages to be "registered" with station names and included in the cave survey data file. When two stations are located on the sketch, WinKarst can place the image on the lineplot in the correct scale and orientation. Alternately, by registering a single station with an sketch, the sketches can be made part of the data file and viewed through the editor for reference. In this example the station Z34, upper right corner and Z30, very lower left corner would have their pixel locations in the image recorded in the data file. Stations that are furthest apart will give the best fit of the sketch on the line plot.

Data Page



STATION	DISTANCE	BEARING	VERT. ANGLE	VERT. HEIGHT	← L	R →	U ↑	↓ D
Z29	25.8	83	+4					
Z30	39.2	126	-8		5	10	4	3
Z31	28.3	117	-8		4	3	3	0
Z32	23.5	201	-3		9	5	6	0
Z33	11	226	0		3	2	2	0
Z34	15	243	-2		4	1.5	1.5	0
Z35					2	2	.7	0

A typical survey data sheet. The **STATION** column records the TO and FROM stations for each shot. When the next shot's FROM station is the same as the current shot's TO station, only half as many station names need to be recorded. The **DISTANCE** column records the linear distance between the FROM and TO stations. The distance should always be a number greater than zero. The **BEARING** column records the angular measurement in the horizontal plane between the FROM and TO stations. This measurement is typically relative to magnetic north, but need not be. At backsight, a measurement of the angle between the TO and FROM stations, will differ from the shot's bearing by 180 degrees. All bearing should be in the range from 0 to 360 degrees. The **VERT** column records the angular measurement in the vertical plane between the FROM and TO station. A positive number indicates the TO station is higher than the FROM station, negative the reverse would be true. All vertical angles should be in the range from -90 to 90 degrees. The **L**, **R**, **U** and **D** columns record the passage dimensions at the Station. These are typical numbers characteristic of the passage, not necessary the exact measurement to the walls from the station.

Stations

Stations are a fundamental object of a *Cave Survey*. A station is a location in three dimensions with a name. Two stations typically form the endpoints of a line that describe a survey *Shot*. An important property of a station is that it must be unique in its location and name within the cave survey. WinKarst does provide a method, through aliasing, to give the same location two names in the raw survey data. But in any calculations, this aliasing is resolved in to unique names for each station. Under no circumstances can two locations have same name, unless the station is contained with a *Loop*. Conversely, any station that has two locations is part of a loop.

WinKarst places no restrictions on the type or number of characters in a station name. Obviously, some characters are better choices than others and good survey techniques suggest that names should have no more than eight characters. Typical station names within a survey share the same prefix characters, e.g. A1, A2, A3, etc.

Optionally, a station may have passage dimensions associated with it. These parameters are named Left, Right, Up and Down (LRUD) and represent the typical passage dimension at the station. The direction of any LRUD measurement will bisect the angle form by the two shots connecting to the station. For example, if the passage makes a right angle turn at station A1, the left and right dimensions will be at an angle of 45 degrees from either of the shots. Obvious, in the case of complex junctions this model is overly simplified. For the Rug plotting mode to be more effective, it is recommended that large rooms be surveyed in a perimeter method rather than the splay method.

When station labeling is enabled a square, triangle, circle, inverted triangle or diamond symbol is drawn at the location of the station. The size of the symbol is controlled by the size of the character font, modified in the Fonts dialog box found on the *Maps* menu. Double clicking near a station symbol will bring up dialog information about that station. If the view of the cave was zoomed in to a particular area when a station was selected through double clicking, the view will zoom into an area around the station. This will also occur when a station is selected through the Station Dialog box.

Station Form

The Station Dialog box is used for selecting Stations and enabling or running the functions associated stations. The **Ok**, **Help**, **Cancel**, **Info** and **Edit** are the major actions that can be applied to the selected Station. A station can be selected by either typing its name in the Station Name line or by **Clicking** or **Double Clicking** on its name in the Station List. **Type** a letter and station names beginning with that letter will begin to appear in the Station List. The **Property**, **Junction** and **Station** check boxes specify station labeling modes for the map. The **Name**, **Elevation**, **Surface**, **LRUD** and **Feature** check boxes enable displaying station properties along with the station symbol for the map.

Control Points

A cave may contain Control Points which are a list of *Stations* which have x, y and z coordinates pre-specified and permanently fixed. Control Points may specify the locations of other entrances in a multi entrance cave or all of the entrances in a multi cave survey. If no control points are specified in a survey, then by default the first station in the first survey is the control point for the cave.

The three separate offset parameters can shift the default control point in the x, y or z directions.

A more sophisticated survey will specify the x, y and z coordinates for one or more stations in the survey. The coordinates may be expressed in relative terms, e.g. A1 1000, 345, 1200, or absolute terms, e.g. A1 123.124 W 45.444 N 3000, expressed in latitude, longitude and elevation.

Relative coordinates are appropriate when it is desired not to embed the cave's location in the survey file for the sake of secrecy or overland surveys have determined entrances relative from each other.

Absolute coordinates allow for the presentation of multiple caves without connecting overland surveys. Entrances can be determined by using Global Positioning System (GPS) devices. Absolute coordinates enable the calculation of the magnetic declination from a mathematical model of the Earth's magnetic field. Locating entrances of a cave system with absolute coordinates allows for the generation of drawings based on several geographic projection methods. Drawing created this way can then be superimposed upon existing topographical maps.

Absolute coordinates must be referenced to a Datum. Older USGS topographical maps are draw to the NAD27 (a.k.a. NAD27 CONUS), while newer maps uses NAD83. Many GPS units will default to the WGS84 datum. Care must be taken not to mix datums, a location may be one hundred meters off with respect to its location reference to another datum. Unless specified in the survey data file, WinKarst uses the NAD27 as the default datum. Surveys with several caves can each specify their own datums.

Station Aliases

A station alias allows for a second text string to be associated with a station. An alias consists of two parts, an aliased station and an equated station. In processing the cave's survey, whenever the equated station's name is encountered, the aliased station's name is substituted. A Station Alias is intended to combine two distinct surveys with out renaming the tie-in station. A single aliased station maybe equated to many equivalent stations.

A word of caution about combining surveys, the station name sets for each cave need to be unique, i.e. non-intersecting. There is no prefixing of station names by the name of the survey to resolve stations within a cave that share the same name.

Surveys

A survey is the base object within WinKarst. A collection of surveys is loosely described as a *Cave Survey* and a collection of cave surveys is a Cave System. In WinKarst, a Survey, as a minimum, consists of a name and a single *Shot*. WinKarst places a programmed limit of 256 unique shots in a survey and in practice few caves ever have exceeded this number (if a survey is encountered in the data file with more than 256 shots, it will automatically be split into two surveys). Shots that exist between the same two *Stations*, either in the forward or backward direction, are averaged together into a single unique shot. The original shot data is always retained in the raw data while the average shot is used in reduced data file formats. There is no limit to the type and number of characters in a survey name, however unique name help identify the survey for plotting or inquiries. The optional parameters of the survey include Date, Team, Magnetic Declination, Comment, Shot Column Order and Shot Units.

The optional parameters provide useful information for future use. If the date of each survey is included, it is possible to assign colors to the survey based upon its age. The date also provides a reference for calculating the change in magnetic declination for some time in the future. A survey's date will allow for the chronological ordering of the surveys in the data file. The Team parameter is simple string of characters than can be used to list the names of the individuals who recorded the survey's data. The Magnetic Declination is added to each shot's bearing in the survey. This is a positive number for the Western three fourths of the United States and negative for Europe. The survey's Comment is another simple string for adding additional notes about how, where or when the survey data was taken. The Shot Column Order and Units parameters record how the user expects to see the data recorded in the raw data file.

The Focus of WinKarst's plot can be set to the current Survey by pressing F4 or by pressing Map in the Survey Dialog box. The current survey can be selected in Survey Dialog box. If there is only one survey in the cave, the survey map will appear exactly the same as the cave map. Furthermore, if there is only one cave in the system, the survey map will appear exactly the same as the system map.

When survey labeling is enabled, double clicking near a survey's name will bring up dialog information about that survey. This action will also set the current survey to this selected survey. If the view of the cave was zoomed in to a particular area when a survey was selected through double clicking, the view will zoom into an area around the survey. This will also occur when a survey is selected through the Survey Dialog box.

Survey Form

The Survey Dialog box is used for selecting surveys and enabling or running the functions associated with Surveys. The **Ok**, **Help**, **Cancel**, **Info**, **Map** and **Edit** are the major actions that can be applied to the selected Survey. A survey can be selected by either typing its name in the Survey Name line or by **Clicking** or

Double Clicking its name in the Survey List. The **Color**, **Reset** and **Auto** buttons will apply colors to the surveys in the cave survey. The **Self** and **Family** check boxes refer to how a survey's color should be applied. The **Label** check box specifies survey labeling for the map.

Survey Exceptions

Exceptions are *Surveys* and *Stations* which do not connect to the main body of the cave. There are two types of exceptions, void and hanging. Void surveys have either the key word Void associated with them or all of the shots within the survey are marked as void. Void surveys are not processed and are included in the raw survey data as documentation. Void surveys are not exported to reduced data file formats.

Hanging surveys have valid shots, but do not connect to any of the stations within the cave. Note that if initially a survey has some shots that do connect to the rest of the cave and some that do not, then the survey will first be split into self connected sub surveys by the connectivity rule and the unconnected section will become a hanging survey. Hanging surveys are not processed and are not exported to reduced data file formats. Hanging surveys may be promoted into new *Caves* through the Export function. In the conversion process, the hanging surveys are extracted from the original cave to form a new cave. Unless a station in one of the hanging surveys has a control point, the station that appears at the physical origin of the resultant cave system will be random. Note it is possible for a collection of hanging surveys to be grouped into more than one cave.

Except Form

The Except Dialog box is used for selecting survey exceptions and running the functions associated with Exceptions. The **Ok**, **Help**, **Cancel**, **Info**, **Edit** and **Export** are the major actions that can be applied to the selected survey. A survey can be selected by either typing its name in the Survey Name line or by **Clicking** or **Double Clicking** on its name in the Survey List.

Survey Shots

Shots are a fundamental object of a *Cave Survey*. In a simple model, a Cave Survey only consists of a connected sequence of shots. Typically, a cave survey group shots into *Surveys* as more and more data is collected over time by different people. A shot consists of three measurements, a bearing, a inclination and a distance and two *Station* names. Technically, the measurements are the polar coordinates of the "TO" station with the "FROM" station placed at the origin of the coordinate system. As the shot sequence continues, the origin is moved from station to station. A shot is a back sight when the origin is placed at the TO station instead of the FROM station.

Duplicate shots are any shot which connect the same two stations, whether in the forward or backward directions. Duplicate shots are averaged into a single unique shot rather than creating the uninteresting case of loops with just two shots. The unique shot is only an internal representation and does not change the raw survey data. Note that duplicate shots may not only exist as simple fore and back sight pairs, but as repeated measurements within the same survey or as resurveys of the same shot sequences in different surveys.

Backsights of bearing and inclination are often taken to improve survey accuracy and detect blunders. Backsights in WinKarst can be represented either corrected or uncorrected, i.e. the bearings differ by 180 degrees and the inclinations are of opposite mathematical sign. When backsights are employed, it is not required to have all four values for fore and back bearing and inclination, just at least a fore or back for the bearing and inclination. Backsights are averaged with the foresight readings.

Shots have the additional parameters of Void or Excluded. A void shot exists only for documentation and is not used for any calculations. Excluded shots are not counted while determining the length of the cave.

How the shot is represented in the raw survey or to the user is a property of the survey containing the shot, e.g. all shots within a survey have the same units of measurement. In addition, passage dimensions are not a parameters of the shot, but a property of the FROM and TO stations of the shot.

Creating shots of zero length to equate or alias station names is not recommended. Use the Alias directive to accomplish this function. If a shot is encountered with zero length, it will be converted into a void shot with the appropriate station alias created. This will be apparent when the survey file is saved to disk.

Properties

A Property List is a group of stations with some feature or attribute in common. Such attributes might include water, wind, animals, etc. With the Property List, the stations within the list can be graphically displayed on the cave line plot.

Currently, only one type of attribute that can be plotted at a time. This part of WinKarst is under construction and is key to future enhancements.

Properties Form

The Attribute Dialog box is used for selecting a particular property from the list. The **Ok**, **Help**, **Cancel**, **Edit** and **Info** are the major actions that can applied to the selected Station. A station can be selected by either typing its name in the Station Name line or by **Clicking** or **Double Clicking** on its name in the Station

List. The **Route** button is used to build a station list from a remote station back to the entrance (the cave's loops must be found first). The **Label** check box specifies Attribute labeling mode for the map.

Loops

A Loop in a cave survey is a collection of *Shots* that when placed head to toe, form a circular chain. The word "circular" implies nothing about the topology of the sequence of shots other than in tracing it, you return to your starting point. An important property of a loop is that it has an equal number of shots and *Stations*. Note that there is nothing preventing a shot from existing in more than one loop within the *Cave Survey*. Alternately, a loop can be described as a collection of one or more *Traverses*. Each Traverse is a collection of non-loop-branching shots, which can be simplified as a single shot describing the Loop network.

Loops are a derived quantity of a survey and can be used to test the quality of the survey. Starting at a station in a loop and tracing it until the station is encounter again, the ending location may be physically different than the starting point. This difference between the physical and logical locations is the loop or closure error. Closure error is a complex function of the length, direction and count of the shots that make up the loop. WinKarst *Calculates* the actual physical error and the expected error for the shot sequence. If the physical error is factor times larger than the expected error, the loop probably contains a blunder shot. Blunder loops may be the results of data entry errors or errors in measurements taken in the cave. Either way, a blunder represents a serious problem in the cave survey.

Loops that pass the blunder test can be *Adjusted by Iteration* or by *Least Squares* such that the physical distance between the starting and ending points is the same. A survey that has been adjusted or "closed" may ease the problem of creating a map of the cave and fix locations within the cave with greater confidence. In the process of closing a survey, the loop closure error is distributed about the shots that make up the loop sequence. The distribution of the error is done such that no shot is stretched or moved more than user defined limits. By controlling the adjustment, the line map will closely match the surveyor's sketch.

WinKarst shows the physical loop closures errors on the line plot as dashed lines. The dashed lines do not show up in the auto scale views of the map and the view must be zoom in to a particular area for the lines to be visible. When the loop network has not been closed and the loops colored, there appears to be an extra shot in the area of the dashed line. This is simply the logical connection that must be made to connect the loop. When the loop labels are displayed, double clicking the mouse near a loop name will bring up an information dialog about the loop.

When a loop is plotted, shots that tie into the stations of the loop are also shown. When searching for errors in a loop, it is important to know how the loop connects to the rest of the cave survey. The side shots of the loop shows the connection. For whatever reason a station of a loop is moved in the cave in a re-survey attempt, all side shots to the revised station location must be re-established. To make the shot sequence that makes up the loop more apparent, color the loop. The side shots will always be in the fore ground color, black or white.

Loop Form

The Loop Dialog box is used for selecting loops and enabling or running the functions associated with Loops. The **Ok**, **Help**, **Cancel**, **Info**, **Edit**, **Find**, **Map** and **Close** are the major actions that can be applied to the selected Loop. A loop can be selected by either typing its name in the Loop Name line or by **Clicking** or **Double Clicking** on the name in the Loop List. When typing a Loop Name, all loops that start with the same characters will be displayed in the Loop List. Backspace all the character or delete the name to show all of the loops in the cave survey. Type a station name in the Station Search to create a list of loops containing the station.

The **Color**, **Reset** and **Auto** buttons will apply colors to the loops of the cave survey. The **Within**, **Start**, **Name** and **Elevation** check boxes specify loop labeling modes for the map. The **Blunder** check box reduces the loops in the Loop List to only those exceeding the *Blunder Limit*.

Traverses

A Traverse in a cave survey is a collection of *Shots* that is a sub-section of a larger *Loop*. A loop can be described as a collection of one or more traverses. Each traverse is a collection of non-loop-branching shots, which can be simplified as a single shot describing the looping network of the cave survey. The shots of a traverse may have branches, but a non-loop-branching shot only leads to a deadend. Describing the cave survey's loops as single shots between junctions is required when applying the Land Surveyors method of loop closure, the *Adjustment by Least Squares*. Alternately, WinKarst can use a less memory intensive method of *Adjustment by Iteration* to close the cave survey's loops. Note, that for surveys in which the loops to not share any shots, each loop is independent of the others, each method of closure yields the exact same results.

Closure error is a complex function of the length, direction and count of the shots that make up the loop. WinKarst *Calculates* the actual physical error and the expected error for the shot sequence. If the physical error is factor times larger than the expected error, the loop probably contains a blunder shot. Blunder loops may be the results of data entry errors or errors in measurements taken in the cave. Either way, a blunder represents a serious problem in the cave survey. When WinKarst determines the cave survey's traverses, the traverses that make up a loop that meets error expectations is marked as acceptable. However, all traverses of blundered loops are marked unacceptable. A traverse that is part of a good loop and another blundered loop is marked as acceptable. In this way, a blundered shot can be isolated to a single traverse. WinKarst keeps track of how may bad loops a blundered traverse participates in, allowing the user to concentrate on the worst offenders.

While adjustment by least squares can also detect traverses with blunders, the resultant closure solution must be discarded because the blunder could have over corrected a good loop. The repetitive sequence of loop adjustment by least squares, blunder detection and adjust again must be avoided due to the time required to calculate the complete solution. It is essential to remove all of the blundered traverses before adjustment by least squares.

WinKarst shows the physical loop closures errors on the line plot as dashed lines. The dashed lines do not show up in the auto scale views of the map and the view must be zoom in to a particular area for the lines to be visible. When the loop network has not been closed and the traverses colored, there appears to be an extra shot in the area of the dashed line. This is simply the logical connection that must be made to connect the traverse. When the traverse labels are displayed, double clicking the mouse near a traverse name will bring up an information dialog about the traverse.

Traverse Form

The Traverse Dialog box is used for selecting traverses and enabling or running the functions associated with traverses. The **Ok**, **Help**, **Cancel**, **Info**, **Find**, **Map** and **Close** are the major actions that can be applied to the selected Traverse. A traverse can be selected by either typing its name in the Traverse Name line or by **Clicking** or **Double Clicking** on the name in the Traverse List. The **Color**, **Reset** and **Auto** buttons will apply colors to the traverses of the cave survey. The **Within**, **Start**, **Name** and **Elevation** check boxes specify traverse labeling modes for the map.

Groups

Groups are collections of surveys. Surveys are assigned to groups on the Survey page of the Editor. A survey can be a member of only one group. There can be any number of groups in a survey. Logically, surveys could be grouped by either time or position. The Group can be viewed as a separate object in the map view, or uniquely color in the entire cave system view. The group name is not used for any calculations.

Groups Form

The Group Dialog box is used for selecting groups. The **Ok**, **Help**, **Cancel**, **Info**, **Find**, **Map** and **Close** are the major actions that can be applied to the selected Group. A group can be selected by either typing its name in the Group Name line or by **Clicking** or **Double Clicking** on the name in the Group List. The **Color**, **Reset** and **Auto** buttons will apply colors to the groups of the cave survey. The **Within** and **Name** check boxes specify group labeling modes for the map.

Sketches

For sketches to be displayed, the cave lineplot view must be plan.

Sketches are any images that geographically contain a station from the survey. For best results, hand drawings of cave passages done during a survey must be to scale. That means the distance between stations must be scaled with a ruler and account for the shortening of the horizontal distance for shots with a steep inclination angle. The relative angle between two shots sharing a common station must be accurately drawn with a drafting compass or protractor. When the Sketch is reasonably true to scale, then it can be scaled, rotated and drawn over the line plot of the survey to match. When more than two stations are found on the sketch, then the image can also be morphed to exactly cover the lineplot.

Sketches can be shown on the map view in one of three ways. The first way is with the lineplot and all of the sketches in the view are displayed. As the field of view changes, due to panning or scaling, more sketches will automatically read from the file system and displayed. WinKarst manages the sketches in memory to save space and up to 100 sketches can be display at one time. If morphing is enabled, then each sketch is morphed as it is read.

The second way to view sketches is without the lineplot, or hiden lineplot. This mode simulates a finished cave map. A PNG file of the map view, up to 4000 pixels wide, can be exported as a cave map. The last way to view a sketch is individually. The Sketch Dialog box on the Preference drop down menu provides a means to select individual sketches. The the single sketch mode is useful in complex, overlying passages where several sketches overlap.

Sketch Form

The Sketch Dialog box is used for selecting Sketches and enabling or running the functions associated sketches. The **Ok**, **Help**, **Cancel**, **Info** and **Edit** are the major actions that can be applied to the selected Sketch. A sketch can be selected by **Clicking** or **Double Clicking** on its name in the Sketch List. **Type** a name in either the Station Name or Survey Name box and sketches associated with that name will selected in to the Sketch List. As characters are typed into the Sketch Name box, sketches starting with the same characters are listed in the Sketch List. Picking a Sketch Sheet from the drop down list will display all of the sketches in the sheet in the Sketch List. The **Label** and **Hide Lineplot** check boxes specify a sketch labeling mode and lineplot control for the map.

To display a single sketch on the line plot, select a sketch in the Sketch List and press the **Map** button. To display a sketch sheet, select a sheet name from the drop down list and press the map button. Information is not available on sketch sheets.

Contents - Elements of a Drawing

Focus of the View

WinKarst as the ability to focus on different object in each view of the Document. Each of the views or windows are connected in how they view the cave survey and independent in where or what they are viewing. For example, all views will have the same labeling and color modes. On the other hand, each view can be centered on different areas of the cave or focused on different objects.

The objects of focus are *System*, *Cave*, *Survey*, *Loop*, *Traverse* and Shots of a *Station*. In a basic sense, each of these objects are simply a collection of Shots. The shots, when connected and calculated in three dimensional space, are an object of focus. When WinKarst focuses on a Survey for example, any searches, coloring or auto scaling will only apply to the shots that make up that survey. Each of the objects of an object type can be selected by various dialog boxes reached from the "Preferences" menu item or Function hot keys. By toggling between the various focused view types while zoomed into an area containing an object can show how that object is connected to the whole.

An object of focus can be selected by *Hot Keys*, through the *Focus* menu or by various object dialog boxes.

Focus

Each open window of a cave survey represents a unique and focusable view of the survey. Each view can be set to different areas of the cave, plan or elevation. However, the modes of the views are in common among all views, e.g. each survey will have the same color in all views, junction stations will be shown in all views.

System F2

When a cave survey is opened, this is the default focus. All of the caves of the system will be plotted in the map. If there is only one cave in the file, then this focus will appear exactly as the Cave Focus. Even though the focus is the system, each view as a prefix to a particular cave. Use the cave dialog box to change the cave prefix.

Cave F3

Pressing F3 or this control will change the focus of the view to the prefixed cave of the view. Changing the cave prefix in the *Preferences* | *Cave* form will redraw the window to the new cave.

Survey F4

Pressing F4 or this control will change the focus of the view to the prefixed survey of the view. Changing the survey prefix in the *Preferences* | *Survey* form will redraw the window to the new survey.

Station F7

Pressing F7 or this control will change the focus to the view to the prefixed station of the view. Changing the *Station* prefix in the *Preferences | Station* form will redraw the window to the new station. The plot will show all of shots that connect to the Station of focus.

Loop F9

Pressing F9 or this control will change the focus to the view to the prefixed loop of the view. Changing the loop prefix in the *Preferences | Loop* form will redraw the window to the new loop. The cave's *Loops* must be calculated and exist before this option will be enabled.

Traverse F10

Pressing F10 or this control will change the focus to the view to the prefixed traverse of the view. Changing the *Traverse* prefix in the *Preferences | Traverse* form will redraw the window to the new traverse. The cave's *Loops* must be calculated and exist before this option will be enabled.

Group F11

Pressing F11 or this control will change the focus to the view to the prefixed group of the view. Changing the group prefix in the *Preferences | Group* form will redraw the window to the new group. Groups are defined in the Survey page of the Editor.

System Overview

Pressing this control will change the focus to the cave System and set the view type to auto scaled plan and profile views. This is a quick exit from, "I am lost" and you want to get back to the overall view of the cave survey.

Labeling Maps

Labels are an import aspect of a map. On USGS topographical maps, labels may indicate roads, elevation or jurisdictions. Labels are a method of encoding more information into the image of the map. WinKarst uses labels to indicate different objects, e.g. caves, loops, surveys, etc.

The labelable objects in WinKarst are Caves, Surveys, Loops, Stations, Junctions and Control Points. In most cases each object has an unique type of label and optionally can include text. Caves are labeled with a square and half circle and if the name of the cave is known, the name is included. Surveys and Loops have no graphical symbol, but their names are displayed at the their origins. Stations and Junctions are indicated with either a square, circle, triangle, inverted triangle or diamond. Optionally, stations and junctions can be labeled with their names and elevation and where the walls are located relatively. Control Points are labeled with a circle with two quadrants black and two white and if the name of the point is known, the name is included.

The size of a label is controlled by the size of the character font, modified in the Fonts dialog box found on the *Maps* menu.

A coloring method can be selected by *Hot Keys*, through the *Label* menu or by various object dialog boxes.

Label

Cave Alt+v

Pick this control or press the Alternate and 'v' keys to label the caves on the map. Each cave's name and a symbol representing an entrance will be placed at the first station of the cave survey. The color of the text will be the same as the cave's.

Survey Cntl+s

Pick this control or press the Control and 's' keys to label the surveys on the map. Each survey's name will be placed at the first station of the survey. The color of the text will be the same as the survey's.

Station Cntl+l

Pick this control or press the Control and 'l' keys to label each station on the map. Each station will be indicated by one of five symbols, constant for the entire survey. The symbols are a square, circle, triangle, inverted triangle and diamond. The color of the symbol will be the same as the survey containing the station. Optionally, each station may show it name, elevation and either left/right or up/down tick marks. This option is controlled in the station dialog box. The color of the text is controlled in the Fonts dialog box.

Junction Cntl+j

Pick this control or press the Control and 'j' keys to label each stations at passage junctions, start of surveys and at dead ends. The symbols and options for junction labeling are the same as described above for Station labeling.

Property Cntl+a

Pick this control or press the Control and 'a' keys to label each station in the attribute list. The attribute list is created and modified in the attribute dialog box. The symbols and options for attribute labeling are the same as described above for Station labeling.

