6 Time-Dependent Data

Most datasets read into SciAn can be time-dependent. Because time dependence is so common in scientific data, time is handled specially rather than as just another dimension, and a variety of tools allow time-dependent data to be visualized. This chapter describes how to create and visualize time-dependent data.

Time-dependent datasets

Time-dependency is done using special time-dependent datasets. Most datasets within SciAn, including fields and geometry, can be time-dependent. A time-dependent dataset looks and for the most part acts just the same as any other dataset. It is represented by a single icon which can be selected, dragged, and double-clicked. The easiest way to tell the difference is to open up the dataset's control panel, which will show whether it is time-dependent or not.

Each time-dependent dataset is made up of two or more timesteps. For geometry datasets, the timesteps can be completely independent pictures. For numeric field datasets, the timesteps are different values of the field.

Because datasets with nonstructured and curvilinear grids use additional internal datasets to give the position of grid vertices, the grid of a dataset can be time-dependent as well. The basic grid topology, that is the number of dimensions and the size along each dimension, may not change from timestep to timestep.

Timesteps do not have to be uniformly spaced through time. Typically, the data for one particular time is used with a visualization object (see "Time and clocks" below). For geometry datasets, the closest timestep is always used. For numeric fields, a check box in the control panel determines whether the closest timestep is used or automatic linear interpolation is done.

Time-dependent files

Before a time-dependent dataset can be used, it must be read in from a file. Some file formats, such as NFF and STF, specify time within the file. (See the reference manual or the technical notes for details on each file reader.)

For most other file formats, there is a naming convention which allows time-dependence even on file formats that do not naturally understand time, such as HDF. To use this naming convention, specify each timestep as a separate dataset. Give the individual timesteps a compound name of the form *name*@*time*. *Name* is the name you want the dataset to have and *time* is the time at which the timestep is sampled.

For example, let's say you had a field named `Q` split up into four timesteps at 1, 2, 4, and 8 seconds. To create a time-dependent dataset, name the individual timesteps `Q@1`, `Q@2`, `Q@4`, and `Q@8`.

You can also time your samples with wall clock time. If you have a sample at 1:37 and another at 2:42, you can call them `Q@1:37` and `Q@2:32`.

Note *SciAn always stores times as the number of seconds as a floating-point number. When clock time is specified, it is stored as the number of seconds since midnight.*

Some file readers which specify the name of the dataset within the file, such as the NCSA HDF file reader which uses the first argument given to the `DFSDsetdatastrs` call for the name. This is the name which should be used for time dependency. However, other file readers create the dataset name from the file name after stripping off the file name extension. For these, the file name must be in the compound form above. For example, files named `Z@1.typ` and `Z@2.typ` represent two separate timesteps at 1 and 2 seconds. See the reference manual to find out where each file reader gets its dataset names.

Hint *Even if the name with the time code is specified inside the file, it is still a good idea to have the file name reflect the time. This makes it easier to keep track of the files.*

The naming convention can be turned off if you have a dataset which really does require an `@` character in its name. Choose Show File Readers from the File menu to bring up icons for all the file readers. Select the one you want and press Show Controls. A control panel for the file reader will appear with a check box to turn off this feature.

Timesteps will be assembled into time-dependent datasets when they are read in. SciAn recognizes that two timesteps belong to each other by looking at the name without the time extension. It does not generally matter how you distribute timesteps within files, as long as you read in all the ones you need. You can have each time step in a different file, all timesteps in one file, or a fixed number of timesteps per file, depending on what you find convenient.

Time and clocks

SciAn understands three kinds of time: real time, video time, and space time. Real time is the time that someone using the program interactively experiences. Video time is the time within a video when a video is being recorded. Playing back the video when it is all done gives a smoother version of real time. Space time is the current time within the space, the time when all the datasets visualized within the space are sampled.

Each space has a clock, which controls the space time within the space as well as how space time changes with respect to real time or video time for animation. Like clocks in the real world, SciAn clocks tell the time. They can be stopped or running; they can run fast or slow; they can be set by hand forward or backward. Like clocks of fantasy, they affect the passage of time as well as report it.

The clock appears in the visualization corral as an icon. Select a clock and choose Show Controls from the Object menu to show the controls. You will see a control panel like Figure 6-1.