Head of Loop Cntl+u

Pick this control or press the Control and 'u' keys to label the head of each loop in the cave. This option is only enabled if the cave's loops have been found or closed. Each loop's name will be placed at the first station of the loop. The color of the text will be the same as the loop's.

Head of Traverse Cntl+k

Pick this control or press the Ctrl and 'k' keys to label the head of each traverse in the cave. This option is only enabled if the cave's loops have been found or closed. Each traverse's name will be placed at the first station of the traverse. The color of the text will be the same as the traverse's.

Head of Group Ctrl+y

Pick this control or press the Ctrl and 'y' keys to label the head of each group in the cave. The group name is specified in the Survey page of the Editor. The name is placed on the first member survey of the group. The color of the text will be the same as the group's.

Within Loop Alt+u

Pick this control or press the Alt and 'u' keys to label the stations within a loop of the cave. This option is only enabled if the cave's loops have been found or closed. Each loop's stations will have one of the five possible station symbols. The additional options for station labeling are also available, i.e. name, elevation and LRUD ticks. The color of the symbols and text will be the same as the loop's. Since a station can be a member of many loops, more than one station symbol may be 'stacked' at the station's location.

Within Traverse Alt+k

Pick this control or press the Alt and 'k' keys to label the stations within a traverse of the cave. This option is only enabled if the cave's loops have been found or closed. Each traverse's stations will have one of the five possible station symbols. The additional options for station labeling are also available, i.e. name, elevation and LRUD ticks. The color of the symbols and text will be the same as the traverse's A station can only be a member of one traverse and as such will have only one symbol at the station's location.

Within Group Alt+y

Pick this control or press the Alt and 'y' keys to label the surveys within a group of the cave. The member surveys of a group are specified in the Survey page of the Editor. The names are placed at the beginning of each survey of the group. The color of the text will be the same as the group's.

None **Cntl+n**

Pick this control or press the Control and 'n' keys to disable what ever label mode is active.

Coloring Maps

Color is an import aspect of a map. On USGS topographical maps, color may indicate forest, water or a type of rock like lava. Color is a method of encoding more information into the image of the map. WinKarst uses color to indicate different objects, e.g. caves, loops, surveys, etc, depth of the view into the page and age of survey.

The colorable objects in WinKarst are Caves, Surveys, Loops, Traverses and Shots of a Station. Objects can be individually or automatically colored. When caves or surveys are automatically colored, the choice of color is random. For loops, loops with the largest expected error is colored red, the lowest error violet and intermediate values with the rainbow spectrum. An object can be individually colored through is corresponding dialog box. The object's name must first be selected in the Name Line or Name list and then the Color button pressed. Pressing the button will bring up a color palette for choosing colors.

Coloring the depth of the view into the page operates independently in plan and elevation views. For the plan view, the depth into the page is always the depth of the cave from the surface. For the elevation view, the depth into the page depends upon the direction of true north, the angle the view has been rotated. If the angle is zero degrees, the depth is the north/south distance. If the angle is 90 degrees, the depth is the east/west distance. In all cases of color by depth, the areas of red are on top, violet on the bottom and intermediate values with the rainbow spectrum.

Coloring the depth of the passage operates independently in all views. For the three dimensional view, the depth coloring is constant for all angles of view. As above, the areas of red are highest, violet on the bottom and intermediate values with the rainbow spectrum.

Coloring by time is based upon the date a survey was recorded. The newest surveys are red, the oldest violet and intermediate values with the rainbow spectrum. Note that some survey data formats do not record dates well and results of coloring by time can be disappointing.

A coloring method can be selected by *Hot Keys*, through the *Color* menu or by various object dialog boxes.

Color

Every Cave Cntl+c

Pick this control or the Alternate and 'c' keys to color each cave in the survey with a unique color. A cave will have the same color in all views of the survey. A cave's color can be individually set in the *Preferences* | *Cave* form.

Every Survey Cntl+e

Pick this control or the Control and 'e' keys to color each survey in the cave with a unique color, up to 64 colors. If there are more than 64 surveys, the color sequence will be repeated. A survey will have the same color in all views of the survey. A survey's color can be individually set in the *Preferences* | *Survey* form.

Every Loop Cntl+q

Pick this control or the Control and 'q' keys to color each loop in the cave with a color keyed to the quality of the loop. The loops must be either found or closed before is option will be enabled. The loop with the worst closure error will be colored red and the best violet, with intermediate errors spread through the rainbow spectrum of colors. A loop will have the same color in all views of the loop. A loop's color can be individually set in the *Preferences* | *Loop* form

Every Traverse Alt+q

Pick this control or the Alt and 'q' keys to color each traverse in the cave with a color keyed to the quality of the traverse. The loops must be either found or closed before is option will be enabled. The traverse contained in the largest number of bad loops will be colored red and the best violet, with intermediate errors spread through the rainbow spectrum of colors. A traverse will have the same color in all views of the traverse. A traverse's color can be individually set in the *Preferences* | *Traverse* form.

Every Group Cntl+x

Pick this control or the Ctrl and 'x' keys to color each group in the cave with a unique color. A group will have the same color in all views of the group. A group's color can be individually set in the *Preferences* | *Group* form.

Into the Page Cntl+d

Pick this control or the Control and 'd' keys to color the object of focus, either system, cave, survey, group, loop or traverse, by indexing the color with depth from the entrance of the passages. For the Plan view, the highest passages are colored red and the lowest violet, with intermediate values spread through the rainbow spectrum of colors. For the Profile view, the closest passages are colored red and the furthest violet, with intermediate values spread through the rainbow spectrum of colors. When the Profile view is rotated, the passage coloring will change. This coloring method is not available in Three Dimensional mode.

Depth Alt+d

Pick this control or the Alt and 'd' keys to color the object of focus, either system, cave, survey, group, loop or traverse, by indexing the color with depth from the entrance of the passages. The highest passages are colored red and the lowest violet, with intermediate values spread through the rainbow spectrum of colors. When the Profile view is rotated, the passage coloring is constant. Use Depth coloring in Three Dimensional mode.

Below Surface Cntl+w

Pick this control or the Ctrl and 'w' keys to color the object of focus, either system, cave, survey, group, loop or traverse, by indexing the color with depth below the surface. The passages closest to the surface are colored red and the furthest violet, with intermediate values spread through the rainbow spectrum of colors. When the Profile view is rotated, the passage coloring is constant. A *DEM or SDTS* data file of surface elevation must be processed before this option is available.

Time Cntl+t

Pick this control or the Control and 't' keys to color the object of focus, either system, cave or survey, by indexing the color with when the survey was recorded, relative to the period the entire cave was surveyed. The newest passages are colored in red and the oldest in violet, with intermediate values spread through the rainbow spectrum of colors.

Station Alt+a

Pick this control or the Alt and 'a' keys to color the station of focus. All shots connected to the station of focus will be colored. A station's color can be individually set in the *Preferences* | *Station* from.

Reset

The Reset control will set the color of all colorable objects, caves, surveys and loops to the opposite color of the background color, either black on white or white on black. For colorable objects, they may be individually reset in their respective dialog boxes. The black and white tool on the tool bar will activate this control.

Black Background

The Black control will set the back ground color to black. Uncolored objects will be switched to the previous back ground color to remain visible. The black tool with the circle on the tool bar will activate this control.

White Background

The White control will set the back ground color to white. Uncolored objects will be switched to the previous back ground color to remain visible. The white tool with the circle on the tool bar will activate this control.

Scaling Maps

A map's scale in the purest sense is a ratio, e.g. 1:24,000. If a lake appeared on a map scaled at such a ratio, it would be 1/24,000 of its actual size. If a map's scale is expressed as 1 inch equals 500 feet, this is also a ratio. To convert that scale to a ration, multiply by the factor of 12 inches per foot, or 500 x 12 = 1:6000. No matter what the scale, it must be clearly indicated on the map. WinKarst can indicate the scale by including a scale bar symbol.

To set the scale, how it is expressed and add a scale bar symbol, use the *Scale, Rotation and Legend* box.

Scale, Rotation and Legend

The scale expressed in this dialog box and in the status bar at the bottom of the main window may be either English, Metric or Ratio'ed. Checking the **Ratio** check box will cause the scale to be expressed as ratio. When the box is unchecked, the scale is expressed with which ever of the **English** or **Metric** boxes are checked. For units that appear else where within WinKarst, check either English or Metric for the desired system.

The scale bar in the drawing automatically adjusts such that some power of ten feet or meters fits within the bounds of the window. As the view is zoomed in, the scale bar grows. But before the bar extents beyond the window's edge, its range is adjust down to the next power of 10. The process works in reverse as the view is zoomed out. Check the **Show Scale** check box to include the bar on the drawing. Specify the value of the scale in the **Scale** box.

The rotation of the view from true North can be specified in the **Rotation** box. While in three dimensional mode, the angle relative to the horizon can be specified in the **Oblique** box. The compass in the drawing will rotate to indicate the direction of true North. When viewing the cave's elevation, the compass still points towards north if the view was in the plan. In three dimensional mode the compass is replaced by 'corner' of a box to help maintain proper perspective of the view. Check the **Show Compass** check box to include the compass or corner on the drawing.

The mouse coordinates shown in the status bar may be either absolute or relative. Relative coordinates are always from the origin of the object displayed, system, cave, survey or loop. Absolute coordinates are longitude and latitude, it they have been specified for the cave's entrance. Press the **Absolute** or **Relative** box to choose how the coordinates are expressed.

A coordinate grid can be placed on the plot by checking the **Show Coord Grid** box. When the Absolute box is checked, the grid is based on two minutes of longitude and latitude. When the Relative box is checked, the grid is based on the UTM system. The spacing of the UTM grid lines decreases as the view zooms in, i.e. 1000 meters, to 100 meters to 10 meters. The grid's lines are labeled with their coordinate values. In the Profile plot, the grid is simply horizontal lines based on either Metric or English units.

Press the **Ok** and **Cancel** buttons to exit the dialog box or the **Help** button to access the help system. Only the window with the focus will be modified by changes made in this dialog box.

Rotating Maps

Most commonly, maps are orientated to True North. Some sketch maps are orientated to Magnetic North. These are not hard set rules and sometimes the cartographer will orientate the map to maximize the use of the paper. For example if the cave could be characterized by a near straight line, the cartographer might orientate the map such the cave is laid out between opposite corners of the paper. No matter the orientation, the direction of North must be clearly marked on the map. WinKarst can show the direction of North by including a compass symbol.

Two rotating modes generate an animated view of the cave survey, Continuous and Two Axis rotation. By drawing the 'upcoming' frame in memory and quickly writing it to the viewing window when the drawing is completed, a smooth, spinning view of the survey is produced. The Continuous rotation is about the vertical axis, but the Oblique angle relative to the horizon can be set to any angle. The Two Axis rotation rotates the view about the vertical and horizontal axes To **STOP** the rotation, press the Escape key on the keyboard or press the left mouse button on the rotating view.

To set the angle of rotation and add a compass symbol, use the *Scale, Rotation and Legend* box.

Three Dimensional Modeling

WinKarst models cave passages from the left, right, up and down (LRUD) information included with each shot. If no LRUD dimensions are available, then an average passage dimension of six by six feet is chosen. The *Passage Model* has three elements, shots, junctions and ends. Shots are modeled as a six sided container, two rectangles for the side walls and two triangles each for the floor and ceiling. This is a natural consequence of defining the direction of the left and right measurements to be the angle bisecting the azimuth of the shots leading to the station where the LRUD measurement is made. In order for passages to be modeled with a simpler four sided box, the direction of the left and right dimensions would have to be restricted to always be north/south. The sides are modeled as rectangles because the direction of the up and down dimensions has been defined as vertical with respect to the center of the Earth. Should the up and down measurements be redefined as an angle bisecting the vertical dip angle of the shot, then the passage would be modeled with a container of eight triangles.

The second element is junctions. At a station which is referenced by more than two shots, a junction, the definition of left and right is ambiguous. WinKarst defines the passage dimension as always right, about the station in a clockwise direction. The direction of each right measurement bisects the azimuth of the shots leading into the junction. After the shot containers are drawn, a gap exists directly above and below the station. For a three shot junction, a triangle is placed above and below the station. For a four shot junction, a square or four sided polygon is used, and so on.

The last element is an end. At each deadend passage, a vertical end cap is placed on the last shot container, so that it is not possible to look into the passage. Due to the internal data structure of the LRUD data, there is only a single dimension for left and right at the deadend station. This means the station will be at the center of the ending cap piece.

Where does the LRUD information exist? In a normal, one way, branching survey, the LRUD data is associated with the "TO" station. This definition breaks down at junctions and surveys with backsights. Internally, the LRUD data is associated with a station. Should there be more than one shot with the same TO station, then the LRUD dimensions are average. Should there be a station that only exists as a "FROM" station throughout the survey, then the average passage dimensions for the survey are used for LRUD data.

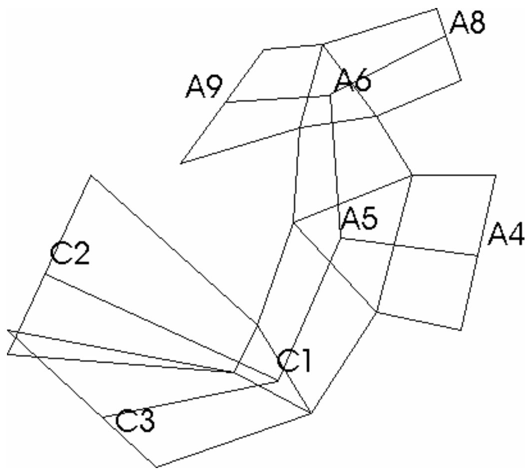
When displaying the LRUD based model of the cave, WinKarst sorts the containers by optical depth and evaluates each face of each container to determine if it can be seen by the user. Occasionally, some faces are dropped and others are drawn out of sequence, cutting into neighboring faces. The routine yield satisfactory results and is a compromise with drawing speed.

The LRUD model can be enlarged or panned through by using either the keyboard hot keys or from the pull down menus. The mouse is used to rotate the cave about two axes Select a point in the window and press and hold the right button. By dragging the mouse to the left or right with the right button depressed, the cave will rotate about its vertical axis. Similarly, by dragging up and down, the cave will rotate about its horizontal axis.

To export a three dimensional view, WinKarst must be in the three dimensional mode, as indicated by the 3D button on the *Tool bar* or by the check mark next to the three dimensional choice in the *Map* pull down menu.

Passage Modeling

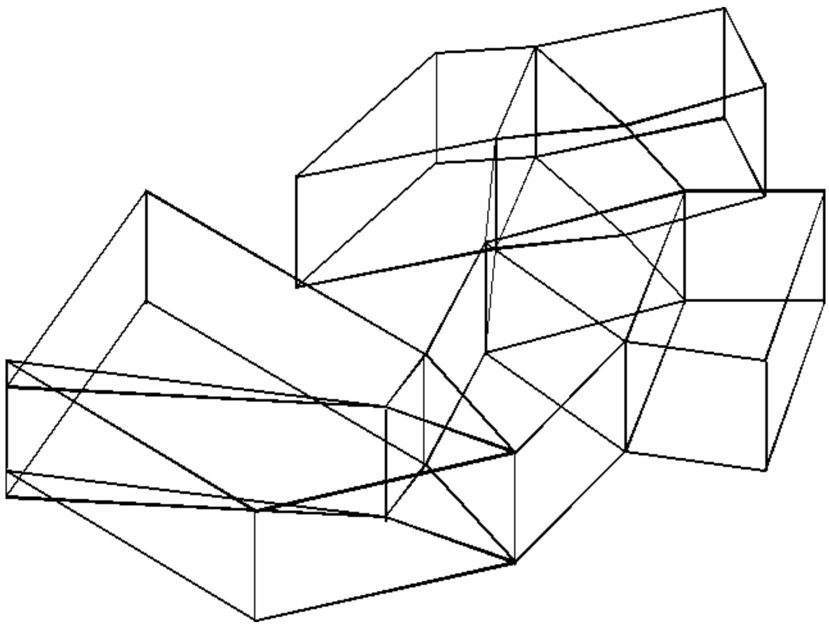
Passage modeling is an approximate method to help visualize a cave's complex nature. Because of the limited nature of the passage dimensions, in the form of Left, Right, Up and Down (LRUD) measurements, only crude drawings can be made. Obviously, the more junctions and rooms a cave survey has, the more difficult it is to describe in a finite set of measurements.



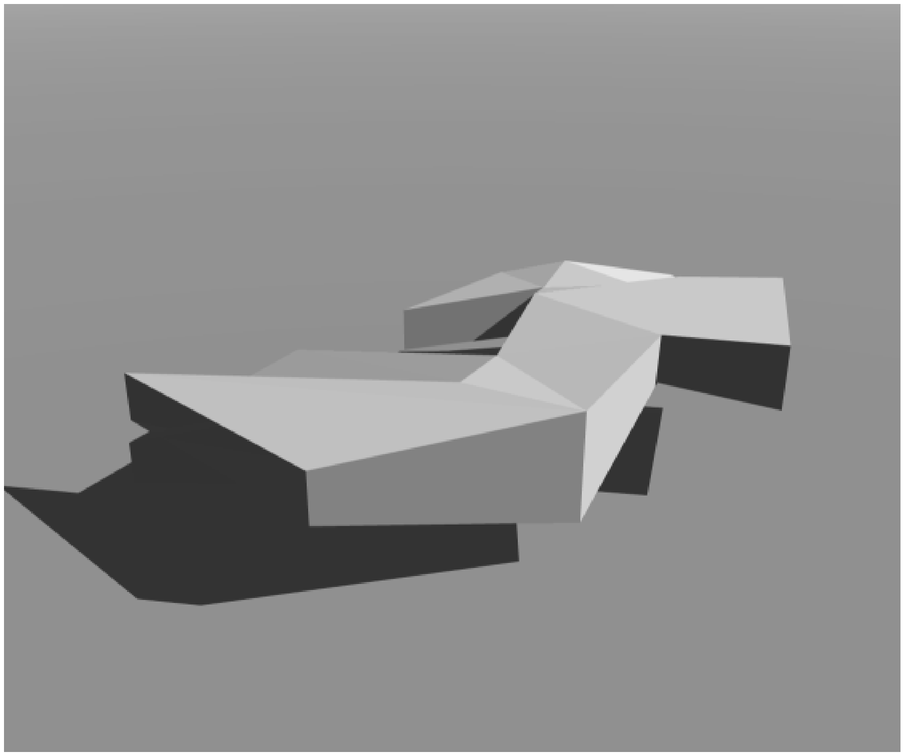
In the sample drawing above, the left and right measurements at A4 adequately describe the passage topology. At station A5 the passage splits left and right. Often, when confronted with this situation, surveyors mark "P" for passage for the left and right measurements at A5. In this case, WinKarst substitutes the survey's average passage dimensions for left and right. The assumption is the average survey dimensions are localized and characteristic of the passage in the vicinity of A5.

The other problem with A5 is which direction is left and right? WinKarst uses two shots to define a left or right direction. In the case of a junction, all of the directions are rights. The shots A5 to A4 and A5 to A6 define a pair of shots and the bisection of the angle created by the pair is the right passage dimension direction. Similarly, the shots A6 to A5 and A5 to C1 define a pair and C1 to A5 and A5 to A4 define another pair. At station A5, there are three passage dimensions and they create the triangle around the station. A another triangle is formed at A6. Should a junction contain four shots, then a four sided polygon will enclose the station and so forth for more complex junctions. Should there be more than on LRUD measurement at a station, they are averaged for the drawn representation.

The shots C1 to C2 and C1 to C3 are an example of a typical inaccuracy. WinKarst does not check whether two adjacent wall sections overlap or not. In this case the solution, assuming the left and right measurements at C2 and C3 are correct, is to shoot an intermediate station mid way along both shots. In general, the more and shorter the shots in a cave survey, the more accurate the passage model will be.



The drawing above shows how a wire mesh for a cave passage is created in WinKarst. The passage's vertical dimensions, up and down, were held to a constant value and flat for simplicity and the base was the drawing at the head of this page. The two wall components for a shot are vertical rectangles. The floor and ceiling for a shot are two triangles each. The floor and ceiling are formed this way because in general, twisting of the passage prevents these plates from being drawn by a simple planar rectangle. The triangles at the junctions C1, A5 and A6 are modeled with flat floors and ceilings.



Final three dimensional rendering after exporting the passage model to a third party graphics program.

Using Digital Elevation Models

Reading DEM Files

WinKarst will read two types of DEM files, the older DEM style and the newer SDTS format. In the older format, all of the DEM information was included in a single file, with the DEM extension. The newer format is actually a collection of files. There may be up to 18 files in a SDTS representation of DEM data, each with the DDF extension. One file in particular is essential, the file with the name in which the last four characters are CATD. For example, the CATD or catalog file for a SDTS file set might be 1276CATD.DDF.

The SDTS catalog file contains a list of files that make up the SDTS set. WinKarst actually only needs a couple of these files to obtain the necessary information for the DEM, but all of the files in the set should be kept together as it was originally distributed. The USGS will typically distribute SDTS files has a gzip'ped tar file. Gzip is a public domain file compression utility and tar is a UNIX utility for bundling up a set of files into a single file. It is important to uncompress each SDTS file set in its own subdirectory, otherwise a previous decompress file could be overwritten. Programs such as WinZip can decode USGS files from their compressed form, but any alternate methods work using public domain software. The USGS has written *Retrieving and Unpacking SDTS Data Tutorial* *and Users Manual*, from June 1998.

WinKarst will connect DEM files that are adjacent into a larger composite model. Each cave which falls within the DEM's area will have its control points elevation calculated and the entire survey recalculated using the new determination of elevation. Cave surveys saved after a DEM is read will retain the elevation values determined for its control points. If subsequent DEM file is read which does not touch the existing model, then the previous DEM files are purged from memory and only the new one is retained.

Displaying Elevation Contours

Typically, the data points a DEM are spaced 30 meters apart. Unfortunately, caves usually do not span more than a few DEM data points. WinKarst solves this problem by interpolating the elevation for locations that do not exactly match a DEM data point's location. Each pixel in the display of a cave map corresponds to a exact physical location and WinKarst calculates the elevation of each pixel through interpolation. When drawing contours, WinKarst marks each pixel in a pair of pixels in which their elevation intersects a contour interval. When all of the pixels are marked on the display, the pixel join into lines. Occasionally, the interpolation process determines a different slope for a different set of adjacent DEM data points. When this happens, the contour lines have irregular jumps.

WinKarst can display contours at three different intervals. Depending whether Metric or English are used for the display, the contour choices are 20, 40 and 200 feet or 10, 20 and 100 meters. The display units are made in the *Scale and Legend* dialog box. The contour lines are always drawn in the display's foreground color. Contours can only be displayed in the Plan view. Contours can be exported to BMP or DXF files, In the case of DXF, the individual pixels

Displaying Surface Shadow

A Surface Shadow is the projection of the cave survey on to the surface calculated from a DEM when viewed from below the cave. The shadow is always drawn in the display's foreground color. The shadow can be displayed in either the Profile, combined Plan and Profile or in the 3D views. The shadow can be exported to BMP or DXF files. The DXF export of the surface is especially useful for drawing profile views of the cave and the surface in drafted maps.

The Surface Shadow immediately allows for the determination of how much overburden exist at all points above the cave. In addition to telling where the cave is close to the surface, it can serve as a quality check to verifying no part of the cave survey is calculated above the surface!

Display Surface Mesh

A Surface Mesh is the calculated surface from a DEM displayed in a three dimensional view. The mesh is always drawn in the display's foreground color and is available only in the 3D unified view. The mesh can be exported to DMP or DXF files. The mesh only covers the surface in a box containing the cave survey. To create a larger mesh, simply add control stations at southwest and northeast corners, enclosing a larger area than the cave itself.

Using the DEM Locator Map

The DEM Locator Map draws a color coded pixel in a child window for every data point in a DEM. A cave survey need not be opened to use the map, but at least only after reading a DEM file. The child window has its own *menu selections* for setting the data compression ratio, color scheme, shading and contours. A BMP file may be exported from the window. When the mouse is moved over the window, the coordinates and elevation are displayed in the status bar of the main window.

The map has three compression ratios, full, half and quarter. In full mode, there is one pixel per DEM data point, in half mode there are four pixels per data point and in quarter mode sixteen. When the DEM map's width or height in terms of data points exceeds the resolution of the computer's display, either half or quarter mode will be automatically chosen to display the map.

The map has two color schemes, rainbow and earth tones. In the rainbow scheme, red represents the highest elevations and violet the lowest. In the earth tones scheme, the color attempts to mimic an aerial view of the landscape, with white at the highest elevations and deep green in the lowest.

The map has three modes for shading, none, relief and shadow. Obviously, the none mode shows no differentiation in coloring other than for elevation. In the relief mode, areas of steep slope are shaded darker, the darker the color the steeper the relief. In the shadow mode, the sun is shining low in the west at sunset and eastern facing slopes are shaded darker in the shadow.

The program can draw contours of 200 feet intervals on the map, with or without the underlying color scheme.

When a cave survey is open in the main window, white circles indicating the locations of control points in the survey are drawn on the locator map. A box is also drawn on the map indicating the extents of the main window. Changing the scale in the main window will cause the box to enlarge or grow smaller. Drawing a box in the locator map with the mouse will cause the main window to display that region (the view will change to Plan).

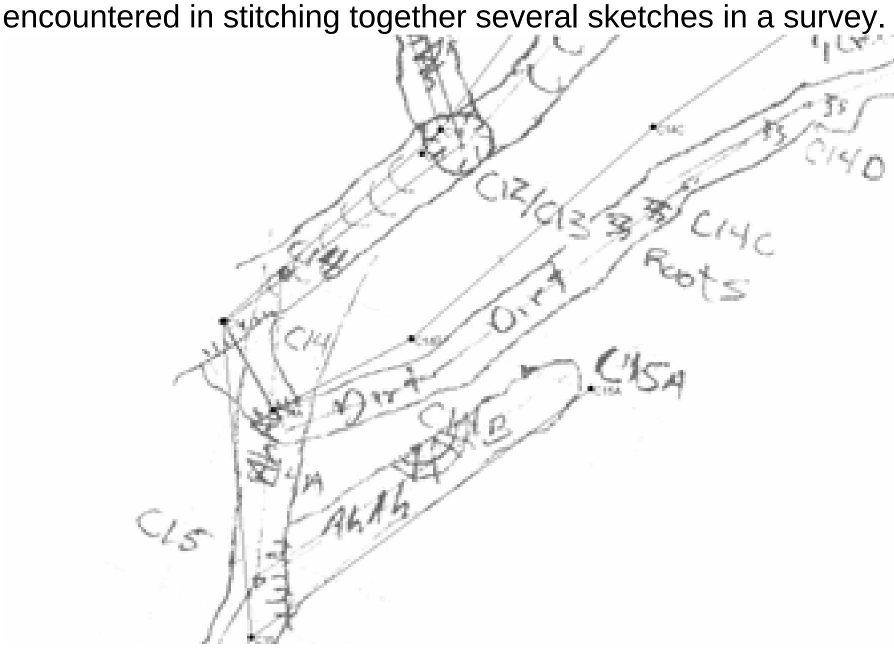
Morphing Sketches

In a perfect world, a surveyors sketches are exactly to scale, the angle and length of each shot precisely drawn. Unfortunately, harsh conditions or skill prevents the surveyor from achieving perfection. In those situations, computers and software can help.

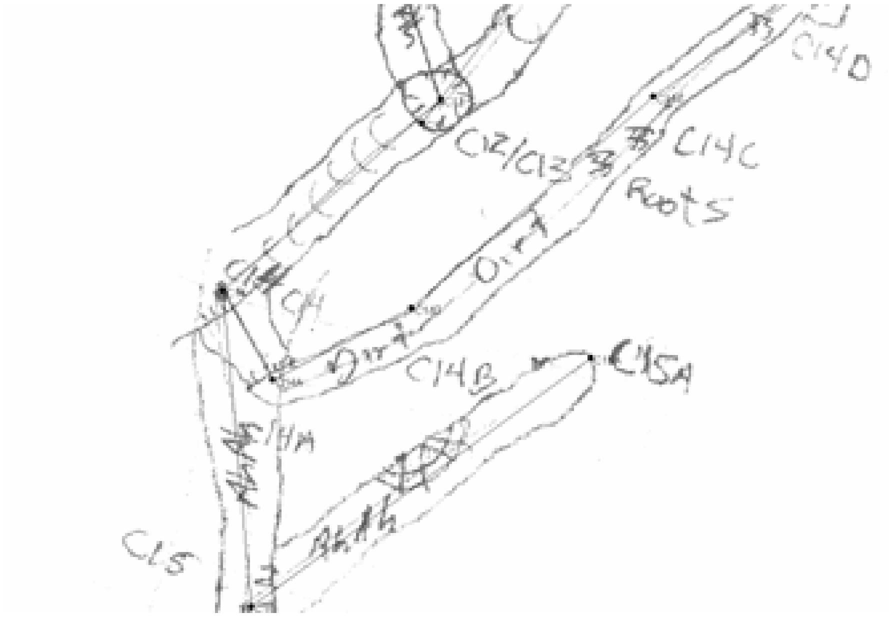
The first step in attaching sketches to the cave survey lineplot is registering two stations in the image of the sketch. With two points, the image can be scaled and rotated to match the calculated position of the corresponding stations. The next step is registering additional stations. When more than two stations are registered, then two processes are enabled. First, the multiple combinations of station pairs allows for the calculation of the best fit in terms of scale and rotation of the image to the lineplot. Because the new scale and rotation is an average of the station pairs, there is an error in the placement of each point in the image to the stations.

It is the function of morphing to proportionally move the pixels of the image towards the correct positions of the stations in the image. Pixels that lie in between several stations will be moved in a direction and distance that considers the influence of all the neighboring station misplacement errors. WinKarst calculates the distance of each pixel to all of the station locations and uses an inverse distance squared (1/r^2) weighting to move the pixel to its morphed position. Provided the error adjustment is not excessive, the resultant morphed image is indistinguishable from the original. When combined with survey loop closure, morphing is a very powerful tool to build a map that stand the additions and corrections of time.

The following sketch of a junction area in a cave shows the typical problem encountered in stitching together several sketches in a survey.



The lineplot for the middle dirt lined passage is off with respect to the calculated lineplot. The junction at station C14 does not match with the main line of the cave. After morphing the sketches, WinKarst produced the following image.



WinKarst pulls the passage on to the lineplot after morphing. The correct relative placement of the three branches is now apparent and drafting the cave map can proceed immediately.

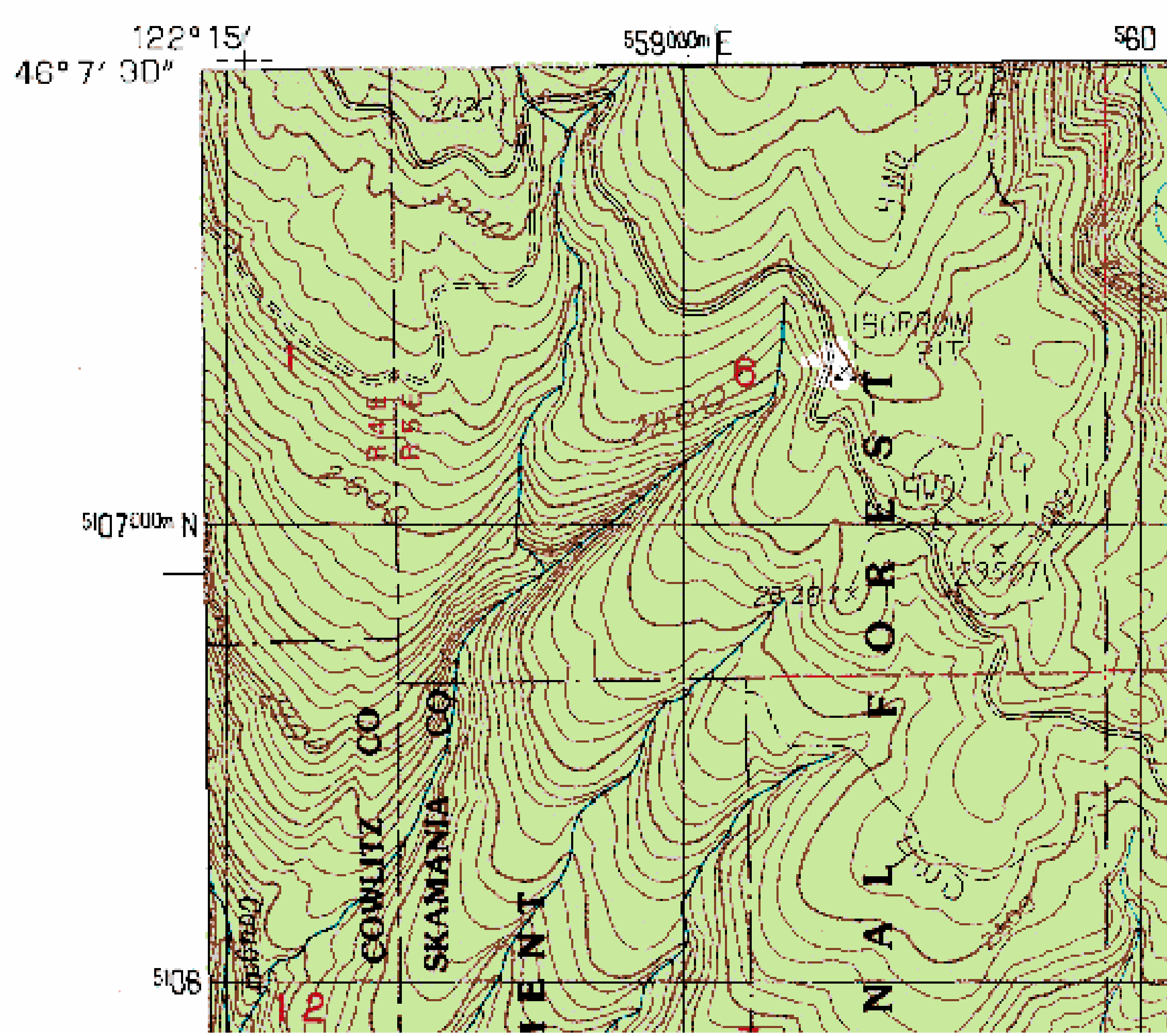
Sketch Sheets

An architech does not draw the plans for a two story house one one sheet of paper, just as a cartographer should not draw a complex cave on one sheet either. WinKarst allows a label to be associated with each sketch, this label is the **Sheet Name**. The Sheet Name can be any character or group of words, e.g. "The Big Room." Sheet Names are created and assigned to sketches on the *Sketch Page* of the Editor. All sketches with the same Sheet Name are treated as a group.

There are three ways to display sketches on a plan view line plot, a single sketch, all sketches or a sheet. All of the sketches in a sheet are drawn in the field of view when selected. The sheet is selected in the Preferences|*Sketch dialog*. Sheets can provide a non-overlapping view of cave passages in a complex area. If a sketch needs to be included on more than one sketch, save the sketch under a different name are re-register the second image with the second Sheet Name.

Background Maps

WinKarst can register bitmaps to either latitude/longitude or UTM coordinates. The color images, in PNG format, can be topographical maps, aerial photographs, property plots, etc. The map page of the editor allows for the creation and placement of control points on the image. The following figure shows a map containing Ape Cave and the necessary information to register the image as a background.



GeoTiff images contain all of the information necessary to plot caves and stations with geographic locations in the image. The user simply reads in the GeoTiff image and presses the World Map icon on the tool bar to draw the map with respect to the cave survey. Without displaying the image, a box indicates the area encompassed by the image.

Non-GeoTiff images must be registered. To register a image, the user must create at least two control points. For background maps, WinKarst uses the Universal Trans Mercator (UTM) projection. UTM coordinates are in terms of meters. Alternately, Latitude and Longitude numbers from a Conformal projection (used on USGS topographic maps) can be used because the distortion at a small scale is not noticeable.

For topographic maps, the best control point locations are grid intersections. The corners of 7.5 minute maps are multiples of 15 seconds of degree. In the image here the upper left corner is 122 degrees west and 15 minutes and 46 degrees, 7 minutes and 30 seconds. Control points are first created by clicking on the **Add** button on the Map page. Create a control point and convert the numbers into decimal degrees, e.g. 122 + 15/60, and enter the numbers in the fields on the Map page of the editor. Remember that western longitudes and southern latitudes are negative numbers.

Alternately, the UTM grid, the fine lines on a one kilometer spacing can be used to locate a control point. The first UTM intersection is at 5107000 N and 559000 E and these numbers can be entered into the UTM boxes on the Map page in the Editor once a control point has been created and the UTM zone identified. The UTM zone is usually found on the legend of the topographical map or can be calculated from the longitude. The UTM coordinates are always positive, but the zone is negative in the southern hemisphere. Once the coordinates are filled in the boxes, click the mouse on the image at the intersection.

The user must extract either road or stream junctions from the field or topo maps for aerial photographs. Once the user registers at least two points, then the software can draw the cave lineplot on top of the image of the map, scaled and rotated. WinKarst will not morph bitmaps used as backgrounds. WinKarst uses the same code in the survey data file to identify background maps and sketches. The assumed difference between sketches and maps is the control points are not connected to the cave survey itself, i.e. images with control points not connected to survey shots are maps.

Retrieving and Unpacking SDTS Data Tutorial and Users Manual

Retrieving and Unpacking SDTS Data
Tutorial and Users Manual
June 23, 1998

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For more information about SDTS, see http://mcmcweb.er.usgs.gov/sdts. To make comments or ask specific questions about SDTS or the USGS implementation of DLG/SDTS, send mail to sdts@usgs.gov

Introduction to Retrieval Procedures

Two digital cartographic products of the U.S. Geological Survey (USGS) are vector (DLG) and terrain elevation (DEM) data in the Spatial Data Transfer Standard (SDTS) format. The USGS distributes these data sets over the Internet as a means of promoting the standard. The SDTS is a relatively new format that has been mandated for federal use. Numerous software packages from vendors such as ESRI, Integraph and ERDAS are able to accept data in this format.

This document is a detailed explanation of procedures for downloading and unpacking USGS SDTS data. DLG data sets were created by reformatting digital line graph optional (DLG-O) data as SDTS. DEM data sets were created by reformatting existing data sets to the SDTS format. These conversions include adding metadata to each transfer, but do not necessarily include any update or other content changes to the spatial data.

Overview of DLG/SDTS and DEM/SDTS Data

2.1 SDTS Overview

The SDTS was designed by a group of people representing government agencies, universities, and private companies that all saw a requirement for a robust way of transferring earth-referenced spatial data between dissimilar computer systems with the potential for no information loss. After 12 years of discussion, development, review, and testing, the resulting SDTS was approved as Federal Information Processing Standard (FIPS) 173, and now also as FGDC-STD 002. Compliance with SDTS, also known as FIPS 173, is now mandatory for all federal agencies. SDTS is a transfer standard that embraces the idea of self-contained transfers; spatial data, attributes, georeferencing, a data quality report, a data dictionary, and other supporting metadata are all included in the transfer.

The SDTS is a standard. Standards are documents that specify rules; they are neither software nor databases.

The SDTS is a standard for data transfer, as opposed to a standard for data processing. SDTS does not replace existing Geographic Information System (GIS) processing formats.

The SDTS is designed specifically for spatial data. Other standards exist for other kinds of data (digital images, documents, electronic signals, etc.).

The National Mapping Division of the USGS is the maintenance agency for the standard. Please visit the SDTS web site at http://mcmcweb.er.usgs.gov/sdts for more information .

A single-document overview of SDTS is available at:
ftp://sdts.er.usgs.gov/pub/sdts/articles/ascii/overview.doc or,
ftp://sdts.er.usgs.gov/pub/sdts/articles/ps/overview.ps

2.2 Mass Conversion of USGS Data to SDTS

In 1995 the USGS began converting digital cartographic data holdings to SDTS. 1:24,000-scale (or 7.5 minute) DEM data were converted in early 1998. Conversion of other DEM scales have not yet been completed.

The 1:2,000,000-scale DLG data were revised in 1995 and are now available in SDTS. This includes coverage of the conterminous United States for the following categories of data: hydrography, transportation, boundaries (county names are included with the transfer), United States Public Lands Survey System, and manmade features.

All 1:100,000-scale DLG files have been converted to SDTS format. This includes national coverage of the hydrography and transportation overlays, with partial coverage of other layers.

All 1:24,000-scale DLG files have been converted to SDTS format. Coverage varies between overlays at this scale, but no overlay has complete coverage.

"All files" means all files for which DLG data have been produced. Coverage of 1:24,000 and 1:100,000- scale DLG data is not complete.

2.3 Sales and Distribution Policies

Most USGS data are neither online nor free. SDTS data are a significant exception to this policy. Other exceptions include 1:100,000-scale DLG-O and 1:250,000-scale native format DEM data.

Production, pricing, and distribution policies for native DLG-O and native DEM data have not changed due to the availability of SDTS data. Data in native format are still available from the same sources at the same prices. Because of data conversion problems, there are a small number of data sets that are available in native format but not available in SDTS. All DEM data now offered in SDTS format are still available in native format

2.4 SDTS data organization

2.4.1 DLG/SDTS Data

DLG-O data are derived from standard USGS topographic quadrangles. The packaging of DLG- O data reflects this: each physical file covers the geographic area of some part of a standard quadrangle, and contains a feature set that approximates the ink colors of a standard published map.

Similarly, DLG/SDTS data are derived directly from DLG-O data, and reflect the DLG-O data packaging. Each SDTS transfer has the same geographic coverage and same spatial data content as the DLG-O it was derived from. This packaging is not dictated by the SDTS; the standard would allow (for example) all road and hydrography data for a county to be contained in one transfer, but reorganizing the data this way would have required a large and costly production operation, instead of a relatively simple data reformat.

A side effect is that the DLG/SDTS data appear more fragmented and complex than necessary. This is not a characteristic of the SDTS, but of policy decisions made when the USGS mass converted DLG-O data to SDTS format.

2.4.2 DEM/SDTS Data

DEM data are derived from standard USGS topographic quadrangles. The packaging of DEM data reflects this: each physical file covers the geographic area of some part of a standard quadrangle,

Similarly, DEM/SDTS data are derived directly from DEM data, and reflect the DEM data packaging. Each SDTS Data transfer has the same geographic coverage and same spatial content as the original source DEM.

Summary of Data Retrieval Procedures

DLG/SDTS and DEM/SDTS data are held on an ftp site.
The base address for DLG/SDTS data is ftp://edcftp.cr.usgs.gov/pub/data/DLG
The base address for DEM/SDTS data is ftp://edcftp.cr.usgs.gov/pub/data/DEM

3.1 DLG/SDTS Data

There are three sub-directories in the DLG FTP site; one for each of the three data scales. These three scales are:

100K holds 1:100,000-scale data. The directory contains an SDTS master data dictionary for this scale, a readme file, and 26 subdirectories, one for each letter of the alphabet. Each of these subdirectories holds the 1:100,000-scale quadrangles whose names start with that letter.

2M holds 1:2,000,000-scale data. The directory contains an SDTS master data dictionary for this scale, a readme file, and 50 subdirectories, one for each state.

LARGE_SCALE holds 1:24,000-scale data. The directory contains an SDTS master data dictionary for this scale, a readme file, and 26 subdirectories, one for each letter of the alphabet. Each of these subdirectories holds the 1:24,000-scale quadrangles whose names start with that letter.

Each data sub-directory in turn has several more levels of directories that reflect DLG overlays, data versions, and physical packaging.

The USGS GeoData web page, at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html provides a user interface to the ftp site. The web page provides several different "views" of the data, including lists by state, by name, and searching by graphic index. All of these views eventually lead to the lowest level of the ftp directory structure.

The Global Land Information System (GLIS), at http://edcwww.cr.usgs.gov/webglis provides another way to reach these data. GLIS provides relatively powerful data search tools.

An SDTS transfer is composed of multiple files. DLG/SDTS transfers have been combined into one physical file with the tar utility, and then compressed using gzip. See section 4.3 for details.

3.2 DEM/SDTS Data

There are four sub-directories in the DEM FTP site. At this time, only 7.5-minute DEMs are in the SDTS format.

15min contains no data at this time. It will hold data based on 2 by 3-arc-second spacing. Coverage of one DEM corresponds to a 1:63,360-scale quadrangle, used primarily for Alaska.

250 holds data based on 3 by 3-arc-second spacing. This directory is populated with data in native DEM format. It contains a readme file, and 26 subdirectories, one for each letter of the alphabet. Each of these subdirectories holds the 1:250,000-scale quadrangles whose names start with that letter.

30min contains no data at this time. It will hold 1:100,000-scale data, also known as 2-arc-second.

7.5 minute has the same coverage as the standard USGS 7.5-minute cell. In some cases, this is not an exact match of the corresponding topographic map. DEMs never contain over edge data for slivers of land just beyond the cell boundary. This directory is populated with data in SDTS format. It contains a readme file and 26 subdirectories, one for each letter of the alphabet. Each of these subdirectories holds the 1:24,000 or 1:25,000-scale quadrangles whose names start with that letter.

The USGS GeoData web page, at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html provides a user interface to the ftp site. This web page provides several different "views" of the data, including lists by state, by name, and searching by graphic index.

The Global Land Information System (GLIS), located at http://edcwww.cr.usgs.gov/webglis provides another way to reach these data. GLIS provides relatively powerful data search tools.

All of these views eventually lead to the lowest level of the ftp directory structure.

An SDTS transfer is composed of multiple files. DEM/SDTS transfers have been combined into one physical file with the tar utility, and then compressed using gzip. See section 4.3 for details.

Each DEM transfer contains a data dictionary; there is no separate master data dictionary to be downloaded.

Detailed Instructions for Retrieving SDTS Data

This section contains step-by-step instructions for retrieving, unpacking, and organizing DLG/SDTS and DEM/SDTS data. The Conifer, CO 1:24,000-scale quadrangle is used as an example of DLG data. The Big Bull Mountain, CO 7.5-minute quadrangle is used as an example of DEM data.

Procedures for the other scales are similar, but vary slightly because of different product characteristics.

These examples show how to find data using "FTP via graphics" capabilities on the GeoData web page. Users who know what they are looking for and know how to use FTP client software may wish to skip these procedures and go directly to the FTP site described in section 3. Reading section 4.3 is strongly recommended before doing this.

4.1 Create Local Directory

Create directories (or folders) on your local computer to hold downloaded files. For the purposes of these examples, we will assume you are using a computer with the Windows 95 operating system installed. If you plan to use multiple quadrangles, it is important to organize the data in a file structure that will help you keep track of all data. Create an additional subdirectory for each quadrangle.

An SDTS transfer typically contains many files. Keeping transfers separate by putting each quadrangle in its own directory is necessary because of the way files within a DLG/SDTS or DEM/SDTS transfer are named. Storing multiple quadrangles in one directory may result in file collisions, where one file may overwrite another with the same naming convention.

For the DLG/SDTS example, create a directory named c:\data\sdts\conifer.
For the DEM/SDTS example, create a directory named c:\data\sdts\big_bull

4.2 Find and Retrieve Data

4.2.1 Find and Retrieve DLG/SDTS Data

A Master Data Dictionary (MDD) must be downloaded for each scale of DLG data (100K, 2M, and Large Scale) data you intend to use. Detailed instructions are included in section 4.2.1.2, below. To download a specific data set, follow these procedures:

1. Go to the USGS GeoData page at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

2. Scroll down the page to Large Scale Digital Line Graphs (DLG) - SDTS format only.

3. Since the name of the quadrangle is known, the data could be found by selecting either FTP via Alphabetical List or FTP via State. However, it is common to not know exact quadrangle names: Select FTP via Graphics.

4. Select Conterminous 48 states.

5. A simple map of the U.S. appears. Click on the state of Colorado.

6. A map of Colorado appears, with 1-degree lines of latitude and longitude. Click near the center of the 1-degree cell immediately west of Denver and immediately south of Boulder. The next display will show approximately 30 7.5-minute quadrangles, centered on where you clicked your mouse.

7. Click on the 7.5-minute cell labeled Conifer, CO.

8. A "list" of one quadrangle appears. (Other paths to this page may produce lists of more quadrangles.) Select the link to Conifer, CO.

A list of nine directories will then appear. Each directory corresponds to one DLG overlay. Conifer is used in this example because all nine overlays are available. This is unusual for 1:24,000-scale data; most quadrangles have fewer than nine overlays finished.

9. Select the second overlay (in this example), hydrography.

10. Select version_1, the most recent version.

The file D3910530_hy0s.1.sdts.tar.gz contains the SDTS transfer for the hydrography layer of the Conifer, CO quadrangle. For an explanation of the file naming convention, see http://edcftp.cr.usgs.gov/pub/data/DLG/LARGE_SCALE/00README

11. Select the file D3910530_hy0s.1.sdts.tar.gz for downloading

12. Save it to the c:\data\sdts\conifer folder. The file can be renamed (for example, conifer.tar.gz). Retaining the .tar.gz extensions is strongly recommended. Some browsers will attempt to rename this file for you. In some cases, this renaming causes problems for decompression software. One common case is a rename from *.tar.gz to *_tar.gz, which confuses the WinZip decompression program.

Repeat steps 9 through 12 for all overlays of interest.

4.2.1.1 DLG/SDTS Transportation Overlay: A Special Case

While you're at the FTP site getting data for the conifer, CO quadrangle, pull up the transportation subdirectory, and click on version_1.

You will see that it contains three DLG/SDTS transfers: roads (the rd0s file), railroads (the rr0s) file), and miscellaneous transportation (for airports, pipelines, etc)(the mt0s file). All DLG-O 1:24,000-scale sales units are packaged this way, and that packaging was retained in the SDTS version of the data: three separate SDTS transportation transfers were created for each quadrangle. The data for these transfers must be kept in separate directories. Untarring two or more transportation transfers for the same quad in the same directory will cause file collisions and loss of data.

If you intend to use more than one of these three transportation layers, create subdirectories for each of them. For example, c:\data\sdts\conifer\railroad. This step need not be done before downloading the data, but must be done before unzipping and untarring the data (section 4.3).

In 1:100,000 and 1:2,000,000 DLG data, the three transportation overlays are combined into one file, and therefore comprise only one SDTS transfer. Creation of additional transportation subdirectories is not necessary for these scales.

4.2.1.2 Retrieve the DLG/SDTS Master Data Dictionary

Each SDTS transfer is required to have a data dictionary, specific to that particular transfer's scale. Because the DLG/SDTS data were created by reformatting DLG-O data, the same data dictionary can be used for all data sets of the same scale. Rather than include this dictionary with each transfer, one data dictionary is stored for all transfers at the top of the FTP directory tree.

To retrieve the MDD:

1. Go to http://edcftp.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

2. Scroll down the page to Large Scale Digital Line Graphs (DLG) - SDTS format only.

3. Click on single tar file.

4. Save it to the c:\data\sdts\conifer folder

This file must be unzipped and untarred like other SDTS data. Placement of the data dictionary files may be software dependent. If using dlgv32, the files may be placed in any directory on your hard drive, including the directory that holds the other SDTS data files. If using ESRI Arc/Info, place the data dictionary files in the master directory as specified by ESRI documentation.

4.2.2 Find and Retrieve DEM/SDTS Data

1. Go to the USGS GeoData page at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

2. Scroll down the page to 7.5-Minute Digital Elevation Model (DEM) - SDTS format only.

3. Since the name of the quadrangle is known, the data we're looking for could be found by selecting either FTP via Alphabetical List or FTP via State. Since it's common to not know exact quadrangle names, make the selection FTP via Graphics.

4. A simple map of the U.S. appears. Click on the state of Colorado.

5. A map of Colorado appears, with 1-degree lines of latitude and longitude. Click on the bullet right next to Colorado Springs. The next display will show approximately 30 7.5-minute quadrangles, centered on this mouse click.

6. Click on the 7.5-minute cell labeled Big Bull Mountain, CO.

7. A "list" of one quadrangle appears. (Other paths to this page may produce lists of more quadrangles.) Select the link to Big Bull Mountain, CO.

The file 30.1.1.934296.tar.gz contains the SDTS transfer for Big Bull Mountain, CO. For an explanation of the file naming convention, see http://edcftp.cr.usgs.gov/pub/data/DEM/7.5min/00README

8. Select the file 30.1.1.934296.tar.gz for downloading.

9. Save it to the c:\data\sdts\big_bull folder. The file can be renamed (for example, bigbull.tar.gz). Retaining the .tar.gz extensions is strongly recommended. Some browsers will attempt to rename this file for you. In some cases, this renaming causes problems for decompression software. One common case is a rename from *.tar.gz to *_tar.gz, which confuses the WinZip

decompression program.

4.3 Unzip and Untar

The DLG/SDTS and DEM/SDTS data were designed in 1994, before the release of Windows 95 and before most PCs were powerful enough to use GIS data. The data were designed for the scientific computers of the time, which were mostly UNIX workstations. The files in each SDTS transfer were combined into one file with the UNIX tar utility, and this combined file was then compressed using the gnu-zip (gzip) utility. This technique for combining and compressing files is common on the UNIX operating system.

Tar and gzip are not as common in the PC world, but a variety of freeware, shareware, and commercial implementations of these utilities exist for all PC operating systems.

4.3.1 WinZip

One of the most common PC compression programs is the shareware program WinZip (http://www.winzip.com). WinZip will unzip and untar DLG/SDTS and DEM/SDTS files if proper procedures are followed. These instructions are for WinZip 6.3 for Windows 95, using the WinZip Classic interface (as opposed to the Wizard; this is a user-selectable option in WinZip).

Ensure that the file has a name of the form *.tar.gz NOT *_tar.gz

1. Start WinZip

2. From the toolbar, select Options

3. Select configuration.

4. There is a checkbox labeled "TAR file smart CR/LF translation". Ensure that this box is not checked.

5. Select OK to exit configuration.

6. Select Open from the tool bar. A popup window appears.

7. In the "Types of files" subwindow, select All Archives.

8. Navigate to the local directory you created earlier (c:\data\sdts\conifer for DLG/SDTS data or c:\data\sdts\big_bull for DEM/SDTS data) . A list of the files downloaded from the USGS GeoData site should be visible. Select one of these files and click Open.

9. A window appears with the message "Archive contains one file .decompress it to a temporary folder and open it?" Select Yes.

10. A list of .ddf files will appear. These are the files contained in the SDTS transfer. To select all files in the transfer, click on the first file, then shift-click on the last file.

11. Select Extract from the tool bar.

12. A popup window labeled "Extract" appears. Enter, or navigate to, the path and directory that you want to place the data into. The extracted files are stored in the same directory as the compressed files, so enter (or navigate to) the local directory you created earlier (c:\data\sdts\conifer for DLG/SDTS data or c:\data\sdts\big_bull for DEM/SDTS data), then click the Extract button. This will unzip and untar the files.

NOTE: Do not rename files extracted from the tar file. The files in an SDTS transfer are referenced by name in other files of the transfer. Renaming .ddf files will break these relationships.

4.3.2 Other tar and zip utilities

Tar and gzip for DOS, UNIX, and NT operating systems are available in the GNU utilities from the Free Software Foundation. Software locations for each operating system listed below.

4.3.2.1 DOS tar and zip utilities

Copies of these can be retrieved from
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/tar.exe
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/gunzip.exe

These must be run in a DOS window, using the following syntax:
to Unzip: <path>\gunzip <filename> to Untar: <path>\tar xvf <filename> where <path> is the path to the directory that contains the gunzip and tar executables.

4.3.2.2 UNIX tar and zip utilities
Copies of these can be retrieved from
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/tar
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/gunzip

4.3.2.3 NT tar and zip utilities
Copies of these can be retrieved from
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/winnt/tar.exe
ftp://ftpmcmc.er.usgs.gov/pub/sdts/software/tools/winnt/gunzip.exe

5. Problems Downloading Data

The availability of free SDTS data has caused severe overloads on the GeoData server and relatively frequent periods of down time. Until hardware upgrades can be applied, we can only suggest trying at "off times" of the day.

Unfortunately, the USGS does not have the staff to provide tutorial support for commercial software. If you cannot access these data through your browser, we recommend either:

- studying your software documentation for anonymous ftp configuration procedures, or
- using an ftp utility instead of a browser.

Problems Downloading Data

5.1 FTP

Different brands and versions of web browsers implement anonymous ftp differently. The USGS has tested a number of browsers on the ftp site described in this paper and believes that the data can be accessed through most browsers. However, the default browser configurations are not always correct for anonymous ftp access, and in some cases changing those configurations is somewhat difficult.

Some sites where ftp utilities can be downloaded and purchased are:

http://www.cuteftp.com
http://www.ftpx.com

As an alternative, users of Win95 or WinNT can ftp data using the Run function on the Start Menu:

Type ftp://edcftp.cr.usgs.gov and select OK.
Login: anonymous
Password: your e-mail address in the form name@domain

From there, make the following choices:
pub/data/DEM/7.5min/B/big_bull_mountain_CO (this will get you to the DEM/SDTS data set we used in our example earlier)

At this point the user is able to navigate to the layer to be downloaded.

To change the data transfer type to binary, type binary.
To specify which directory the data is to be downloaded to, type lcd name of directory.
To download the data, type get name of file.
To exit, type quit.

Contents - Calculations

Geodetic Datums and Ellipsoids

Hundreds of geodetic datums are in use around the world. The Global Positioning system is based on the World Geodetic System 1984 (WGS-84). Parameters for simple XYZ conversion between many datums and WGS-84 are published by the Defense mapping Agency. Coordinate values resulting from interpreting latitude, longitude, and height values based on one datum as though they were based in another datum can cause position errors in three dimensions of up to one kilometer.

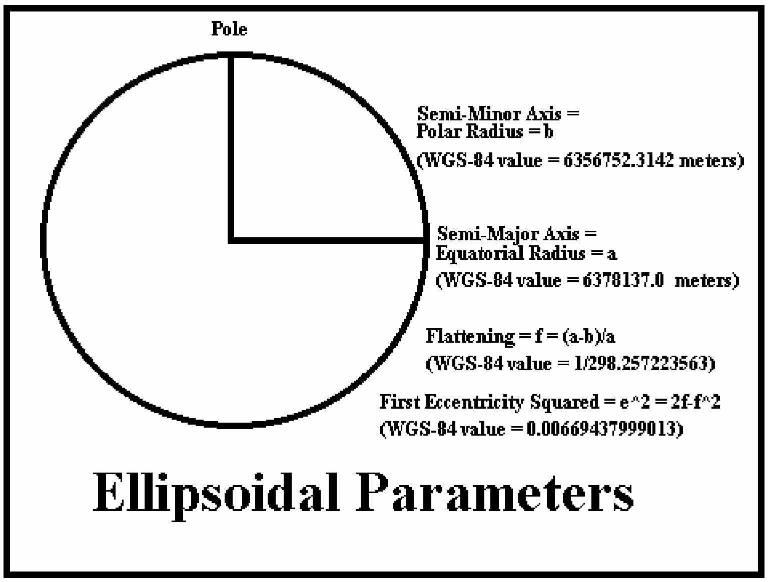
Datum conversions are accomplished by various methods. Complete datum conversion is based on seven parameter transformations that include three translation parameters, three rotation parameters and a scale parameter. Simple three parameter conversion between latitude, longitude, and height in different datums can be accomplished by conversion through Earth-Centered, Earth Fixed XYZ Cartesian coordinates in one reference datum and three origin offsets that approximate differences in rotation, translation and scale. WinKarst uses the Standard Molodensky formulas to convert latitude, longitude, and ellipsoid height in one datum to another datum.

Datums and their Parameters Available with WinKarst

Datum	Ellipsoid	DX	DY	DZ
Adindan	Clarke 1880	-162.0	-12.0	206.0
Arc 1950	Clarke 1880	-143.0	-90.0	-294.0
Arc 1960	Clarke 1880	-160.0	-8.0	-300.0
Australian 1966	Australian National	-133.0	-48.0	148.0
Australian 1984	Australian National	-134.0	-48.0	149.0
Camp Area Astro	International 1909	-104.0	-129.0	230.0
Cape	Clarke 1880	-136.0	-108.0	-292.0
European 1950	International 1909	-87.0	-98.0	-121.0
European 1979	International 1967	-86.0	-98.0	-119.0
Geodetic 1949	International 1967	84.0	-22.0	209.0
Hong Kong 1963	International 1967	-156.0	-271.0	-189.0
Hu Tzu Shan	International 1967	-634.0	-549.0	-201.0
Indian	Everest	289.0	734.0	257.0
North American 1927	Clarke 1866	-8.0	160.0	176.0
North American 1983	GRS 80	0.0	0.0	0.0
Oman	Clarke 1880	-346.0	-1.0	224.0
Ordnance Survey 1936	Airy	375.0	-111.0	431.0
Pulkovo 1942	Krassovsky 1942	27.0	-135.0	-89.0
South American 1956	International 1967	-288.0	175.0	-376.0
South American 1969	South American 1969	-57.0	1.0	-41.0
Tokyo	Bessel 1841	-128.0	481.0	664.0
WGS 1972	WGS 72	0.0	0.0	-4.5
WGS 1984	WGS 84	0.0	0.0	0.0

Early ideas of the figure of the Earth resulted in descriptions of the Earth as an oyster (The Babylonians before 3000 B.C.), a rectangular box, a circular disk, a cylindrical column, a spherical ball, and a very round pear (Columbus in the last years of his life). Flat Earth models are still used for plane surveying, over distances short enough so that Earth curvature is insignificant (less than 10 km).

Spherical Earth models represent the shape of the Earth with a sphere of a specified radius. Spherical Earth models are often used for short range navigation (VOR-DME) and for global distance approximations. Spherical models fail to model the actual shape of the Earth. The slight flattening of the Earth at the poles results in about a twenty kilometer difference at the poles between an average spherical radius and the measured polar radius of the Earth.



Ellipsoidal Earth models are required for accurate range and bearing calculations over long distances. Loran-C, and GPS navigation receivers use ellipsoidal Earth models to compute position and waypoint information. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape of the Earth over the smoothed, averaged sea-surface to within about one-hundred meters.

Ellipsoids and their Parameters Available with WinKarst

Ellipsoid	Semi-Major Axis	Semi-Minor Axis	1/f
Clarke 1866	6378206.4	6356583.8	294.979
Clarke 1880	6378249.145	6356514.86955	293.465
Australian National	6378160.0	6356774.719	298.240
International 1909	6378388.0	6356911.94613	297.000
International 1967	6378157.5	6356772.2	298.250
Everest	6377276.3452	6356075.4133	300.802
GRS 80	6378137.0	6356752.31414	298.257
Airy	6377563.396	6356256.91	299.325

Krassovsky 1942	6378245.0	6356863.0188	298.300
South American 1969	6378160.0	6356774.7192	298.250
Bessel 1841	6377397.155	6356078.96284	299.153
WGS 72	6378135.0	6356750.519915	298.260
WGS 84	6378137.0	6356752.31414	298.257

UTM Coordinate System

The UTM (Universal Transverse Mercator) grid was devised as one way of solving the cartographer's dilemma: how to represent the (nearly) spherical earth's surface on a fiat sheet of paper. Latitude and longitude coordinates are sufficient when long distances are to be covered. (Pilots and sailors use them almost exclusively.) However, for ground teams who cover only a few miles, latitude-longitude is much too cumbersome to be practical. For example, subdividing tic-marks for latitude-longitude are shown only in two places along the edge of a 7/2 minute quad map. Furthermore, the subdivisions of the units (minutes and seconds) are one-sixtieth of the larger unit. We are not accustomed to dividing lengths by sixtieths, as were the Babylonians who invented this system 4000 years ago. Another limitation is that a unit of longitude, a degree, represents less distance as one moves away from the equator. This complicates matters when one needs to calculate the distance or bearing from one point to another.

Spherical trigonometry or other complex mathematical methods must be used to make these calculations. These are not impossible of course, just inconvenient.

The UTM system was developed with guidelines that it would: (1) be a square grid; (2) have no negative numbers in the coordinates; (3) read left-to-right and bottom-to-top; and (4) be decimal - based.

To accomplish these goals, the UTM system divides the earth's sphere into 60 zones, each being six degrees of longitude wide. The zones are numbered I through 60, west-to-east, beginning at 180 degrees west longitude. Figure 1 shows the zone numbering system on a continental outline map. Although not shown on this map, the zones cover only the area between 80 degrees south and 84 degrees north latitudes. Different grids (not described here) cover the polar areas.

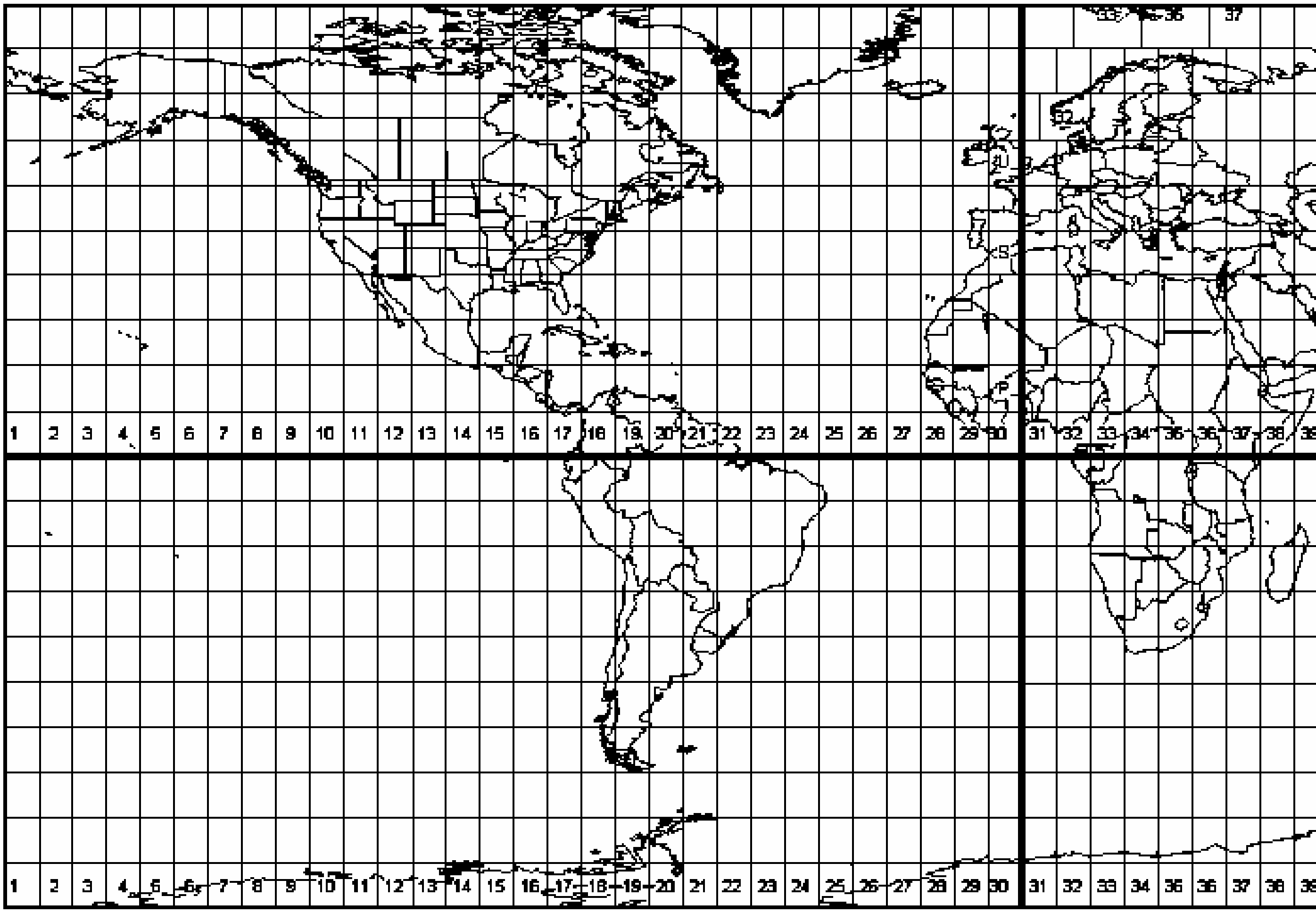


Figure 1: The numbering system for UTM zones. The zones extend from 80 degrees south to 84 degrees north latitudes.

The metric system is used as the units of the UTM coordinates. It may be convenient to remember (as a possible trivia answer) that the distance from the equator to either pole is 10,000,000 meters or 10,000 kilometers. to be exact, a kilometer is equal to nearly 0.625 of a mile or 0.62137 miles.

A square grid is superimposed on each zone and aligned so its vertical lines are parallel to the center of the zone. This centerline is called the central meridian, and is three degrees of longitude from each zone boundary.

The UTM coordinates (measures of distance) are arranged so they always read from left-to-right and from bottom-to-top. This is done as follows. In the northern hemisphere the origin, or zero point, of the horizontal lines is at the equator, while in the southern hemisphere the origin is at the south pole.

Establishing coordinates for the vertical lines was done differently. The vertical line at the center of each zone (central meridian) was arbitrarily assigned the value of 500 km to avoid having negative coordinate values. Assigning the value of 500 km to the center of each zone causes the zero point to fall in another zone - the one to its left (west). For this reason, you will never see a zero value for an east-west coordinate. The smallest value is 160 km and it is at the equator. As one moves away from the equator, the UTM east coordinate at the zone's western edge has larger and larger values. At 84 degrees north latitude it is 465 km. Likewise, the eastern (right) zone boundaries will have coordinates of 834 km at the equator and 515 km at 84 degrees north latitude. The way the square grid is placed on each zone is shown in Figure 2. Note that this drawing is not to scale; the horizontal axis is highly exaggerated.

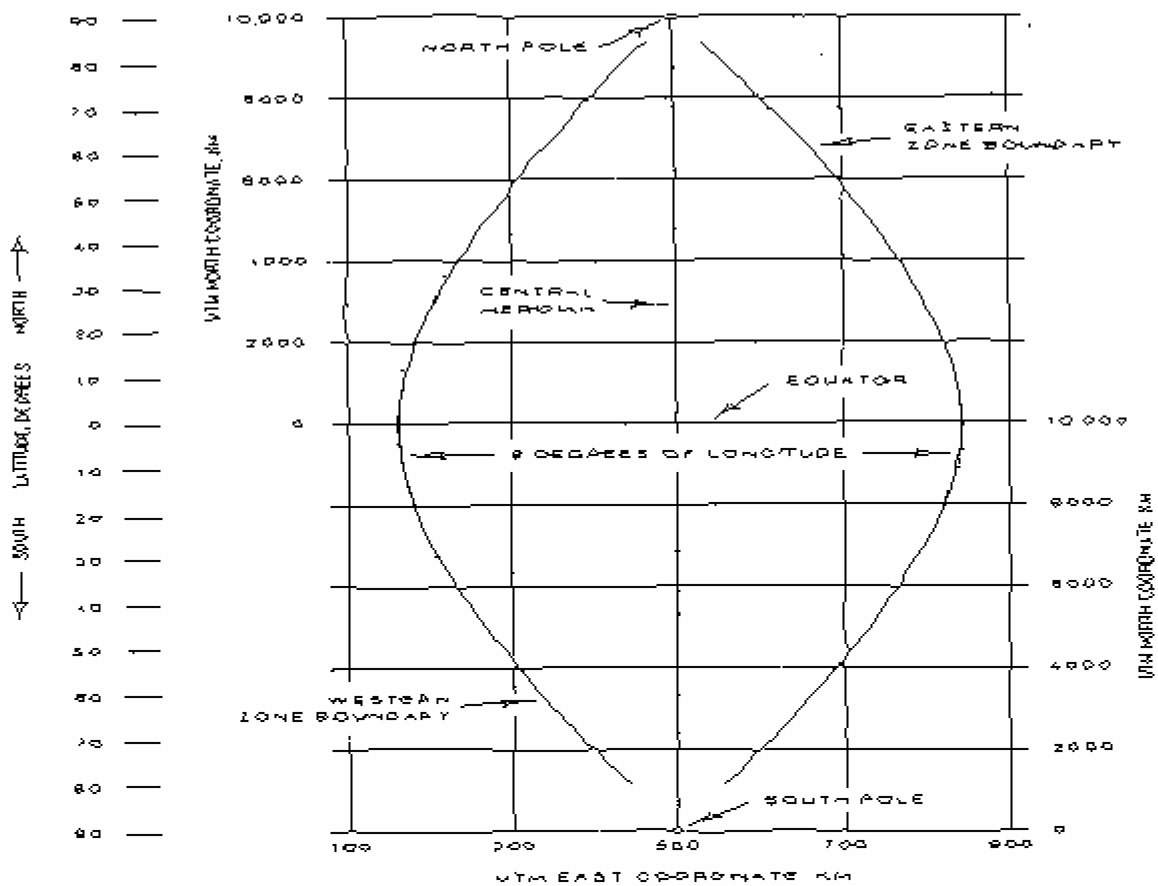


Figure 2: The square UTM grid that is superimposed on each :one. This drawing is not to scale.

Figure 3 shows a portion of zones 10 and 11 in the western U.S. Nevada, quite accidentally, lies totally in zone 11, while California falls in both zones 10 and 11. The latitude-longitude and UTM coordinates are both shown in this figure to illustrate their relationship. Note that the UTM lines at zone boundaries meet at slight angles, and the width (number of kilometers) of the zones is greater near the bottom (south) than at the top in this illustration. Observe also the square UTM grid is parallel to the central meridian.

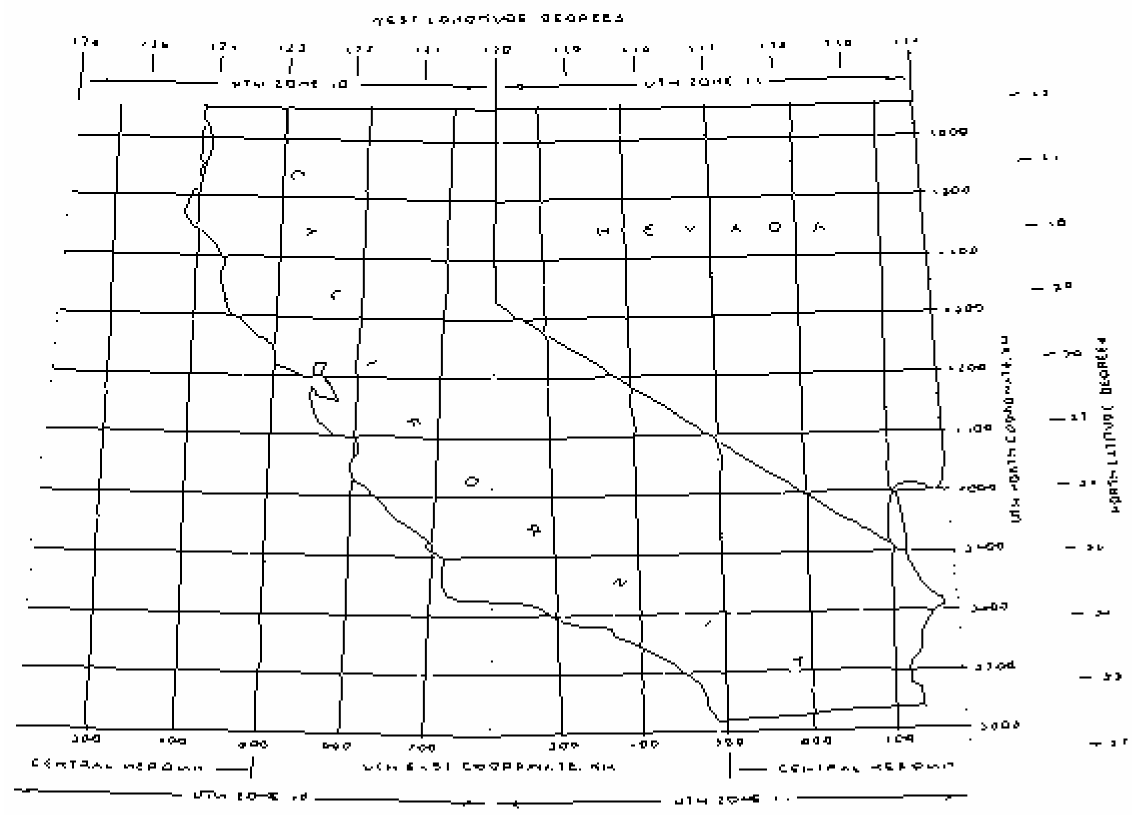


Figure 3: UTM zones 10 and 11 in California and Nevada.

Taking a closer look at the UTM grid, refer to Figure 4, which is a familiar 7 .5 minute quad with emphasized UTM grid lines 1000 meters (I kilometer) apart. All USCS topographic maps published in the last 30 years or so have this grid. Since about 1982, the grid lines have been printed on the map, while earlier maps show only the positions of the grid lines on the map's edges as blue tic-marks. A close-up view of a comer of a 7.5 minute quad is shown in Figure 5. On the lower right edge of the map is the notation 3957000mN. The numerals 5 and 7 are printed in larger type size than the others, but ignore the difference in type size. This number is the UTM coordinate of the black line just to its left. It is 3,957,000 meters (3957 kilometers) north of the equator and is called the UTM north coordinate. The other numbers along the edge are also UTM north coordinates but are expressed in kilometers. Again, ignoring type size, the next number up the map edge is 3958, one kilometer greater than the first one. Along the bottom of the map there is the notation 398000mE, a UTM east coordinate. The vertical line above it is 398 kilometers east (right) of the zone's zero point. Put another way it is 500 minus 398 or 102 kilometers west (left) of the central meridian. The next grid line to the left of this one has no number under it. The UTM coordinates are sometimes omitted if they interfere with the printing of other information. The number corresponding to this line is 397, one kilometer less than the one to its right.

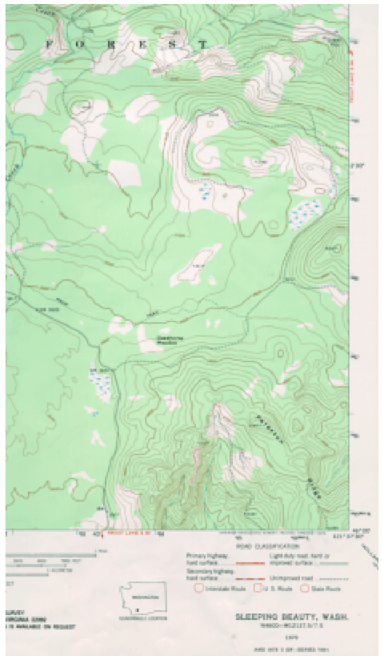


Figure 4: UTM grid on a 7.5 minute USGS topographic map.

Locations between grid lines may be specified by dividing the space between them into tenths. For example, in the upper right-hand comer of Figure 5 is the elevation notation 6728, printed in black. The digit 6 in this number is about eight-tenths of the distance between the 397 and 398 vertical lines. The UTM east coordinate would then be 397.8 km. Likewise the 6 is about one-tenth of the distance up from the 3958 line and its UTM north coordinate is 3958.1 km. Just by giving these two numbers, 397.8 east and 3958.1 north, plus the zone number, you have uniquely specified this point on the earth's surface. And it was done just by looking at the map with no calculations or measurements needed. For more accurate subdivision between UTM grid lines, you can use a transparent overlay or the metric scale at the bottom of the map.

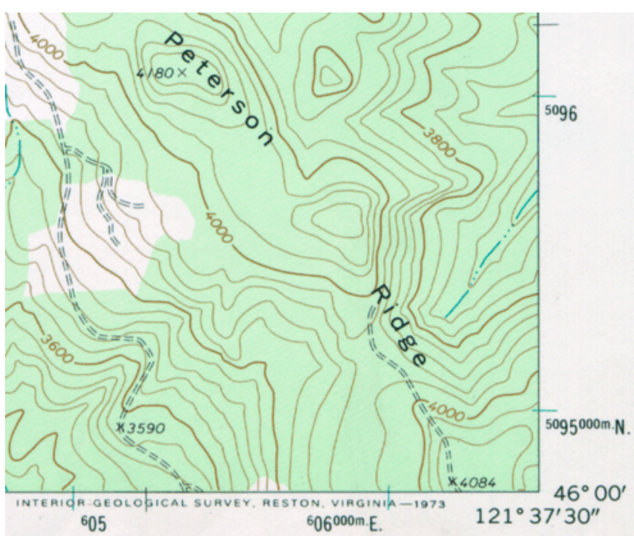


Figure 5: A corner of a 7 .5 minute USCS topographic map showing UTM coordinates

As taught in the U.S. Army, it should be noted that some teams learn UTM coordinates as a six-digit number. This number is created using the two large, bold-type UTM numbers from the map, and the tenths from dividing the space between the grid lines. The decimal point is omitted. In addition, they learn to "read right up"; thus, presenting the number in the correct format. Therefore, the coordinates mentioned above would be transmitted as 978-581.

The UTM zone number will be found in the information printed on the lower left-hand corner of the map.

If you are plotting bearings very accurately, as you would during radio location of an ELT, one additional factor should be considered.

The only place where the UTM grid is aligned exactly true north is at the midpoint of a zone (at the central meridian). The grid will be rotated slightly counterclockwise for locations west (left) of the central meridian. This can be seen in Figure 4. Note how the UTM grid is not quite parallel to the edges of the map. Similarly, it will have a small clockwise rotation east of the central meridian. The amount of rotation increases as you move away from the central meridian and is maximized at the zone boundaries. This difference between true north and UTM grid north is called the convergence, so named because the meridians converge as they approach the poles. In the continental U.S. the convergence will never exceed 2.5 degrees. If you need to know the convergence, it is shown on a diagram on the map in Figure 6. The vertical line with the star at its end represents true north, while the line with the notation GN (abbreviation for grid north) at its end shows the angle (not to scale) of the UTM grid. The convergence for this map is shown as 0 degrees, 42 minutes, which is the same as 42 divided by 60 or 0.7 degrees. On this map grid north is counterclockwise from true north by 0.7 degrees.

Figure 6 also shows the relation between true north and magnetic north. Note the legend below the figure gives a year associated with the magnetic declination. That's because declination is not a constant value - it changes with time. The change is slow; one degree every 10 years is common in parts of the U.S. But if you're using a 30-year-old map, the declination printed on it may be wrong by three degrees. On this map, the difference between magnetic north (in 1984) and UTM grid north is 11.5 degrees plus 0.7 degrees, or 12.2 degrees. Knowing the exact values of convergence and declination is not important unless you are doing precise navigation or making extremely accurate plots of bearings.

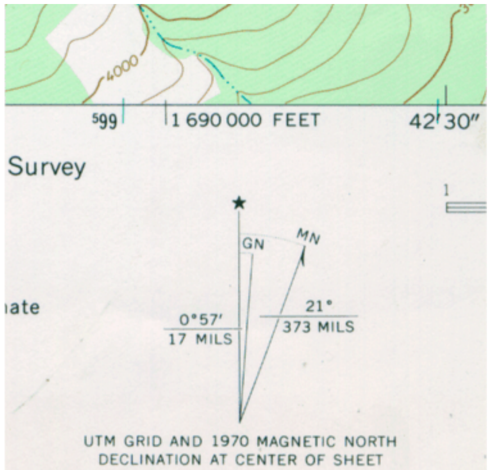


Figure 6: Diagram on USGS topographic maps that shows the angular relations among grid north,
true north and magnetic north.

One further advantage the UTM system offers is its coordinates can be convened to latitude-longitude and vice versa. The mathematical equations for doing this are very complicated, but are easily handled by computers, including small hand held ones. Being able to make these conversions is quite useful when coordinating search operations involving both ground teams and air resources. If a ground team requests a victim evacuation by helicopter and gives its location in UTM coordinates, these can be converted to latitude-longitude. The aircraft crew can then use its on-board navigation equipment to locate the pickup site. Another use of the conversion process is in the plotting of locations on a map. In searches for missing aircraft, the FAA is sometimes able to furnish a record of the aircraft's flight path from its radar records (NTAP). These locations are always given in latitude-longitude coordinates. Plotting these on a map can be very time-consuming. But, if they are converted to UTM coordinates. they can be plotted very quickly.

These are the features of the UTM coordinate system that you need to use in the field. It provides a rapid, simple and accurate way to report your location. All that remains to be done is adding the UTM grid lines to your maps. Use a long straightedge to connect the blue tic-marks with a pencil or fine-point pen. This would be a good project for a cold winter night or at a team meeting when discussing map reading. Then, on your next mission, the UTM grid will be waiting for you to use it.

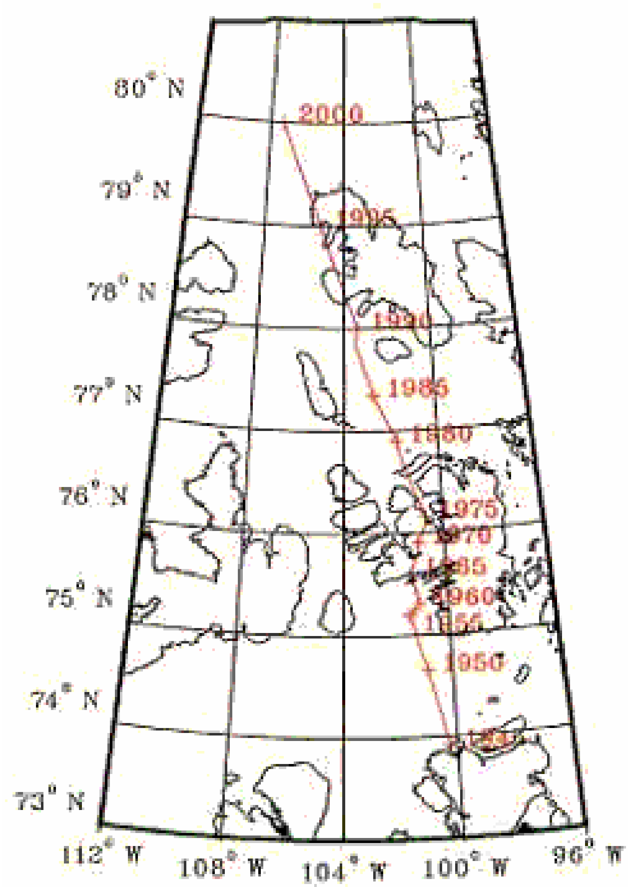
For those interested in more details about the UTM system. the following references are recommended:

Maps for America, by Morris M. Thompson, published by the United States Geological Survey, 1979. This is an excellent reference book that describes all the features on USGS maps. The appendix has a thorough description of the UTM coordinate system.

United States Army Technical Manuals TM 5-241-1, "Grids and Grid References", and TM 5-241-8, "Universal Transverse Mercator Grid". The first of these describes the way the UTM system forms the basis for the Military Grid Reference System. The latter provides the mathematical equations for converting UTM coordinates to latitude - longitude and vice versa.

Magnetic Declination

The Earth's magnetic field resembles, in general, the field generated by a dipole magnet (i.e., a straight magnet with a north and south pole) located at the center of the Earth. The axis of the dipole is offset from the axis of the Earth's rotation by approximately 11 degrees. This means that the north and south geographic poles and the north and south magnetic poles are not located in the same place. At any point, the magnetic field is characterized by a direction and intensity which can be measured. The geomagnetic poles are located in the area where the lines of force are perpendicular to the Earth's surface and are sometimes referred to as the dip poles (dip = 90 degrees). The physical location of the magnetic pole is actually an area rather than a single point. Because of the changing nature of Earth's magnetic field, the location of the magnetic poles also changes. The following figure shows how the north magnetic poles has moved over the past 40 years.



The current location of the magnetic poles are approximately:

North Pole 78.5 N and 103.4 W degrees, near Ellef Ringnes Island, Canada
South Pole 65 S and 139 W degrees, in Commonwealth Bay, Antarctica

The Earth's magnetic field is described by seven parameters. These are declination (D), inclination (I), horizontal intensity (H), vertical intensity (Z), total intensity (F) and the north (X) and east (Y) components of the horizontal intensity. The parameter most frequently requested and most often misunderstood is magnetic declination or variation, D. This is the angle made between the trace of the total magnetic field in the horizontal plane, H, and true north. D is considered positive when the angle measured is east of true north and negative when west.

The inclination or dip, I, is the angle between the horizontal plane and the total magnetic field. Inclination, also called magnetic dip, is considered positive when downward pointing. These elements, D, I and H give a full vector representation of the magnetic field, F. Vertical intensity is the trace of the total intensity in the vertical plane and is considered positive when I is positive, that is downward pointing. The east component, Y, is considered positive when pointing east and the north component, X, is positive when pointing towards geographic north.

At any specific point, the values of the magnetic elements are changing. The changes are not uniform over area or time. Some types of change are distinguishable. Three important, classifiable changes are the diurnal, secular and storm variations. The small regular fluctuations in the magnetic field that occur more or less regularly every 24 hours are called diurnal variations. Secular changes extend over years with generally smooth increases or decreases in the field. Magnetic storms are sudden and potentially large disturbances in the magnetic field which may last hours or days.

Of these changes, the least understood is the long-term change that occurs over years in the main magnetic field. The magnetic field can be approximated by mathematical models over short periods of time, but because the secular change is not predictable, the potential for error increases the further in time from the base epoch the calculations are. For this reason, it is important to use the most current accepted models of the magnetic field. These models are produced about every 5 years and are available from NGDC and the World Data Centers.

WinKarst contains the current parameters for the magnetic mathematical model for the period between the year 1995 and 2000. The program also contains the parameters for the years 1900 to 1995, in 5 year intervals. The method used to calculate the magnetic declination for these two types of data sets is different, but correct. Using the longitude, latitude and elevation of the entrance of a cave, WinKarst can calculate the magnetic declination for any point in time in this century. For any date, the model's parameters are interpolated proportionally within a five year period. For every date data was collected in a cave survey, a unique magnetic declination will be automatically determined.

The automatic calculation can be enable or disabled in the *Calculations* form on the main menu bar.

Projections

A cartographer (mapmaker) begins making a map by reducing the surface of the Earth in size. For small-scale maps of the entire earth, a GLOBE is the only accurate representation. Unfortunately, globes are difficult to handle and store, and the entire surface of the earth cannot be viewed at one time. Further, globes are very limited in size and can only show the world at a very small scale. Many different schemes for transforming the spherical surface to a flat surface have been devised, called map projections. The goal of these projections is to reproduce the Earth, or a portion of it, with a minimum of distortion. Different projections have specific properties that make them useful for particular purposes, and a cartographer must select the map projection best suited to the use of the map.

In conformal projections the angles are shown correctly; maps of this type are useful for navigating and surveying. Equivalent, or equal-area, projections show all areas on the Earth's surface in proper proportion and are used to visualize patterns of distribution of spatial data. There are other properties that can be retained when the spherical surface is transformed to a plane.

One very important, and often overlooked, feature of a map projection is the way in which it arranges the network of parallels and meridians, called the graticule. This grid on the globe has a number of obvious visual characteristics. Scale is true on a globe--angles are shown correctly and areas are shown in proper proportion. This is altered when the spherical surface is transformed to the flat map, although in some places on the map the spherical surface is represented more correctly than in others.

On the globe, parallels, or latitude lines, are parallel and are spaced equally on the meridians, or longitude lines. Meridians converge toward the poles and diverge toward the equator, so that their distance apart decreases from the equator to the poles. At the equator, meridians are spaced the same as parallels. On the globe, parallels and meridians intersect at right angles, except at the poles. The area of the surface bounded by two parallels and two meridians (at given distances) is the same anywhere between the two parallels.

When comparing a flat map with a globe, the arrangement of the graticule provides an indication of the scale variation that has been introduced as a result of the flattening of the surface. There is a large exaggeration of area in the Mercator projection. This exaggeration has been eliminated in the Lambert projection, but there is a great distortion of angular relationships. In the Lambert azimuthal and the Albers conic projections, areas are shown in correct proportion, but angular relationships are not retained.

WinKarst supports five types of projections, Trans Mercator, Universal Trans Mercator (UTM), Albers conic, Lambert Conformal conic (or azimuthal) and Polyconic. Each projection is based on a elliptical model of the Earth, in which a major and minor axis is specified. WinKarst has include 23 different *datums of the Earth*. The type of projection and datum is selected in the Projection Dialog box. A word of caution, if a map has UTM grid marks, e.g. USGS 7.5 minute topographical maps, it still may not be a Trans Mercator projection. Check the legend. All of the included projections except UTM have configurable parameters which are specified in the Specification Dialog box.

A cave survey must have a control point in its data file specified with a Longitude/Latitude pair before the projection sections of WinKarst are enabled. After a projection has been specified from the *Projection Specification* dialog, a projection *Geographic Calculator* is available. From the calculator, the user can determine how far from the cave's entrance a point is by either entering a Longitude/Latitude. The calculator has a inverse function also, by entering a X/Y distance in the projection from the cave's entrance, the Longitude/Latitude of the point can be calculated.

Projection Form

The Projection Dialog box is used for selecting a projection and datum type, specifying the projection's parameters and accessing the Projection Calculator. The **Ok**, **Help**, **Cancel**, **Specify**, **Calculate** and **Info** are the major actions that can be applied to the selected projection. A project can be selected by pressing the arrow on the right edge of the **Projection Type** line to open the drop down list and **Clicking** its name in the Projection List. The datum is selected in the same manner, except using the **Datum List**. Note that most existing maps in the United States the datum for the UTM projection is the NAD27 datum.

Specification of the Projection

Each *projection* has a unique Dialog box is used for specifying the projection's parameters. The **Ok** and **Cancel** are the only actions that can be used after completing the parameter form. The **Parameter From** may include a Longitude/Latitude pair for the projection center and parallels of true scale. In the Parameter Form, type a value in each of the boxes for the geographic projection. Typically, a reasonable value is something near the cave's entrance. Western longitudes and Southern Latitudes are negative numbers.

Geographic Calculator

The Projection Calculator can calculate either Longitude/Latitude or X/Y distance relative to the cave entrance's location in the projection's space. The **Ok**, **Help** and **Cancel** are the main actions that can be used while computing coordinates. Changing the values in the **Longitude** or **Latitude** boxes will cause the X/Y coordinate and distances from the entrance to change. Western longitudes and southern latitudes are negative numbers. Changing the values in the **X** or **Y** boxes will cause the Longitude/Latitude coordinate and distances from the entrance to change. All distances and XY values are expressed in meters and are calculated with the *projection* specified in the Projection and Specification dialogs. All Longitude/Latitude numbers are express in decimal degrees.

Determination of Coordinates

Coordinates are the locations in three dimensional space of the *Stations* of a *Cave Survey*. Coordinates consist of three numbers, x, y and z. Coordinates are necessary for drawing a map representing the cave survey. *Raw survey files* are automatically "reduced" to coordinate data when their file is opened. There is no need to reprocess the raw data unless it has some how changed. Previous reduced data or raw data can be changed in the process of *Adjusting* Loops. WinKarst automatically reprocesses the data to determine the new station coordinates after loop adjustment.

In a perfect world, all loops close without errors and it does not matter in which order the shots and stations are processed in determining their coordinates. In practice, some loops will not close due to Blunders. In this case, shot ordering matter in what the drawn map will look like. WinKarst provides two methods for ordering the shots, Survey and Branch.

Survey processing refers to a "native" mode. Shots are ordered as they appear and can be connected in the raw data file. Branch processing is possible after the loops of the cave have been determined. In this method, sequences of shots are arranged not to contain any loops and the "branches" of the tree are then reassembled. Using this method, it is much easier to visually spot blunders.

Variations on how the cave system's shots and surveys are calculated into coordinates are selected in the *Calculations* form

Determination of Dip and Strike

Most elementary courses in statistics describe Linear Regression or Trend when examining data on a graph. In general, this concept can be extended to systems of many variables, where the function is to be expressed as a linear combination of the variables. Strangely enough, the mathematics borrows from the same Least Squares theory used in some Loop closure algorithms. In the case of a cave, the stations in the represent a distribution function based on three variables, x, y and z. Just has a two dimensional graph of a collection of data can be approximated with a "best fit" line, a system with three variables can be approximated with a best fit plane. How well the data fits to the approximation can be measured by how well the data correlates to the fit, the correlation factors.

The mathematical equation of the best fit plane determines the best fit Strike and Dip of the Cave. The Strike and Dip of the Cave often are determined by the local geology the cave is formed in. WinKarst can subtract the Strike and Dip of the Cave and in effect level the cave to appear flat (effectively applying a permanent three dimensional rotation to the cave). Color by Depth will now use the Strike and Dip corrected depth to color the cave plot. Through this way, it is possible to determine where the cave is close to its geologic limits.

WinKarst can calculate the best fit plane to the three dimensional station distribution from the *Calculations* form and its Gradient check box.

Calculation Dialog

The Calculation form is used to initiate various calculations based on the cave survey data. The **Ok**, **Help**, **Cancel**, **Make**, **Find** and **Close** are the major calculation functions. When the **AutoMag** box is checked the magnetic declination for each survey is calculated from its date and the geographic location of the cave. The cave must have a longitude/latitude location and the survey's bearings shot to magnetic north for automatic magnetic declination to be applied.

The **Survey** and **Branch** check boxes choose how the shots in the cave are sequenced in calculating the station coordinates. For the Branch check to be enabled, the cave's loops must be determined first. A branch is a collection of shots without any loops. The Survey check box represents how the data is calculated when the cave survey file is initially opened.

The **Gradient** check box enables the calculation of the Strike and Dip of the Cave system and adjust the coordinates such that the strike and dip plane is horizontal, or flat.

The form's six thumb wheels are used for adjusting loop closure parameters.

Iteration The number of passes the closure routine attempts in adjusting the loops of the cave survey
Convergence The amount of improvement the closure routine will stop at between successive iterations.
Blunder A multiplying factor applied to the calculated expected error for a loop. Loops with an error Blunder times the expected error are marked as blunders and will not be closed.
Length The relative distance (+/-) a shot's length will not be adjusted beyond.
Azimuth The relative angle (+/-) a shot's azimuth angle will not be adjusted beyond.
Vertical The relative angle (+/-) a shot's dip or vertical angle will not be adjusted beyond.

Determination of Loops

A simple calculation can determine how many, if any, *Loops* exist in a *Cave Survey*. The number of loops in a survey is equal to the number of unique *Shots* minus the number of *Stations* plus one. A unique shot is the only shot connecting two stations. Any duplicate shots or fore and back sight combinations are combined into a single unique shot for counting and as a preprocessing step in Adjustment of Loops.

WinKarst's looping method resembles the "Oil Driller" game from Atari. In that game, a well is started at the surface and follows subterranean passages, eating up prizes. If the player was not careful, the well head could turn on its own pipe and cut into it, terminating the play. That process of intersecting its own path is the identification of a loop. Because loops appear in a random order, WinKarst will examine all of the branches along the path of the loop. If one of the branches leads to another station along the loops route, the new resulting loop is compared to the original loop. If the new route is a short cut, the loop is revised to the smaller size, otherwise the new loop is discarded. This process is continued until all of the branches from the loop are exhausted. By using this method, WinKarst will describe the loops of the cave with a minimum number of shots. When loops are small, it is much easier to find the errors or blunders in them, if present.

Loops are a valuable tool for testing the quality of a cave survey and the extra work in the field to collect the data creating loops should be encouraged.

See *Determination of Coordinates* to learn how to control the loop closure process.

Adjustment of Loops by Iteration

Loop adjustment is the process of modifying the bearing, inclination and distance measurements of a shot such that the closure error of the loop is zero. Adjusting the loops of a *Cave Survey* make drawing the cave map easier. This is because each area of shots and *stations* will more closely match the cave's sketch after closure. This is only true if the closure method does not close loops with blunders and no *shot* is unnecessarily "stretch" beyond recognition.

WinKarst, through the calculation of expected loop errors, can detect blunders. The user can select a multiplying factor at which the measured error must exceed the expected error before the loop is called a blunder. WinKarst also reports an empirically based expected error for comparison.

The process of closing all of the loops in a cave survey is actually quite complex and many methods exist with various attributes. WinKarst uses a method of simulated annealing. In this method all of the loops are simultaneously adjusted a small amount towards zero closure error. The process continues in an iterative fashion until no more improvement is detected between adjustment cycles.

WinKarst will not unnecessarily stretch any shots. The amount any shot measurement can be adjusted is controlled by the error limits. For example, the user can specify that no length measurement can be adjusted by more than six inches. Note, it is possible to set the error limits so tight the loop will not close to zero loop error even though the loop was not identified as a blunder. The three independent error limits allow the error to be distributed in a manner most appropriate, as chosen by the user.

See *Determination of Coordinates* to learn how to control the adjustment process.

Adjustment of Loops by Least Squares

This method of loop adjustment has not been implemented in WinKarst to date.

The Method of Least Squares has been haled as the only method to close cave survey loops, yet few people understand or are even aware of its limitations. Quoting from V. A. Schmidt and J. H. Schelleng in their paper, "The Application of the Method of Least Squares to Closing of Multiply-Connected Loops in Cave or Geological Surveys," Bulletin of the National Speleological Society, 1970, pages 51-58,

> "A few words of caution should be extended concerning this method. First, application to a survey will not magically increase its accuracy to any great extent unless a large number of closures are present throughout the survey. For most rough surveys it should be regarded primarily as a sensible method for distributing errors to yield a self-consistent survey. Second, gross mistakes in a survey will be assimilated by this method along with normal measurements errors, possibly producing an inaccurate and misleading survey. Hence it is always advisable to look at an uncorrected plot as well as the corrected final result to see if any closures are badly out of line, indicating the need for a resurvey."

UTM Coordinate Export

WinKarst exports a general purpose UTM coordinate format. Each field on a data line is separated by a comma, which make the file easily imported as a table in MSWord or spread sheet in MSExcel. The file can be directly imported in to the shareware program WayPoint+,
which can interfaces directly to a number of GPS receivers. With WayPoint+ and WinKarst, it is possible to upload a cave plot into a GPS
receiver and use it to walk the surface above the cave. The file can also be

imported in to TOPO!GPS, which can display the cave plot on
a CDRom version of a USGS topographic map.

An example of the UTM Coordinate export file format is:

```
Datum,WGS84,WGS84,0,0,0,0,0
WP,UTM,A0 , 10T
,597007.8944,5080918.941,12/20/1998,00:00:00,Resurrection
TP,UTM, 10T ,597007.8944,5080918.941,12/20/1998,00:00:00,1
TP,UTM, 10T ,597003.5936,5080918.458,12/20/1998,00:00:00,0
WP,UTM,A2 , 10T
,597003.5936,5080918.458,01/28/1995,00:00:00,Resurrection
TP,UTM, 10T ,596990.9507,5080910.432,12/20/1998,00:00:00,0
WP,UTM,A3 , 10T
,596990.9507,5080910.432,01/28/1995,00:00:00,Resurrection
```

Notice the datum is fixed has WGS84. There are two types of lines, WP and TP. The WP line is a waypoint and represents an individual station from the cave survey (the third column). The waypoints included are those selected by the Station labeling mode, plus the six north/south, east/west and up/down extremes of the survey. The second line, TP, is a track and represents the actual line plot of the cave. TP lines which end in a '1' are a "jump" to a start of a traverse.

The 3rd, 4th and 5th columns on a TP line (4th, 5th and 6th on WP lines) are the UTM zone, easthing and northing. By extracting the 3rd, 5th and 6th columns from the WP lines, the x/y coordinates of the cave, in meters, can be selected.

TXT Exporting to Database

The entire cave system survey, raw and reduced data, can be exported into a comma delimited text file suitable for import into programs such as MSExcel and MSAccess. Each objects are defined only once in the exported table and reference else where by unique indexes. For example, a station has a name, but in a shot the station's name does not appear, a station index appears. In the single table's row the station's name appears, the station index also appears for cross referencing. There are 59 columns in the export table.

Conceptually, the exported table can be broken down into several smaller tables and the indexes appear has keys in the smaller tables. An implementation of equivalent smaller tables might include tables for caves, control points, aliases, surveys, shots, stations, sketches, groups and properties.

lame	Location	Datum	Index

tation	Longitude	Latitude	Elevation	Name	Cave	Index				
lias	Equate	Cave	Index							
lame	Cave	Date	Declination	Team	Comment	Codes	Index	Group		
rom	To	Survey	Length	Bearing	Dip	Left	Right	Up	Down	Comment
lame	Cave	X	Y	Z	Longitude	Latitude	Elevation	Index		
lame	Index									
lame	X	Y	Sheet	Index						
lame	Cave	Station	Description		Index					

Database Contents

Data Field Name	Numeric or Character	Width
Author	C	32
FileDate	C	16
Units	C	16
Auto	C	16
SDTS	C	128
CaveID	N	16
CaveName	C	32
Location	C	128
Datum	C	32
AutoMag	C	16
ControlID	N	16
Station1ID	N	16
AliasID	N	16
EquateID	N	16
SketchID	N	16
SketchX	N	16
SketchY	N	16
SketchName	C	128
SurveyID	N	16
SurveyName	C	32
SurveyDate	C	16
MagneticN	N	16
Team	C	128
Comment1	C	128
Comment2	C	128
SurveyCode	C	16
SurveyType	C	16
ShotID	N	16
ShotType	N	16

Station2ID	N	16
Length	N	16
Azimuth	N	16
BackAzm	N	16
Dip	N	16
BackDip	N	16
DeltaZ	N	16
Left	N	16
Right	N	16
Up	N	16
Down	N	16
Comment3	C	128
Station	C	32
StationX	N	16
StationY	N	16
StationZ	N	16
Longitude	N	16
Latitude	N	16
Elevation	N	16
PropertyID	N	16
PropName	C	32
Comment4	C	128
Overburden	N	16
Group	C	32
GroupID	N	16
Sheet	C	32
SheetID	N	16
Easting	N	16
Northing	N	16
Zone	N	16

PNG

A Portable Network Graphics file (PNG) is a rasterize representation of an image. The standard was developed by the Open Source movement to counter royalties charged to write software that wrote the GIF file format. It is widely accepted across multiple operating systems and platforms. A bit map may have one of half a dozen color depths and variable dimensions. The dimensions are what ever the window has been stretched to. The PNG format has superior compression with respect to the GIF format.

TIF

A Tag Image Format file (TIF) is a rasterize representation of an image. It is widely accepted across multiple operating systems and platforms. A bit map may have one of half a dozen color depths and variable dimensions. TIF is an extendable format where addition image meta data can be stored in the tags of the format. An example is the GeoTIFF extension. The TIF format can be compressed in several ways or not at all. WinKarst does not use the LZW compression, but can read files stored that way.

Bit Map

A bit map file (BMP) is a rasterize representation of an image. The standard was developed by Microsoft for its Windows products and is probably the most widely accepted file format for images. A bit map may have one of half a dozen color depths and variable dimensions. The dimensions are what ever the window has been stretched to. Because the bit map is an uncompressed format, their size can be very large, often several mesa bytes of data.

SEF Export

Any object that has the focus in the map view may be exported. That includes a group of surveys, loop, traverse, single survey, branch survey and cave. The SEF format is the native data format for SMAPS.

SUR Export

Any object that has the focus in the map view may be exported. That includes a group of surveys, loop, traverse, single survey, branch survey and cave. The SUR format is the native data format for WinKarst.

DAT Export

Any object that has the focus in the map view may be exported. That includes a caves, group of surveys, loop, traverse, single survey, branch survey and cave. The DAT format is the native data format for COMPASS. MAK files can not be exported, use "Save As" from the file menu instead.

Track and WayPoint

The track (TRK) and waypoint (WPT) file formats are used by Garmin (others?) to exchange data between their Global Position System (GPS) products and desktop computers. These files are ascii based and can easily be edited. The track file is a vector file and a cave's line plot can be displayed on a GPS unit.

The waypoint file is a station list which the user can use to navigate towards a specific location. Care should be exercise to prevent uploading more data than can reside in a GPS unit, WinKarst sets no limits on file size. The format employed by WinKarst is described in Garmin's PCX5 software and test files have been successfully uploaded to a Garmin 45XL unit. Exported files may need additional editing before they can be used by other applications and GPS manufactures.

WinKarst by default exports the cave's control points and four positional extremes into the waypoint file. If **Station** or **Property** labeling is active, then the displayed station's locations will be exported to the waypoint file.

Drawing Exchange Format

Drawing Exchange Format (DXF) is a data file format developed by AutoDesk for transferring drawings between computer applications. It is widely used in architecture and engineering. Recently, it has become more important as a method to describe three dimensional objects. AutoDesk pioneered virtual reality drawings with its 3DStudio and RenderMan products. Many applications accept DXF files, including Microsoft Word, Corel Draw and of course AutoCAD.

Unfortunately,AutoDesk has redefined DXF through its versions of AutoCAD and the latest version can not read the DXF files from earlier versions, nor from exporting third party products. WinKarst can export two types of DXF, defined by version 12 and 14 of AutoCAD. The new type, for version 14, can also be read by AutoDesk's AutoCAD Lite program.

WinKarst can generate two types of DXF files, two and three dimensional representations of cave surveys. For two dimensional exports, all of the Z or depth coordinates have been forced to zero. For three dimensional exports, the cave's Z coordinates are calculated. In addition, a three dimensional export may contain "3dface" objects, which are either a triangle or rectangle in space. WinKarst will tag the exported objects with a color number shown in the display, but in general, an importing application will have a different color map or may not show color differences at all. Note, that some applications may not understand three dimensions and part or all of the file may not import.

If the cave survey has a geographic reference point (longitude and latitude), then the units of the DXF file will be in meters and represent UTM coordinates. Otherwise, the units are specified by the cave system property and reference to the location of the first control point (default is 0,0,0).

WinKarst exports elements of the cave survey on to the following layers:

DXF Layer	Survey Element
Survey	Shots

Text	Station names
Legend	Compass and scale
Symbol	Station, entrance and control markers
Passage	LRUD wall outline

DBF Export

The entire cave system survey, raw and reduced data, can be exported into a dBaseIII file suitable for import into programs such as MSExcel and MSAccess. Each objects are defined only once in the exported table and reference else where by unique indexes. For example, a station has a name, but in a shot the station's name does not appear, a station index appears. In the single table's row the station's name appears, the station index also appears for cross referencing. There are 59 columns in the export table.

Conceptually, the exported table can be broken down into several smaller tables and the indexes appear has keys in the smaller tables. An implementation of equivalent smaller tables might include tables for caves, control points, aliases, surveys, shots, stations, sketches, groups and properties.

lame	Location	Datum	Index							
tation	Longitude	Latitude	Elevation	Name	Cave	Index				
lias	Equate	Cave	Index							
lame	Cave	Date	Declination	Team	Comment	Codes	Index	Group		
rom	To	Survey	Length	Bearing	Dip	Left	Right	Up	Down	Comment
lame	Cave	X	Y	Z	Longitude	Latitude	Elevation	Index		
lame	Index									
lame	X	Y	Sheet	Index						
lame	Cave	Station	Description		Index					

Database Contents

Data Field Name	Numeric or Character	Width
Author	C	32
FileDate	C	16
Units	C	16
Auto	C	16

SDTS	C	128
CaveID	N	16
CaveName	C	32
Location	C	128
Datum	C	32
AutoMag	C	16
ControlID	N	16
Station1ID	N	16
AliasID	N	16
EquateID	N	16
SketchID	N	16
SketchX	N	16
SketchY	N	16
SketchName	C	128
SurveyID	N	16
SurveyName	C	32
SurveyDate	C	16
MagneticN	N	16
Team	C	128
Comment1	C	128
Comment2	C	128
SurveyCode	C	16
SurveyType	C	16
ShotID	N	16
ShotType	N	16
Station2ID	N	16
Length	N	16
Azimuth	N	16
BackAzm	N	16
Dip	N	16
BackDip	N	16
DeltaZ	N	16
Left	N	16
Right	N	16
Up	N	16
Down	N	16
Comment3	C	128
Station	C	32
StationX	N	16
StationY	N	16
StationZ	N	16
Longitude	N	16
Latitude	N	16
Elevation	N	16
PropertyID	N	16
PropName	C	32

Comment4	C	128
Overburden	N	16
Group	C	32
GroupID	N	16
Sheet	C	32
SheetID	N	16
Easting	N	16
Northing	N	16
Zone	N	16

Shapefile Export

A shapefile stores nontopological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates. Attributes are held in a dBaseIII format file.
Each attribute record has a one-to-one relationship with the associated shape record. The objects exported by WinKarst are either PointZ or PolylineZ types. Environmental Systems Research Institute, Inc. (ESRI), defines the technical features of shapefiles.

An ESRI shapefile consists of a main file, an index file, and a dBASE table. The main file is a direct access, variable-record-length file in which each record describes a shape with a list of its vertices. In the index file, each record contains the offset of the corresponding main file record from the beginning of the main file. The dBASE table contains feature attributes with one record per feature.

WinKarst creates six ArcView/ArcExplorer (ESRI) themes. The themes are Identification, Cave, Survey, Shots, Stations and Control Points. The data fields in the various dBase files correspond to the tables described in the *DBF export*. A total of 18 files are created when a shapefile is exported. The file names are:

Identification "<root name>.shp"
Identification "<root name>.shx"
Identification "<root name>.dbf"

Identification "<root name> caves.shp"
Identification "<root name> caves.shx"
Identification "<root name> caves.dbf"

Identification "<root name> surveys.shp"
Identification "<root name> surveys.shx"
Identification "<root name> surveys.dbf"

Identification "<root name> shots.shp"
Identification "<root name> shots.shx"
Identification "<root name> shots.dbf"

Identification	"<root name> stations.shp"
Identification	"<root name> stations.shx"
Identification	"<root name> stations.dbf"

Identification	"<root name> controls.shp"
Identification	"<root name> controls.shx"
Identification	"<root name> controls.dbf"

Spatial Data Transfer Specification (SDTS)

What is SDTS?

The Spatial Data Transfer Standard, or SDTS, is a ***robust*** way of transferring earth-referenced spatial data between dissimilar computer systems with the potential for no information loss. It is a transfer standard that ***embraces*** the philosophy of self-contained transfers, i.e. spatial data, attribute, georeferencing, data quality report, data dictionary, and other supporting metadata all included in the transfer.

Purpose of SDTS

The purpose of the SDTS is to promote and facilitate the transfer of digital spatial data between dissimilar computer systems, while preserving information meaning and minimizing the need for information external to the transfer. Implementation of SDTS is of significant interest to users and producers of digital spatial data because of the potential for increased access to and sharing of spatial data, the reduction of information loss in data exchange, the elimination of the duplication of data acquisition, and the increase in the quality and integrity of spatial data. SDTS is neutral, modular, growth-oriented, extensible, and flexible--all characteristics of an "open systems" standard.

The SDTS provides a solution to the problem of spatial data transfer from the conceptual level to the details of physical file encoding. Transfer of spatial data involves modeling spatial data concepts, data structures, and logical and physical file structures. To be useful, the data to be transferred must also be meaningful in terms of data content and data quality. SDTS addresses all of these aspects for both vector and raster data structures.

History of SDTS

The Federal Information Processing Standards (FIPS) Program was established in the 1960s to standardize federal usage of computers. FIPS are government standards for federal agencies and organizations. The administrator of the FIPS Program is the National Institute of Standards and Technology (NIST). In the mid-1970s, computers began popping up throughout many federal geographic and cartographic agencies. As the application of computers in geography and cartography grew within the federal government, the need for earth science data standards became apparent.

In 1980, the U.S. Geological Survey (USGS) was designated the lead agency in developing earth science data standards for the federal government. The USGS worked with academic, industrial, and federal, state, and local government users of computer mapping and GIS to develop a standard for transfer and exchange of spatial data. In 1992, after twelve years of developing, reviewing, revising, and testing, the resulting standard--SDTS, was approved as Federal Information Processing Standard (FIPS) Publication 173, known as **FIPSPUB 173-1, 1994**. The FIPS version has been superceded by current version, known as **ANSI NCITS 320-1998** and was ratified by the American National Standards Institute (ANSI) June 9, 1998.

Compliance with SDTS is now mandatory for federal agencies. SDTS is available for use by state and local governments, the private sector, and research and academic organizations.

The USGS SDTS Information Site is

http://mcmcweb.er.usgs.gov/sdts/

SDTS data organization

Digital Line Graph - DLG/SDTS Data

DLG-O data are derived from standard USGS topographic quadrangles. The packaging of DLGO data reflects this: each physical file covers the geographic area of some part of a standard quadrangle, and contains a feature set that approximates the ink colors of a standard published map.

Similarly, DLG/SDTS data are derived directly from DLG-O data, and reflect the DLG-O data packaging. Each SDTS transfer has the same geographic coverage and same spatial data content as the DLG-O it was derived from. This packaging is not dictated by the SDTS; the standard would allow (for example) all road and hydrography data for a county to be contained in one transfer, but reorganizing the data this way would have required a large and costly production operation, instead of a relatively simple data reformat. A side effect is that the DLG/SDTS data appear more fragmented and complex than necessary. This is not a characteristic of the SDTS, but of policy decisions made when the USGS mass converted DLG-O data to SDTS format.

WinKarst utilizes "Trails and Roads" from the transportation layer and "Stream" from the hydrography layer DLG records.

Digital Elevation Model - DEM/SDTS Data

DEM data are derived from standard USGS topographic quadrangles. The packaging of DEM data reflects this: each physical file covers the geographic area of some part of a standard quadrangle,

Similarly, DEM/SDTS data are derived directly from DEM data, and reflect the DEM data packaging. Each SDTS Data transfer has the same geographic coverage and same spatial content as the original source DEM.

WinKarst utilizes 7.5 minute DEM records.

Using SDTS data

WinKarst can make use of three types of SDTS data - DEM, DLG Transportation and DLG Hydrograph. When the SDTS zipped file is unpacked, it will generate a set of 20 to 30 files. One of the files is the master catalog which itself lists all of the files of the data set. Typically, the first four characters of the catalog filename are a set of numbers for a DEM, TR01 for Transportation and HY01 for Hydrograph. The next four characters specify the SDTS sub-file type, e.g. CATD for catalog. All of the SDTS files have the extension DDF.

WinKarst selects a SDTS data set by finding and reading the catalog file. The catalog filename can be embedded in the cave survey data file or loaded independently of a survey. Once loaded, either embedded or independently, the SDTS data can be used by any survey than falls within its boundaries. The SDTS data is retained even if all of the surveys are closed.

WinKarst can tile together SDTS data sets. If a subsequent SDTS data file is loaded and it touches any edge of an existing set of SDTS data, then the new data is merged into the set. If the subsequent data does not touch, then all the previous data is discarded in favor of the last data read. There is no limit to the number of SDTS data sets that can be merged together, but a practical limit if eight is probably reasonable.

WinKarst can read 1:24,0000 DEM - 7.5 minute quad maps, 1:24,0000 DLG and 1:100,000 DLGs. The DLG and DEM data sets need not be adjacent or overlapping as they are handled as independent objects. DLG and DEM data (viewed as contours) can only be displayed in the Plan view. DEM data as a surface can be viewed in the 3-dimensional and profile views.

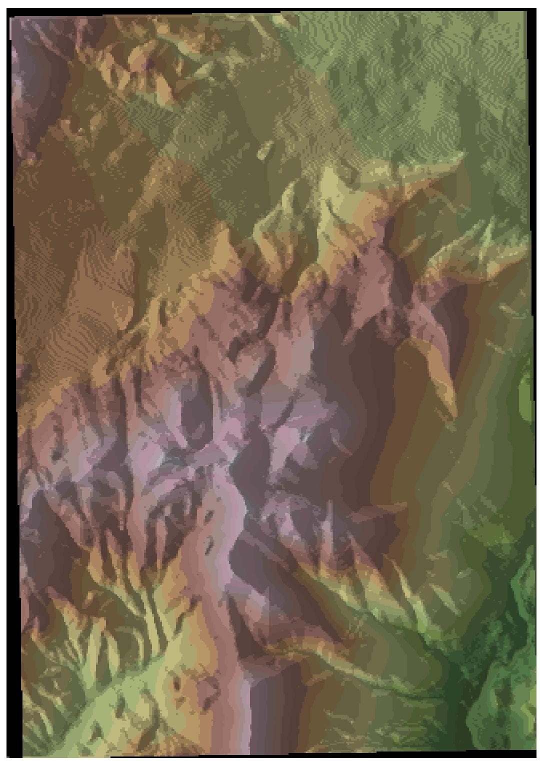
DEM Background

The USGS Digital Elevation Model (DEM) data files are digital representations of cartographic information in a raster form. DEMs consist of a sampled array of elevations for a number of ground positions at regularly spaced intervals. These digital cartographic/geographic data files are produced by the United States Geological Survey (USGS) as part of the National Mapping Program and are available in 7.5-minute, 15-minute, 2-arc-second (also known as 30-minute), and 1-degree units. The 7.5- and 15-minute DEMs are included in the large scale category while 2-arc-second DEMs fall within the intermediate scale category and 1-degree DEMs fall within the small scale category.

Large scale

The DEM data for 7.5-minute units correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series for all of the United States and its territories. Each 7.5-minute DEM is based on 30- by 30-meter data spacing with the Universal Transverse Mercator (UTM) projection. Each 7.5- by 7.5-minute block provides the same coverage as the standard USGS 7.5-minute map series.

The 7.5-minute Alaska DEM data correspond to the USGS 1:24,000 and 1:25,000 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 7.5-minute Alaska DEM data consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of the North American 1927 Datum (NAD 27) or the North American 1983 Datum (NAD 83). The spacing between elevations along profiles is 1 arc second in latitude by 2 arc seconds of longitude.



Guler Mountain, Washington

The 15-minute DEM data correspond to the USGS 1:63,360 scale topographic quadrangle map series of Alaska by unit size. The unit sizes in Alaska vary depending on the latitudinal location of the unit. The 15-minute DEM data consist of a regular array of elevation referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27. The spacing between elevations along profiles is 2 arc seconds of latitude by 3 arc seconds of longitude.

Intermediate scale

The 2-arc-second DEM data cover 30-minute by 30-minute areas which correspond to the east half or west half of the USGS 30- by 60-minute topographic quadrangle map series for the conterminous United States and Hawaii. Each 2-arc-second unit is produced and distributed as four 15- by 15-minute cells. The spacing of elevations along and between each profile is 2 arc seconds.

Small scale

The 1-degree DEM (3- by 3-arc-second data spacing) provides coverage in 1- by 1-degree blocks for all of the contiguous United States, Hawaii, and most of Alaska. The basic elevation model is produced by or for the Defense Mapping Agency (DMA), but is distributed by the USGS, in DEM data record format. In reformatting the product, the USGS does not change the basic elevation information. The 1-degree DEMs are also referred to as 3-arc-second or 1:250,000 scale DEM data.

DEM Data Characteristics

Large scale

Each 7.5-minute unit of DEM coverage (based on the 7.5-minute quadrangle) consists of a regular array of elevations referenced horizontally in the UTM projection coordinate system. Elevation units are in meters or feet relative to National Geodetic Vertical Datum of 1929 (NGVD 29) in the continental U.S. and local mean sea level in Hawaii and Puerto Rico. The data are ordered from south to north in profiles that are ordered from west to east.

These horizontally referenced data may be NAD 27, NAD 83, Old Hawaiian Datum (OHD), or Puerto Rico Datum (PRD) of 1940.

The 7.5-minute Alaska DEMs consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27 or NAD 83. The data are ordered from south to north in profiles that are ordered from west to east. The unit of coverage corresponds to four basic quadrangle sizes for 1:63,360 scale graphics (depending on latitude):

Cell size limits

7.5 by 18 minutes -- State of Alaska north of 68°N latitude
7.5 by 15 minutes -- Between 62°N and 68°N latitude
7.5 by 11.25 minutes -- Between 59°N and 62°N latitude
7.5 by 10 minutes -- State of Alaska south of 59°N latitude

The 15-minute Alaska DEMs consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27 or NAD 83. The data are ordered from south to north in profiles that are ordered from west to east. Elevation units are in meters or feet relative to NGVD 29. The unit of coverage corresponds to four basic quadrangle sizes for 1:63,360-scale graphics (depending on latitude):

Cell size limits

15 by 36 minutes -- State of Alaska north of 68°N latitude
15 by 30 minutes -- Between 62°N and 68°N latitude
15 by 2.5 minutes -- Between 59°N and 62°N latitude
15 by 20 minutes -- State of Alaska south of 59°N latitude

Intermediate scale

The 2-arc-second DEM data consist of a regular array of elevations referenced horizontally to the geographic (latitude/longitude) coordinate system of NAD 27 or NAD 83. The unit of coverage is a 30- by 30-minute block. Saleable units are four 15-minute DEMs covering a 30- by 30-minute area. Elevation data on the integer minute lines (all four sides) correspond to the same profiles on the surrounding eight blocks. Elevations are in meters or feet relative to NGVD 29.

Small scale

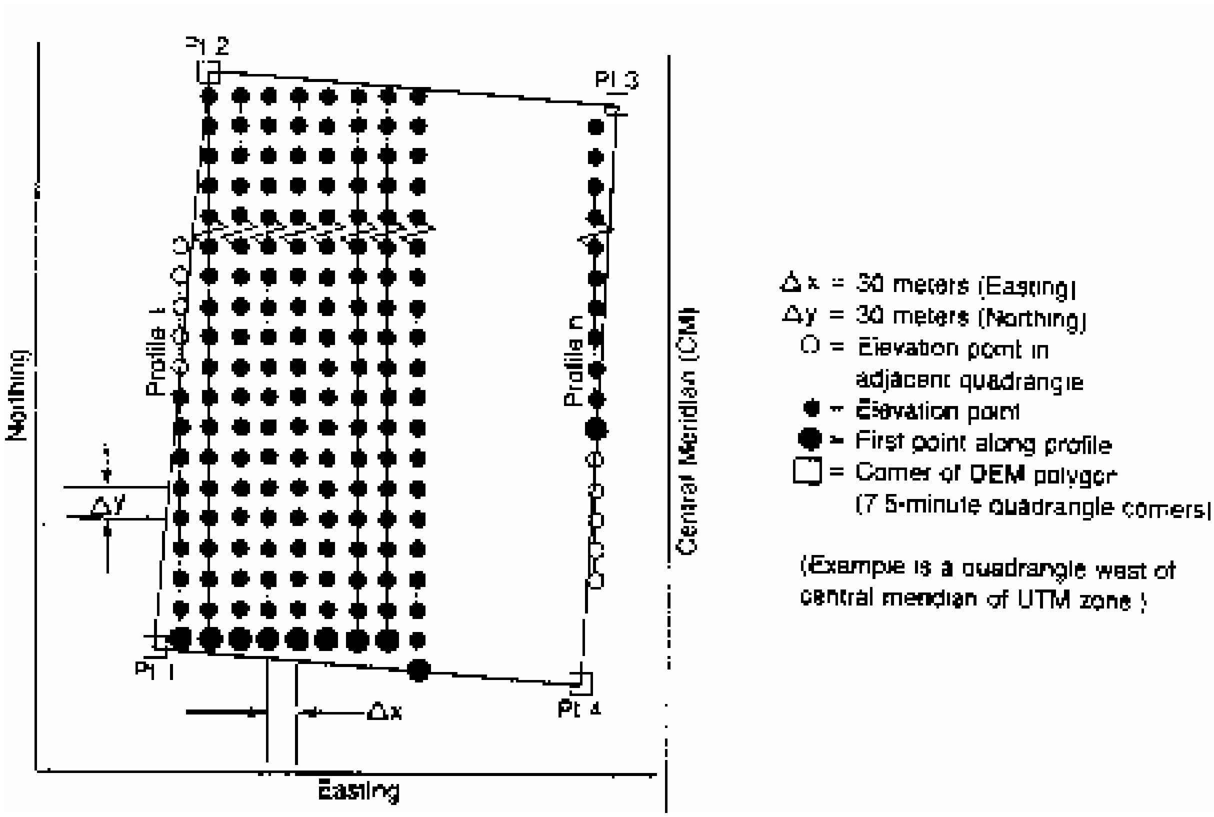
The 1-degree DEM consists of a regular array of elevations referenced horizontally on the geographic (latitude/longitude) coordinate system of the WGS 72 (converted to WGS 84). The information content is approximately equivalent to that which can be derived from contour information represented on 1:250,000 scale maps. the unit of coverage is a 1- by 1-degree block. Elevation data on the integer degree lines (all four sides) overlap with the corresponding profiles on the surrounding eight blocks.

Elevations are in meters relative to NGVD 29 in the continental U.S. and local mean sea level in Hawaii. DEM accuracy information is provided in the Appendix.

DEM Data Resolution

Large scale

The 7.5-minute DEM data are stored as profiles in which the spacing of the elevations along and between each profile is 30 meters. The number of elevations in a profile will vary because of the variable angle between the quadrangle's geographic boundary (neatline) and the UTM coordinate system. DEM data of low-relief terrain or generated from contour maps with intervals of 10 feet or less are recorded in feet while DEM data of moderate to high-relief terrain or generated from maps with terrain contour intervals greater than 10 feet are generally recorded in meters.



UTM Meter Grid for 7.5 DEM

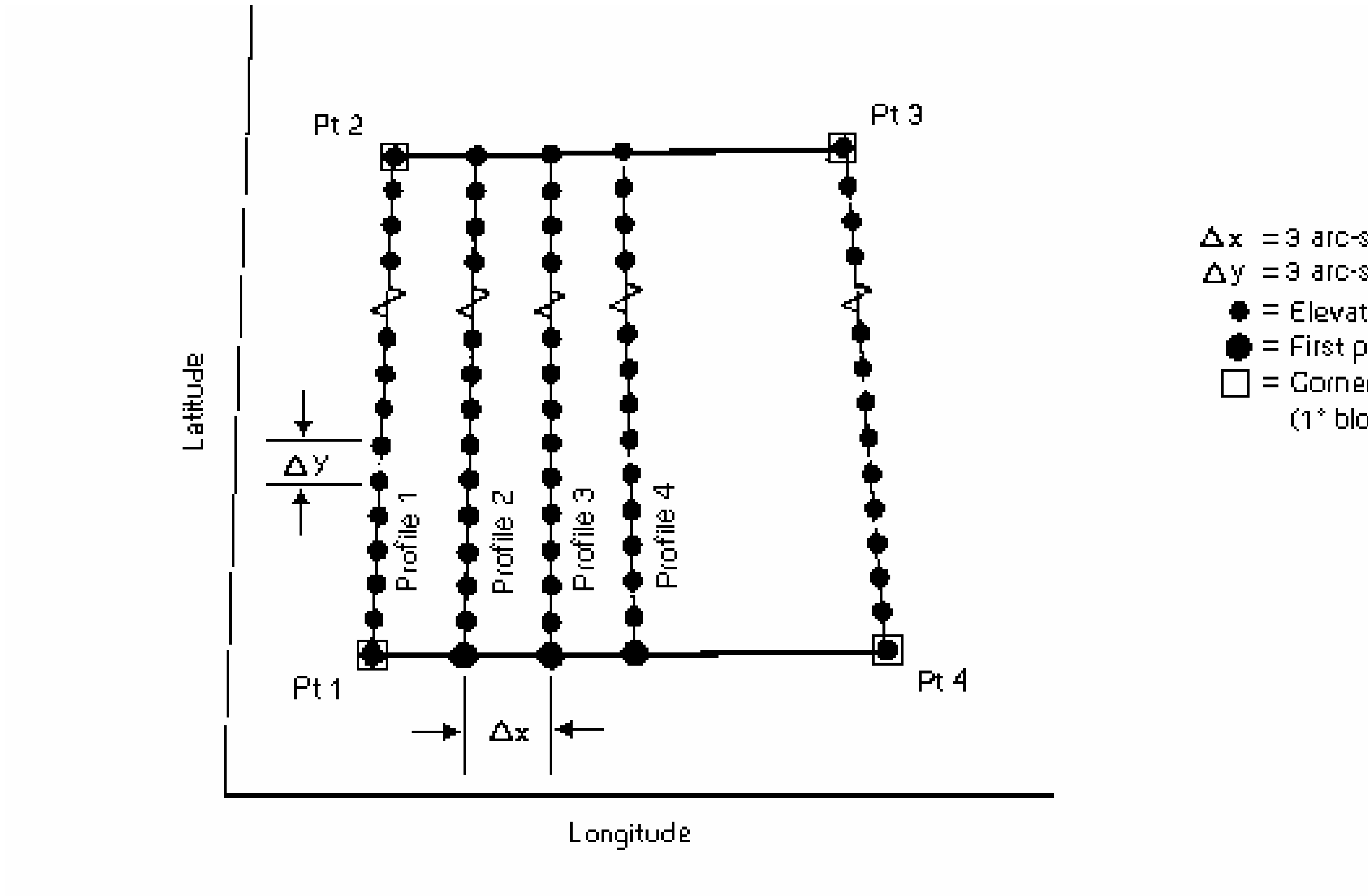
The 15-minute DEM data are collected with a 2- by 3-arc-second spacing in latitude, and longitude, respectively. The first and last data points along a profile are at the integer degrees of latitude. Elevation data on the quadrangle neatlines (all four sides) share edge profiles with the surrounding eight quadrangles.

Intermediate scale

Spacing of the elevations along each profile is 2 arc seconds. The first and last data points are at the integer 15 minutes of latitude. A 15-minute profile will, therefore, contain 451 elevations.

Small scale

Spacing of elevations along and between each profile of 1-degree DEMs is 3 arc seconds with 1,201 elevations per profile. The exception is DEM data in Alaska, where the profile spacing varies depending on the latitudinal location of the DEM. Latitudes between 50 and 70 degrees north have spacings at 6 arc seconds with 601 profiles per 1-degree unit and latitudes greater than 70 degrees north have spacings at 9 arc seconds with 401 profiles per 1-degree unit.



Arc Second Grid for 1-degree DEM

DEM Data Accuracy

General Information

The accuracy of a DEM is dependent upon its source and the spatial resolution, that is grid spacing, of the data profiles. One factor influencing DEM accuracy is source data scale and resolution. A dependency exists between the scale of the source materials and the level of grid refinement possible. The source resolution is also a factor in determining the level of content that may be extracted during digitization. For example, 1:250,000-scale topographic maps are the primary source of 1-degree DEMs.

Another factor is the horizontal and vertical dimension of the DEM. Horizontal accuracy of DEM data is dependent upon the horizontal spacing of the elevation matrix. Within a standard DEM, most terrain features are generalized by being reduced to grid nodes spaced at regular intersections in the horizontal plane. This generalization reduces the ability to recover positions of specific features less than the internal spacing during testing and results in a de facto filtering or smoothing of the surface during gridding.

Vertical accuracy of DEM data is dependent upon the spatial resolution (horizontal grid spacing), quality of the source data, collection and processing procedures, and digitizing systems. As with horizontal accuracy, the entire process, beginning with project authorization, compilation of the source data sets, and the final gridding process, must satisfy accuracy criteria customarily applied to each system. Each source data set must qualify to be used in the next step of the process. Errors have the effect of compounding for each step of the process. Production personnel are directed to account for each production step leading to the final DEM.

The method of determining DEM accuracy involves computation of the root-mean-square error (RMSE) for linearly interpolated elevations in the DEM and corresponding true elevations from the published maps. Test points are well distributed and representative of the terrain. Collection of test point data and comparison of the DEM to the quadrangle hypsography are conducted by USGS quality-control groups.

Large scale

The vertical accuracy of 7.5-minute DEMs is equal to or better than 15 meters. A minimum of 28 test points per DEM is required (20 interior points and 8 edge points). The accuracy of the 7.5-minute DEM data, together with the data spacing, adequately support computer applications that analyze hypsographic features to a level of detail similar to manual interpretations of information as printed at map scales not larger than 1:24,000 scale.

Accuracy of the 15-minute DEMs is equal to or better than one-half of a contour interval of the 15-minute topographic quadrangle map. The accuracy of the 15-minute DEM data, together with the data spacing, adequately support computer applications that analyze hypsographic features to a level of detail similar to manual interpretations of information as printed at map scales not larger than 1:63,360 scale. The plotting of contours from the 15-minute Alaska DEMs at scales larger than 1:63,360, or reliance on the elevation heights without incorporating the National Map Accuracy Standard (NMAS) horizontal error tolerance, will lead to less reliable results.

Intermediate scale

The 2-arc-second DEM accuracy is equal to or better than one-half of a contour interval of the 30- by 60-minute topographic quadrangle map. The accuracy of the 2-arc-second DEM data, together with the data spacing, adequately support computer applications that analyze hypsographic features to a level of detail similar to manual interpretations of information as printed at map scales not larger than 1:100,000 scale. The plotting of contours from 2-arc-second DEM data at scales larger than 1:100,000, or reliance on the elevation heights without incorporating the NMAS horizontal error tolerance, will lead to less reliable results.

Small scale

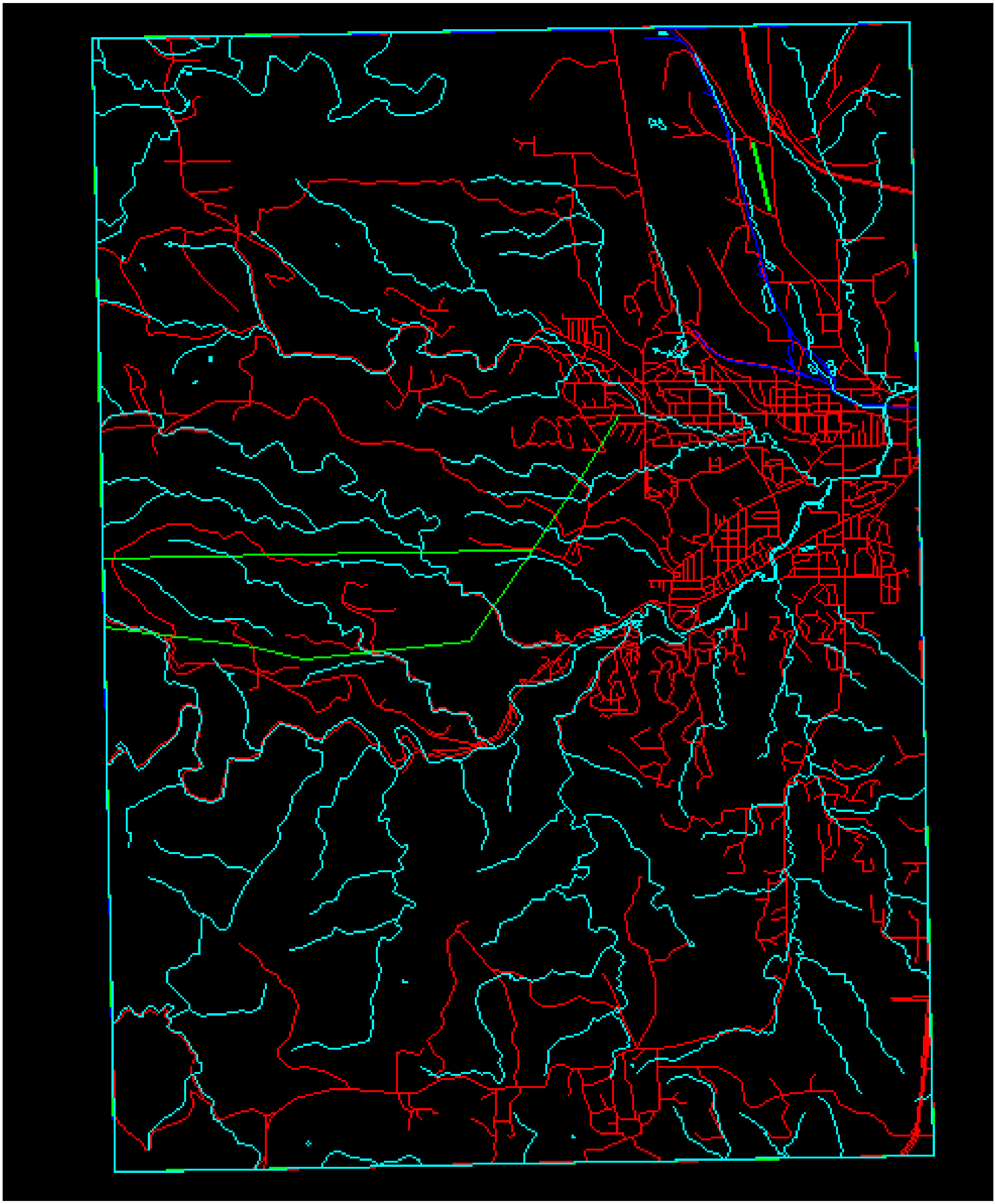
The 1-degree mosaic data set spacing of elevation and profile data is the same as the 1-degree DEM contiguous U.S. data. The accuracy of the 1-degree DEM data, together with the data spacing, adequately support computer applications that analyze hypsographic features to a level of detail similar to manual interpretations of information as printed at map scales not larger than 1:250,000 scale. The plotting of contours from the 1-degree DEM at scales larger than 1:250,000, or reliance on the elevation heights without incorporating the NMAS horizontal error tolerance, will lead to less reliable results.

DLG Background

The United States Geological Survey's digital line graph (DLG) files are digital vector representations of cartographic information. Data files of topographic and planimetric map features are derived from either aerial photographs or from cartographic source materials using manual and automated digitizing methods.

Large Scale

> The large-scale DLG data primarily are derived from USGS 7.5-minute topographic quadrangle maps at 1:24,000 and 1:25,000 scales (1:25,000 and 1:63,360 scales for Alaska).



Intermediate Scale

Intermediate or 100,000-scale DLG data are derived from USGS 1:100,000-scale, 30-

by 60-minute quadrangle maps. If these maps are not available, Bureau of Land Management planimetric maps at a scale of 1:100,000 are used.

Small Scale

Small or 1:2,000,000-scale DLG data are organized two ways (by section or by State) and contain information on planimetric base categories, including transportation, hydrography, and boundaries for all 50 States. The Section DLG data files are historical files dating between 1973 and 1980 that are organized by sections of the United States (e.g., northeastern States). The State data files are recent files dating between 1990 and 1994 that are organized by State.

DLG Data Characteristics

The large-, intermediate-, and small-scale DLG data distributed by the USGS are in the DLG Level-3 (DLG-3) format. All DLG data in the NDCDB are level-3 data, which have the full range of attribute codes and have a full topological structure.

A DLG-3 file is composed of node, line, and area-identifier elements. Nodes define the location of the endpoints of every line. A single node may mark the start or the end of one or more lines; therefore, nodes occur at intersections of linear features and at other places on linear features where the feature is subdivided into separate line segments. A line is an ordered set of points (vertices) that describes the position and shape of a linear feature on a map. Each line starts and ends at a node, thus, having an explicit order from start to stop and a left-to-right connotation. Lines may not cross over themselves or any other lines except at a node. An area is a continuous unbroken region of a map bounded by lines. Every DLG data file identifies at least two areas (one representing an area covered by the file and the other representing the area outside the coverage of the file).

Attribute codes are used to describe the physical and cultural characteristics of DLG node, line, and area elements. The codes are based on cartographic features symbolized on source maps. Each DLG element has one or more attribute codes composed of a three-digit major code and a four-digit minor code. The attribute scheme is open-ended so that additional codes may be added as needed. It is not necessary for each element to have associated attributes. In general, attribute codes are not assigned to an element if the attributes can be derived based on relationships to adjacent elements.

Large Scale

The large-scale DLG data files are produced in 7.5-minute units that correspond to 1:20,000-, 1:24,000-, and 1:25,000-scale topographic quadrangle maps (1:25,000- and 1:63,360-scale maps for Alaska). The unit sizes in Alaska vary depending on latitude.

The DLG data files derived from the 1:24,000-scale maps contain selected base categories of cartographic data in digital form. These categories include: (1) political boundaries (e.g., State, county, city, and other municipal boundaries) and administrative boundaries (e.g., National and State forest boundaries); (2) hydrography, including all flowing water, standing water, and wetlands; (3) Public Land Survey System (PLSS) data describing the rectangular system of land surveys administered by the BLM, representing or referencing property boundaries (e.g., township, range, and park information); (4) transportation data, including major transportation systems collected in three separate overlays (roads and trails; railroads; and pipelines, transmission lines, and miscellaneous transportation features); (5) other significant manmade structures, including miscellaneous cultural features not in the other major data categories (e.g., schools, churches, hospitals); (6) hypsography; (7) surface cover, including information about vegetative surface cover (e.g., woods, scrub, orchards, and vineyards); (8) nonvegetative surface features, including information about the natural surface of the Earth (e.g., lava and sand); and (9) survey control and markers (i.e., information about the points of established position and third-order or better elevations that are used as fixed references in positioning and correlating map features).

Intermediate Scale

The 100,000-scale DLG files are derived from USGS topographic maps published as 30- by 60-minute quadrangles at 1:100,000 scale. Editions of BLM 1:100,000-scale maps or archival compilation materials are used when the USGS maps are not available.

The DLG data files derived from the 1:100,000-scale maps contain selected base categories of cartographic data in digital form. These categories include: (1) hydrography, including flowing water, standing water, and wetlands; (2) transportation collected in three different categories (roads and trails; railroads; and pipelines, transmission lines, and miscellaneous transportation); (3) hypsography, including contours and supplementary spot elevations; (4) boundaries, including State, county, city, and other National and State lands such as forests and parks; and (5) PLSS, including township, range, and section information.

The DLGs are distributed in groups of files that make up 30- by 30-minute areas of coverage representing the selected category of information in the east half or west half of a 1:100,000-scale source map. Each 30-minute area consists of a varying number of DLG files depending on the category and the feature density. The normal distribution group is four 15-minute files per 30-minute area. If the feature density in an area is such that the file size exceeds the limitations of the processing programs, then the 30-minute area is covered by sixteen 7.5-minute files.

Small Scale

The Section DLG files were created by manually digitizing the 1:2,000,000-scale sectional maps of the National Atlas of the United States of America. Originally, three levels of DLG data (DLG-1, DLG-2, and DLG-3) were defined. The DLG-3 data have the most accurate positional control and have been topologically structured for use in mapping and geographic information system (GIS) applications. Of the three file levels, the DLG-3 files are the only files that are distributed to the user community.

The U.S. State data are broken into 52 rectangular cells. Cell corners are represented in even degrees of latitude or longitude, and cell size is determined by the area necessary to encompass a given State (except for Alaska, which is divided among three cells along arcs of longitude and latitude). The registration points for each cell are the cell corners. The data for each cell are encoded in multiple categories including: (1) boundaries; (2) hydrography; (3) manmade features; (4) pipelines, transmission lines, and miscellaneous transportation features; (5) railroads; roads and trails; and (6) PLSS. There is one file per category. The files for each cell are vertically registered and the State boundaries are edge matched to each other.

DLG Data Resolution

Large and Intermediate Scales

The data are either manually digitized using equipment with a resolution of 0.001 inch and an absolute accuracy from 0.003 to 0.005 inch or the data are scanned on an automatic device with a resolution of 0.0013 inch (30 points per millimeter).

Small Scale

The 1:2,000,000-scale DLG files were digitized using the National Atlas of the United States of America as a base map. The National Map Accuracy Standards states that 90 percent of well-defined points on the map must be within .02 inch at scale. At 1:2,000,000 scale, this corresponds to a maximum displacement of 3333.33 feet or 1,016 meters.

DLG Data Organization

The SDTS format differs from the graphic and optional formats. The character set consists of a binary data file that contains non-ASCII characters. The characters are formatted according to International Organization for Standardization (ISO) standards 646 and 2022. The binary floating point is determined according to the ANSI/IEEE 754-1985 standard, and binary integers are determined according to the ISO/IEC 8632-3 standard. The logical record length is variable as defined in ISO 8211 and the block size is media dependent. The coordinate system is geographic (latitude/longitude) for the small-scale DLG data and planimetric for the large- and intermediate-scale DLG data; the topological linkages are only in lines (though SDTS supports all objects, DLG to SDTS supports only in lines).

Large and Intermediate Scales

Large-scale DLG files are available in SDTS formats. Intermediate-scale DLG files are available in SDTS formats.

Data in the optional format are organized into 11 distinct record types (4 header records and 7 data records). The four header record types are file identification and description; accuracy (not currently used); control point identification; and data category identification. The seven data record types are node and area identification; node-to-line linkage; area-to-line linkage; line identification (also contains line-to-node and line-to-area linkages); coordinate string; attribute code; and text (not currently used).

Small Scale -- 1:2,000,000-Scale DLG Sectional Data (1973-1980)

Each of the 21 sections of the 1:2,000,000-scale DLG file has one or multiple layers. There are three layers for each section:

- Boundaries
    - States, counties, and Federal lands
- Hydrography
    - Streams and water bodies
- Transportation
    - Roads and Trails

      (e.g., Interstate and primary State highways)
  - Railroads

      (e.g., Main line and branch line railroads)
  - Miscellaneous transportation features

      (e.g., Airports and pipelines)

The DLG standard distribution format was designed to minimize storage requirements. Explicit topological linkages are contained only in the line elements. The DLG optional format is topologically structured and is widely used with GIS technologies. The graphic format is commonly used in the generation of maps and plots by using the Geological Survey's Cartographic Automatic Mapping (GS-CAM) software.

Small Scale -- 1:2,000,000-Scale DLG State Data (1990-1994)

The 1:2,000,000-scale DLG State data are available in five categories:

- Boundaries
    - States, counties, and Federal lands
- Hydrography
    - Streams and water bodies
- Transportation
    - Roads and Trails

      (e.g., Interstate and primary State highways)
  - Railroads

    (e.g., Main line and branch line railroads)
  - Miscellaneous transportation features

    (e.g., Airports and pipelines)

- Manmade features
  - Built-up areas, capitols, county seats, populated places, and population range
- U.S. Public Lands Survey System (collected only for the 30 public land States)
  - Land grants, township, range, and subdivisions of public lands

In addition to the DLG data, there are two associated data files in ASCII format for each State which contain airport names and populated place names with population figures. There are also two national files. One file contains land grant names and identifiers for the entire United States. The other file contains the Federal Information Processing Standard (FIPS) five-digit codes for all States, State equivalents, counties, and county equivalents. Records in these data files can be associated with cartographic features contained in the DLG files.

SDTS Data Availability

USGS Data Available in SDTS

The USGS offers a vast amount of spatial data in SDTS. This transition to standardized transfer formats, containing robust metadata, complies with Federal mandate.

A large amount of USGS **Digital Line Graph (DLG)** and **Digital Elevation Model**

(DEM) data are available for immediate download, at no charge. Normally, there is a fee associated with USGS data orders, but SDTS is being made available to foster development of software that can use the data. Visit the US GeoData web site (http://edc.usgs.gov/geodata/) to find out what data sets are available for download today.

- **DLG** data sets are available in the Topological Vector Profile.
- **DEM** data sets are available in the Raster Profile.

Create a Directory

Create directories (or folders) on your local computer to hold downloaded files. If you plan to use multiple quadrangles, it is important to organize the data in a file structure that will help you keep track of all data. Create an additional subdirectory for each quadrangle.

An SDTS transfer typically contains many files. Keeping transfers separate by putting each quadrangle in its own directory is necessary because of the way files within a DLG/SDTS or DEM/SDTS transfer are named. Storing multiple quadrangles in one directory may result in file collisions, where one file may overwrite another with the same naming convention.

GeoTiff

What is GeoTiff?

The TIFF imagery file format can be used to store and transfer digital satellite imagery, scanned aerial photos, elevation models, scanned maps or the results of many types of geographic analysis. Over the past several years many users of such images have urged geographic data suppliers to provide imagery in TIFF format. TIFF is the only full-featured format in the public domain, capable of supporting compression, tiling, and extension to include geographic metadata. GeoTIFF implements the geographic metadata formally, using compliant TIFF tags and structures.

The term "GeoTIFF" refers to TIFF files which have geographic (or cartographic) data embedded as tags within the TIFF file. The geographic data can then be used to position the image in the correct location and geometry on the screen of a geographic information display.

GeoTIFF is a metadata format, which provides geographic information to associate with the image data. But the TIFF file structure allows both the metadata and the image data to be encoded into the same file.

GeoTIFF makes use of a public tag structure which is platform interoperable between any and all GeoTIFF-savvy readers. Any GIS, CAD, Image Processing, Desktop Mapping and any other types of systems using geographic images can read any GeoTIFF files created on any system to the GeoTIFF specification.

GeoTiff Background

TIFF has emerged as one of the world's most popular raster file formats. But TIFF remains limited in cartographic applications, since no publicly available, stable structure for conveying geographic information presently exists in the public domain.

Several private solutions exist for recording cartographic information in TIFF tags. Intergraph has a mature and sophisticated geotie tag implementation, but this remains within the private TIFF tagset registered exclusively to Intergraph. Other companies (such as ESRI, and Island Graphics) have geographic solutions which are also proprietary or limited by specific application to their software's architecture.

Many GIS companies, raster data providers, and their clients have requested that the companies concerned with delivery and exploitation of raster geographic imagery develop a publicly available, platform interoperable standard for the support of geographic TIFF imagery. Such TIFF imagery would originate from satellite imaging platforms, aerial platforms, scans of aerial photography or paper maps, or as a result of geographic analysis. TIFF images which were supported by the public "geotie" tagset would be able to be read and positioned correctly in any GIS or digital mapping system which supports the "GeoTIFF" standard, as proposed in this document.

The savings to the users and providers of raster data and exploitation softwares are potentially significant. With a platform interoperable GeoTIFF file, companies could stop spending excessive development resource in support of any and all proprietary formats which are invented. Data providers may be able to produce off-the-shelf imagery products which can be delivered in the "generic" TIFF format quickly and possibly at lower cost. End-users will have the advantage of developed software that exploits the GeoTIFF tags transparently. Most importantly, the same raster TIFF image which can be read and modified in one GIS environment may be equally exploitable in another GIS environment without requiring any file duplication or import/export operation.

GeoTiff History

The initial efforts to define a TIFF "geotie" specification began under the leadership of Ed Grissom at Intergraph, and others in the early 1990's. In 1994 a formal GeoTIFF mailing-list was created and maintained by Niles Ritter at JPL, which quickly grew to over 140 subscribers from government and industry. The purpose of the list is to discuss common goals and interests in developing an industry-wide GeoTIFF standard, and culminated in a conference in March of 1995 hosted by SPOT Image, with representatives from USGS, Intergraph, ESRI, ERDAS, SoftDesk, MapInfo, NASA/JPL, and others, in which the current working proposal for GeoTIFF was outlined. The outline was condensed into a prerelease GeoTIFF specification document by Niles Ritter, and Mike Ruth of SPOT Image.

Following discussions with Dr. Roger Lott of the European Petroleum Survey Group (EPSG), the GeoTIFF projection parametrization method was extensively modified, and brought into compatibility with both the POSC Epicentre model, and the Federal Geographic Data Committee (FGDC) metadata approaches.

GeoTiff Features

GeoTIFF fully complies with the TIFF 6.0 specifications, and its extensions do not in any way go against the TIFF recommendations, nor do they limit the scope of raster data supported by TIFF.

GeoTIFF uses a small set of reserved TIFF tags to store a broad range of georeferencing information, catering to geographic as well as projected coordinate systems needs. Projections include UTM, US State Plane and National Grids, as well as the underlying projection types such as Transverse Mercator, Lambert Conformal Conic, etc. No information is stored in private structures, IFD's or other mechanisms which would hide information from naive

TIFF reading software.

GeoTIFF uses a "MetaTag" (GeoKey) approach to encode dozens of information elements into just 6 tags, taking advantage of TIFF platform-independent data format representation to avoid cross-platform interchange difficulties. These keys are designed in a manner parallel to standard TIFF tags, and closely follow the TIFF discipline in their structure and layout. New keys may be defined as needs arise, within the current framework, and without requiring the allocation of new tags from Aldus/Adobe.

GeoTIFF uses numerical codes to describe projection types, coordinate systems, datums, ellipsoids, etc. The projection, datums and ellipsoid codes are derived from the EPSG list compiled by the Petrotechnical Open Software Corporation (POSC), and mechanisms for adding further international projections, datums and ellipsoids has been established. The GeoTIFF information content is designed to be compatible with the data decomposition approach used by the National Spatial Data Infrastructure (NSDI) of the U.S. Federal Geographic Data Committee (FGDC).

While GeoTIFF provides a robust framework for specifying a broad class of existing Projected coordinate systems, it is also fully extensible, permitting internal, private or proprietary information storage. However, since this standard arose from the need to avoid multiple proprietary encoding systems, use of private implementations is to be discouraged.

Using GeoTiff Images

WinKarst uses GeoTiff images in two ways, as a background map for plotting surveys and as a color scheme in the Locator window tool. As a background map, the user almost needs to know nothing about the technical details. The user simply reads an image file from the Files or Images main menus and presses the World-Map icon on the tool bar and the image is placed in relationship to the cave survey.

For the caves to appear on the image, the survey must have control points, GPS locations, within the area of the image. Without drawing the image, a box outlining the area of the map is drawn. The cave entrances should be within this box. It is not possible to place cave surveys with "relative" coordinates within an image, only "absolute" or geographic world coordinates. The GeoTiff image itself must be projected in the UTM coordinate space.

WinKarst can optionally remove the white boarders or collars on USGS topographical GeoTiff images. The boarder area typically contains coordinate tick marks and numbers and the legend of the map. With the boarders removed, WinKarst can seamlessly tile together adjacent GeoTiff images. Do not attempt to trim the boarder with a photo-editing program such as Photoshop, the resultant image will be stripped of all geographic references.

When tiling together several GeoTiff images, they must be read in such that the latest image touches those that have already been assembled. If a newly accessed image does not touch the previous set of images, then the entire set in memory is replaced by the new image. In this way WinKarst manages its memory usage. A single 7.5 minute USGS topographical GeoTiff image requires 50MB of memory.

WinKarst can also display the GeoTiff images in the Locator window tool. Typical 7.5 minute GeoTiff images are over 5000 pixels tall and the displayed image in the Locator window will be at a reduced resolution. The window can be scaled to a different size, but it is not possible to zoom in to a region on the map. When SDTS or DEM data is available that matches the same 7.5 minute region, it is possible to produce a shaded relief map using the skin of the GeoTiff image. This works for topographical or aerial photographs.

WinKarst can also export GeoTiff images. Using the export feature, users can create custom GeoTiff images of a smaller region of a full size 7.5 minute map or collect a new image that boarders two or more GeoTiff images. It is also possible to create a new 7.5 minute map from an GeoTiff image not created in the UTM coordinate space or a non-GeoTiff image. This method requires the raw image to be registered in the Map page of the survey editor and then set the scale in the main window to view the entire registered map. Then export the main window view as a GeoTiff and the new file will contain the coordinates setup in the survey editor.

Contents - Data File Formats

SUR Data File Format

The SUR file format is the native and complete representation of the cave survey for WinKarst. It is ascii and can be edited by any simple text editor.

General

The raw data file format is a "tag" orientated ASCII or text file. The tags or directives are identified by a "#" symbol in the first character of a line. The idea behind a tag orientated file is that future enhancements can be added without totally rewriting the existing data files. Tags or directives can occur anywhere in the file and absolute line ordering is not important. There maybe one or two key words associated with a directive, along with a number of words or numbers to complete the line. There may or may not be spaces between the # and the first key word and the last key word may or may not end with a colon. The key words maybe lower or upper case.

A considerable amount of effort has been put into creating the raw data file format so that any text editor can add or delete information from the file. Through out the data file, the number of spaces between words and numbers is not important. What is important is the first character of a line. If that first character is a #, then the line will be interpreted as a directive. Lines with a # and key words not listed as directives below are ignored. Lines in which the first character is not a # or carriage return will be interpreted as survey shot information (excluding a special case for comments described below).

Once a directive is encountered, it remains in effect until a directive of the same type is encountered again. In this manner a directive may apply to more than one cave or survey. For example, if all the surveys occurred during the same year, then the magnetic declination directive need only be placed once at the beginning of the file. If certain directives are missing from the file, then WinKarst assumes default conditions exist for all caves and surveys. The exception to this rule is the comment directive, which only applies to the current survey.

Numbers may or may not include a decimal point and leading or trailing zeros. Data items may be separated by either spaces or tab characters.

Cave Name

Specifies the name of the cave.

Cave Location

A textural description of the location of the cave.

Control Stations

The fixed location description of a station within the cave survey.

Datum

Specify Datum coordinates are referenced with.

East/West Quad Origin

The east/west location of the first station of a cave survey.

North/South Quad Origin

The north/south location of the first station of a cave survey.

Elevation

The elevation of the first station of a cave survey.

Sketch Map

Locate a station in a sketch map.

SDTS Catalog

Read a set of SDTS files.

Survey Name

Specifies the name of a survey and delineates sections of shot data.

Survey Date

Specifies the date a survey was recorded.

Survey Group

Specifies the group of a survey.

Survey Team

Specifies people's names that are to be associated with a survey's data.

Survey Declination

Specifies the survey's magnetic declination.

Survey Comments

Specifies comments to be associated with an entire survey.

Survey Column Ordering

Specifies how the columns of shot data should be interpreted for an individual survey.

Survey Units

Specifies the units for the shot data for an individual survey.

Shot Comments

Describes how comments are attached to individual shots.

Include Files

Describes now external files may be included in the base survey file.

Aliases

Creates a text substitution for station names.

Station Properties

Assign a property to a particular station.

Metric and English

Allows the user to view the cave survey in either metric or English units. Does not effect the individual units of the surveys.

File Creation Date

Specifies when the file was last written.

File Creator

Specifies who wrote the file or who is responsible for the cave survey.

End of File

Last line of a cave survey file.

Typical Survey Shot

Examples of survey shots with optional key characters

Cave Name

Syntax: #CAVE NAME: <cave name>

Example: #CAVE NAME: OREGON CAVES

The cave name may consist of one or more words. Only 24 characters of the first word are recorded in the reduced data file. The directive #CAVE NAME may appear more than once in a raw data file. If the cave name is different on subsequent occurrences of the directive, then the following surveys will be associated with the new cave name. The directive is optional for surveys contained in a single cave.

Cave Location

Syntax: #CAVE PLACE: <cave location>

Example #CAVE PLACE: JOESPHINE COUNTY, OREGON

The cave location may consist of one or more words. Currently, WinKarst does not use the cave location words for any function and inclusion of this directive is optional. Ideally, for every occurrence of the #CAVE NAME directive a #CAVE PLACE directive should follow.

Datum

Syntax: #DATUM <datum name>

Examples: #DATUM WGS 84
#DATUM NAD27 CONUS

The #DATUM directive allows for the specification of a Geodetic Datum that global coordinates are referenced with. A datum is necessary to place a cave in an existing topographic map. The inclusion of this directive is optional. If no permanent stations are represented with a longitude/latitude pair, then this directive will have no effect. The <datum name> must be one of the following Garmin specific names:

Adindan	ARC 1950	ARC 1960	Astrln Geod '66
Astrln Geod '84	Camp Area Astro	Cape	European 1950
European 1979	Geod Datm '49	Hong Kong '63	Hu-Tzu-Shan
Indian Bngldsh	NAD27 CONUS	NAD83	Oman
Ord Srvy GB	Pulkovo '42	Prov S Am '56	Sth Amrcn '69
Tokyo	WGS 72	WGS 84	

Each cave can specify its own datum, different from others within the survey. In this way, including surveys in a larger composite survey need not worry if all the individual surveys use the same datum. The drawn line plot will use the first #DATUM encountered and all subsequent coordinates will be converted to this datum.

WinKarst uses the NAD27 CONUS datum if no #DATUM statement is encountered.

Control Stations

Syntax: #CONTROL POINT: <station x y z> [name]

Examples: #CONTROL POINT: EV9 940.00 400.00 4000.00 Backyard Entrance
#CONTROL POINT: A1 124.33 W 45.15 N 3000.00

The #CONTROL POINT directive allows for the permanent fixing of a station's location in three dimensional space. Using this directive it is possible to specify an x, y, z location other than 0,0,0 for the first station of the cave. Ideally, for every occurrence of the #CAVE NAME directive a #CONTROL POINT directive should follow. This allows for the placement of more than one cave in a single coordinate system. The inclusion of this directive is optional. It is not necessary to specify the first station of the raw data file to be located at 0,0,0. Optionally, if the letters 'E', 'W', 'N' or 'S' follow either of the first two numeric values, then the values are interpreted as a Longitude/Latitude pair. A space must appear between the number and the letters. Optionally, if the letters 'M' or 'FAT' the last numeric value, then the value is interpreted as either in metric or English units. The remainder of the line, if present, is a text field that can be associated with the station at the control point.

Subsequent #CONTROL POINT directives to the same station will be ignored.

A #CONTROL POINT directive which references an non-existant station is ignored

While not recommended, a #CONTROL POINT station that is aliased is accepted.

North/South Quad Origin

Syntax: #Y ORIGIN: <y> [N/S]

Example: #Y ORIGIN: 45.45 N

The #Y ORIGIN directive specifies the north/south placement of a cave's entrance in a grid space of 1500 x 1000 foot rectangles. Ideally, for every occurrence of the #CAVE NAME directive a #Y ORIGIN directive should follow. Like the #CONTROL POINT directive, this allows for the placement of more than one cave in three dimensions. this directive refers to the first station listed in the data file. Optionally, if the letters 'N' or 'S' follow the numeric value, the value is interpreted as a Latitude. This directive is optional.

East/West Quad Origin

Syntax: #X ORIGIN: <x> [E/W]

Example: #X ORIGIN: 123.65

The #X ORIGIN directive specifies the east/west placement of a cave's entrance in a grid space of 1500 x 1000 foot rectangles. Ideally, for every occurrence of the #CAVE NAME directive a #X ORIGIN directive should follow. Like the #CONTROL POINT directive, this allows for the placement of more than one cave in three dimensions. This directive refers to the first station listed in the data file. Optionally, if the letters 'E' or 'W' follow the numeric value, the value is interpreted as a Longitude. This directive is optional.

Elevation

Syntax: #Z ORIGIN: <z>

Example: #Z ORIGIN: 9000

The #Z ORIGIN directive specifies the depth of a cave's entrance. Ideally, for every occurrence of the #CAVE NAME directive a #Z ORIGIN directive should follow. Like the #CONTROL POINT directive, this allows for the placement of more than one cave in three dimensions. This directive refers to the first station listed in the data file. This directive is optional.

Aliases

Syntax: #ALIAS: <Station name> <Equated name>

Example: #ALIAS: A45 B19

Often new surveys are added to existing data in which the surveyors had no knowledge of the tie-in or connecting station's name. In this case it is desirable to say the new name is equivalent to the tie-in station's name. In this way the survey can retain the name recorded by the the existing data and the new data. On the drawn map and in station selection, only the <Station name> is used. All occurrences in survey shots of the <Equated name> will be substituted with the Station name. Duplicate Aliases and Equated names that don't exist are ignored. The Equated name will be retained in the Raw data file and removed from Reduced data files.

Include Files

Syntax: #INCLUDE: <filename>

Example: #INCLUDE: C:\SURVEYS\BIG CAVE.SUR

A raw survey may just list a series of includes files which in themselves describe separate caves or surveys. The filename must be an absolute path to the file or the file must exist in the current directory or in the directory the original raw survey exists in.

Nesting of include files up to ten levels is supported.

The filename many include 'space' or blank characters in the Windows '95 environment.

The filename can be absolute or relative to the working directory of the main cave data file

Metric and English

Syntax: #METRIC

Example: #METRIC

The #METRIC directive causes WinKarst to generate all plots and reports with metric units. In addition, this directive changes the default assumptions for the linear units, defined in the #FROM TO directive, from decimal feet to meters. For completeness, the directive #ENGLISH is also defined and sets up a decimal feet units environment. WinKarst's default is English units

SDTS Catalog

Syntax: #SDTS CATALOG: <filename>

Example: #SDTS CATALOG: 1409CATD.DDF

The filename specifies the catalog file of a set of SDTS files. Typically, there are 20 or more files in a set. The program reads the catalog to determine the names of the other files in the set. The filename can be absolute or relative to the working directory of the main cave data file

Sketch Map

Syntax: #SKETCH MAP: <station> <x> <y> <filename> <sheet name>

Example: #SKETCH MAP: A1 140 601 Big_Cave_Page1.PNG The Big Room

The point (x, y) represents the pixel location of the station in the PNG image. Only the PNG image format is allowed. For a image to be correctly placed and orientated in the cave plot, there must be at least two #SKETCH MAP entries for each image file. The filename can be absolute or relative to the working directory of the main cave data file. The sheet name is optional.

Survey Column Ordering

Syntax: #SHOT STATION STATION <3 shot parameters> <4 wall dimensions> Comment

Example: #SHOT STATION STATION LENGTH AZIMUTH VERTICAL LEFT RIGHT UP DOWN AZM2 DIP2 Comment

#SHOT STATION STATION LENGTH AZIMUTH DELTA LEFT RIGHT UP DOWN Comment

Any directive with two occurrences of STATION is used to specify the ordering of the columns in the shot sequences. The valid key words for "shot parameters" are LENGTH, AZIMUTH and VERTICAL. The valid key words for "wall dimensions" are LEFT, RIGHT, UP and DOWN. All of the key words can appear in any position. This directive is optional and the default ordering is shown in the example above. The directive must appear in conjunction with the #SURVEY UNITS directive and the column pairings between the two directives must be consistent.

If Backsights are included, add the key words AZM2 and DIP2 to the set of shot parameters.

If vertical control is determined by a depth gauge or topographic information, include the key word DELTA instead of VERTICAL. Not that DELTA represents the vertical distance between the two stations of the shot, the the elevation of either of the stations.

The column under SHOT holds a shot descriptor or attribute. Currently, the valid descriptors are N, B, R, V and X. The X means the shot's length should be excluded from the caves total length calculation. V means the entire shot should be void for all calculations and station searches. B is for back sight, while R refers to a back sight that should be exclude from cave length calculations. N specifies a normal shot.

The two columns with STATION are for the FROM and TO stations of the shot. In the #SURVEY UNITS directive, the key words FROM and TO resolve which column is for the FROM and TO stations. Back sights are indicated either by using the shot descriptor character or by reversing the from and to stations relative to the fore sight between the stations or including the AZM2 and DIP2 fields.

If a second #STATION directive is encountered before another #SURVEY NAME, then the second #STATION ordering is assumed for the survey. Shots interpreted earlier for the survey are rearranged to the new order.

Typical Survey Shot

Syntax: <shot type character><three primary measurements><four passage measurements>[comment]

Example:	V	A1	A2	3.0	145.0	50.0	-	-	-	-

This is an example of a voided shot. The shot type character is a "V".

Example:	B	A1	A2	3.0	145.0	50.0	-	-	-	-

This is an example of a backsight shot. The shot type character is a "B" and indicates the azimuth and inclination angles are relative to the second or "TO" station.

Example:	X	A1	A2	3.0	145.0	50.0	-	-	-	-

This is an example of a length excluded shot. The shot type character is a "X" and the length of this shot will not be added into the total length of the cave.

Example:	R	A1	A2	3.0	145.0	50.0	3	4	4	5

This is an example of a backsight shot that is also length excluded. The shot type character is a "R". The passage measurements are located at the "TO" station and point in the direction that bisects the shot's angles to and from this station. If the station is at a dead end, then the direction is perpendicular to the shot's angles.

Example:	N	A1	A2	3.0	145.0	50.0	3	4	P	5

This is an example of a typical shot. The shot type character is a "N". The "P" character in the passage measurement group indicates a passage is the left, right, up or down direction from the "TO" station.

Exceptions

Shots with the same 'TO' and 'FROM' station will be processed as a void or non-data shot.

Shots with a length of zero will be converted to an Station Alias, the 'TO' aliased to the 'FROM' name.

Survey Units

Syntax: #FROM TO <3 shot unit types> <1 wall dimension unit type>

Example: #CODE FROM TO FT DEG DEG FT FT FT FT

The first field in the example is the Shot Code type. The next two fields of this directive, "FROM" and "TO" specify with columns are the FROM and TO station columns. There is no limit on the length of Station names and can include numerals and the shifted numeral characters, e.g.!, @, # etc. This directive is optional and the default condition is shown in the example above. The directive must appear in conjunction with the #SURVEY ORDERING directive and the column pairings between the two directives must be consistent.

The following four fields of this directive are interpreted according to the column ordering. For example, if the next column after the "TO" station column is the shot's length, then the column unit field would be interpreted as a linear type unit descriptor. The valid descriptors for length are "FT" and "M". The valid descriptors for azimuth are "DEG" and "GRAD". The valid descriptors for dip angle are "DEG" and "PERCENT". The valid descriptors for wall dimensions are "FT" and "M".

If a second #FROM TO directive is encountered before another #SURVEY NAME, then the second #FROM TO units are assumed for the survey. Shots interpreted earlier for the survey are converted to the new order.

Survey Comments

Syntax: #COMMENT: <text>

Example: #COMMENT: Resurvey of confusing loop

The directive #COMMENT is one of two ways to associate a comment with the survey. Use the #COMMENT directive to create a single line comment. If a second #COMMENT directive is encountered before another #SURVEY NAME directive, then the first comment is ignored.

Use the characters "{" and "}" to describe a comment consisting of more than one line. The left bracket should appear as the first character of the first line of the comment and the right bracket the last character of the last line. It is possible to have one single line comment declared by #COMMENT and one multi-line comment delineated by brackets per survey. Note is also possible to associate a comment with each shot of a survey.

Survey Name

Syntax: #SURVEY NAME: <survey name> [FIXED|VOID]

Example: #SURVEY NAME: A

The #SURVEY NAME directive specifies text that will be associated with a connected series of survey shots. There is no limit to the number of characters in a survey name, but only six characters saved in the reduced data file. The characters can include numerals and the shifted numeral characters, e.g.!, @, # etc. It is not required for the station names in a survey to be related to the survey name and the survey name is not used for any data processing. However, the name serves has a handle to access data associated with the survey's shots. Therefore, unique survey names are desirable. If in processing a raw data file WinKarst determines that a series of shots are disjoint, then a second survey is spawned from the first and will have the same name. If #SURVEY NAME does not appear in the raw data file, then the survey shots will be associated with the name "NONAME."

One of two keywords may follow the survey name, FIXED or VOID. The keyword VOID indicates that every shot in the survey will be ignored are present only for documentation purposes. A FIXED survey has two special characteristics. The first characteristic is the survey should not be adjusted during loop closure. The other function is to exclude the stations of the survey from various calculations, e.g. depth, and prevent the survey from being draw in certain plotting modes. A surface survey is generally set to FIXED.

Placing two #SURVEY NAME directives without any survey shot data between them will generate an error.

Survey Date

Syntax: #SURVEY DATE: <month day year>

Example: #SURVEY DATE: 12 25 1909

The survey data is a sequence of three numbers representing month, day and year the survey's data was recorded on. The use of this directive is optional, but is recommended should it ever be required to recover the magnetic declination for the compass bearings.

Survey Group

Syntax: #SURVEY GROUP: <survey group>

Example: #SURVEY GROUP: Lower Level

The #SURVEY GROUP directive specifies text that will identify a survey as a member of a group. There is no limit to the number of characters in a group name. The characters can include numerals and the shifted numeral characters, e.g.!, @, # etc. A survey can only be a member of one group. The group name is not used in processing the survey data, but only for data management in the map view.

Survey Team

Syntax: #SURVEY TEAM: <person, person....>

Example: #SURVEY TEAM: LARRY, CURLY, MO

The optional directive #SURVEY TEAM is used to record who participated in the recording of the survey's measurements. No provision has been made to specify particular survey duties, but since WinKarst treats the line as simple text the person's duties could be include on the same line.

Survey Declination

Syntax: #DECLINATION: <declination in degrees | AUTO>

Example: #DECLINATION: 10.1

This directive specifies the magnetic declination associate with compass bearings. Since most of the United States is west of magnetic north, this number is added to the compass shots to obtain true north referenced surveys. The directive is optional. The units are assume to be 360 degrees per circle with 0 at true north.

Optionally, the key word AUTO may be substituted for the magnetic declination's value. When AUTO is used, WinKarst will automatically determine the declination based upon the survey's date and the location of the cave. The cave must have an absolute latitude and longitude control point locating the cave for this function. If no control point exists, then the declination will default to the last #DECLINATION value used or 0.0. If a survey has no date, the last #SURVEY DATE value is used or the current date.

Shot Comments

The #FROM TO directive determines how many columns are in a shot entry. There may be as few as ten and as many as 18 columns describing a shot. After the last column of the wall dimensioning fields (i.e. LRUD), anything remaining on the line is interpreted as a comment for that shot.

Station Properties

Syntax: #PROPERTY: <Property type> <Station name> [optional text]

Example: #PROPERTY: LEAD A9 Twenty feet to the east

Any property can be assigned to any station. To assign more than one property to a station, repeat this directive as often as required. All of the stations of a particular property type must have the same exact spelling of the property type. There is no limit to the number of property types that can be used in a cave survey, nor on the number of properties a station can have.

File Creator

Syntax: #FILE AUTHOR: <name>

Example: #FILE AUTHOR: Harvey Mudd

This directive is used by WinKarst to allow the user to personalize the raw data file.

File Creation Date

Syntax: #FILE DATE: <month day year>

Example: #FILE DATE: 12 25 1994

This directive is written by WinKarst automatically and uses Window's date function to determine the current date. The user may optional update the date should the file ever be edited externally from WinKarst. The date is ignored when reading the survey file.

End of File

Syntax: #END

This directive may optionally appear as the last line in a raw data file. Information occurring after the #END will not be read and will be lost on subsequent writing of the raw data file.

KST

The KST file format is a native format for WinKarst. It is a reduced binary representation of the cave survey.

General

The KST data file type is a binary reduced representation of the cave survey. For compactness, some information is absent or truncated from the original raw representation of the cave survey. The format has three sections, header records, survey record and station records. Each record is 32 bytes long.

Header

The header section in ten records long and contains information about the cave, when the cave was processed and by who. The header also contains a format revision number and copyright information for the user.

Survey

The survey record is a single record that contain some information about the survey and the number of following station records.

Station

The station record contains the station's name, location, passage dimension information and how the station in connect to proceeding stations.

Header

The Header consists of 10 32 byte records. The following code snippet show how the records are arranged and decoded:

struct reducedata

```
	{
	unsigned short	COMMAND;	//   2 bytes draw/move
	char	TEXT[14];	// 14 bytes station name
	float	X,Y,Z;	// 12 bytes
	unsigned char	L,U,D,R;	//   4 bytes
	};	// 32 total bytes
```

```
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//get header
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//x max station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//x min station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//y max station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//y min station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//z max station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//z min station name
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//dip vector
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//author
fread(SURVEYDATA,sizeof(reducedata),1,FP);	//cavename
```

Not every field in each of the 10 leading records are valid and in some case, e.g. author, the entire record must be recast to char*.

There is a 32 byte record of all zero's between caves.

Station

The following structure definition describes a Station Record

```
struct reducedata
	{
	unsigned short	COMMAND;	//   2 bytes draw/move
	char	STATION[14];	// 14 bytes station name
	float	X,Y,Z;	// 12 bytes
	unsigned char	L,U,D,R;	//   4 bytes
	};	// 32 total bytes
```

COMMAND is zero if the "FROM" station of the shot is the previous record. If it is non-zero, a MOVE describes how many records previously to search to find the FROM station. The MOVE will always be within the data range of the Survey. The following code snippet shows how to calculate the MOVE. Note the very first station record of a survey contains the year the survey was recorded.

```
reducedata* R;	// R points to a Station record
unsigned char I = *R;
```

```
mydata* MOVE = CURRENT;              // CURRENT points to location in
an array of mydata
if (NOT_FIRST)
        MOVE = MOVE - *R;            // pointer arithmetic
else
        DATE = TDate(1,1,I + 1900);
```

If (*R == 0xFFFF) then there is a break in the shot sequence. The STATION and its location become the "FROM" station of the shot, which is completed by reading the next record.

The STATION name is not a proper string and does not have a terminating null character. If the station name is less than 14 characters, then the remaining characters are spaces, #32.

The X,Y and Z coordinates are floating point

The passage dimensions are simple bytes. Values of 255 indicate infinite or "P" dimensions.

Survey Record

```
struct
        {
        unsigned short    COUNT;
        char              NAME[12];
        unsigned char     FIXED;
        unsigned char     SPARE;
        float             XOFF,YOFF,ZOFF;
        short             RADIUS,LENGTH
        };
```

COUNT is the number of shots in the survey. Shot is a survey can form discontinuous tree structures.

NAME is the truncated, if necessary, six character name of the survey. If the name is less than fourteen characters, then the remaining characters are spaces, #32.

FIXED is non-zero if the survey is not be adjusted in loop closure.

X,Y and ZOFF are the location of the center of the survey. They are the simple average of each of the coordinate directions for all of the stations in the survey. The number are floating point, where n represents X,Y and Z..

RADIUS is the radius of a sphere when located at the survey's center which contains all of the stations in three dimensional space.

LENGTH is the length of the survey.

MAK

The MAK file format is the native format for "COMPASS." COMPASS is a cave surveying program for PC compatible computers.

General

The MAK data file format is a raw representation of a cave survey used by the cave surveying program, "COMPASS." The MAK file brings together DAT files and specifies geographic coordinates. Contact that programs author for exact details of that format. WinKarst can read and write MAK files to facilitate exchanging cave surveys between the two programs.

An important difference exists on how WinKarst and COMPASS handles station naming between the component files of the MAK or SUR files. COMPASS requires a connection exist between all of the individual DAT files of the MAK, as a minimum pair wise. WinKarst does not require connections between included files and locates distinct caves with geographic coordinates.

DAT

The DAT file format is the native format for "COMPASS." COMPASS is a cave surveying program for PC compatible computers.

General

The DAT data file format is a raw representation of a cave survey used by the cave surveying program, "COMPASS." Contact that programs author for exact details of that format. WinKarst can read and write DAT files to facilitate exchanging cave surveys between the two programs.

PLT

The PLT file format is the native format for "COMPASS." COMPASS is a DOS based cave surveying program for PC compatible computers.

General

The PLT data file format is a reduced representation of a cave survey used by the cave surveying program, "COMPASS." Contact that programs author for exact details of that format. WinKarst can read and write PLT files to facilitate exchanging cave surveys between the two programs.

SEF

The SEF file format is the native format for "SMAPS." SMAPS is a DOS based cave surveying program for PC compatible computers.

General

The SEF data file format is a raw representation of a cave survey used by the cave surveying program, "SMAPS." Contact that programs author for exact details of that format. WinKarst can read and write SEF files to facilitate exchanging cave surveys between the two programs.

TXT

The TXT file format is a generic file format for "WAYPOINT+." WAYPOINT+ is a shareware program for Windows computers and allows the user to transfer data between their computer and GPS unit.

General

The TXT data file format is a comma delimited format used by the program, "WAYPOINT+." Contact that program's author for exact details of that format. WinKarst can read and write TXT files to facilitate exchanging cave surveys between a computer and a GPS unit. The TXT data file can also be imported into the program TOPO!USA. The file format does not support elevation or vertical control.

About WinKarst

WinKarst is a shareware program and is copyrighted. Distribute freely and test drive. WinKarst has a user-name coded registration number which must be recorded by the program for the message, "Please register your software" to disappear from all displays and plots. After 30 days, the program will not run if the registration number is not obtained. If you like the software, send $25 to the author and you will receive a unique registration number, software patches for bugs and updates automatically via surface mail or email.

Garry Petrie is the author of WinKarst.
He can be reached at:

19880 NW Nestucca Drive
Portland, Oregon 97229

503-712-3345 day
503-690-5465 evenings

support@resurgentsoftware.com