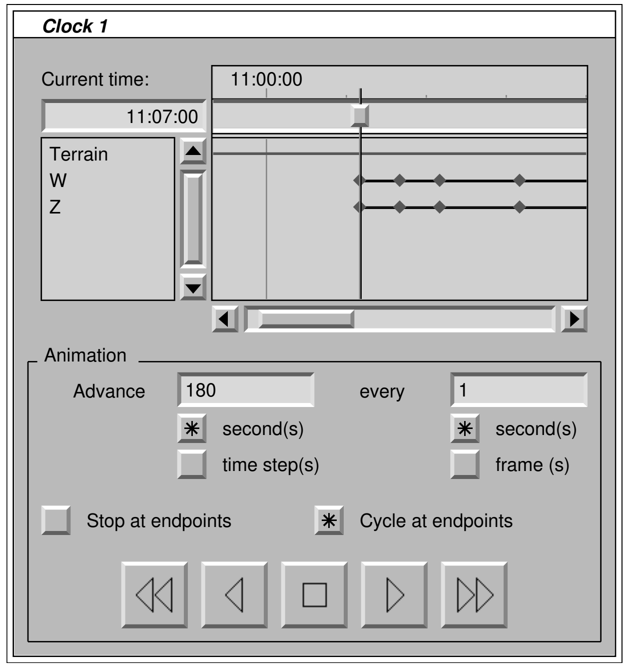

Figure 6-1. *Clock control panel*

At the top is a time control with several parts. The slider at the top controls the current time. The current time is also shown in text format in the text box at the top left. You can change the current time being displayed either by dragging the slider or by entering a number into the text box and pressing the Enter key.

Below the text box and current time slider is a list of datasets on the left and their time lines on the right. The cursor of the time slider runs over the time lines showing which time steps are displayed for each dataset. Eternal datasets, which are valid for all times, appear as horizontal blue lines. The time steps of time-variant datasets appear as blue diamonds. If a dataset is set to be interpolated through time (see Chapter 8), the diamonds are connected with solid black lines. These datasets are automatically interpolated to the current time. If a dataset is not interpolated, the diamonds are connected with dashed black lines. The clock will choose the closest available timestep to display. Vertical black marks on the time lines show the dividing points between the timesteps.

Once you have clicked on a time control, the left and right arrow keys will move the current time back and forth by one timestep.

Animating time

Below the time control is a group of controls which specify animation through time. There are a few basic concepts about animation that must be understood first. The clock object controls the time in the space, or space time. In order to do animation through time, set the clock to advance space time at a certain rate relative to real time or video time. Video time is used when you are in the process of recording a video animation; otherwise, real time is used.

The animation is specified using the controls within the Animation box. The text boxes and radio buttons at the top specify the mapping of space time onto real or video time. To understand how they work, it is best to read them from left to right as a single sentence. For example, the controls in Figure 6-1 can be read as "Advance 0.25 seconds every 1 second." What this means is that the clock will advance 0.25 seconds in space time for every 1 second that passes in real time or video time. This will effectively result in a display at one-quarter actual time.

The advancement in space time can be expressed in seconds or time steps, depending on which radio button is on. If the second(s) button is on, the rate remains constant through time. If the time step(s) button is on, one time step will be displayed for every unit of real time or video time, regardless of how the time steps are spaced through time.

Hint *Remember that you can always specify automatic interpolation between time steps in the control panel of the dataset.*

The advancement in real time can be expressed in seconds or frames, depending on which radio button is on. If the second(s) button is on, the advancement in space time will occur in the specified number of seconds. If the frame(s) button is on, the advancement in space time will occur for every frame that is drawn.

When recording a video, the playback frame rate is fixed at 30 frames per second for NTSC video. Frame rates other than 30 fps can be set in the Video Recorder Driver control panel; see Chapter 9, "Animation," for more information. When viewing the data interactively, the frame rate varies depending on how long it takes to draw a given visualization. If you want to see the data advance at the same rate as a video, though not as smooth, specify a real time rate in seconds. If you want to see every time step and don't care how long each time step takes to draw, specify a real time rate in frames.

At the bottom of the control panel is a group of radio buttons which look like the buttons of a tape recorder, each identified with a shape. The stop button (square) stops the animation. The play button (triangle pointing to the right) starts time advancing forward at the specified rate. The reverse button (triangle pointing to the left) starts time advancing backward at the specified rate. The fast forward and fast reverse buttons (two triangles) advance forward or reverse at three times the specified rate.

For more information on making movies, see Chapter 9.

Sharing clocks

A space can only be controlled by one clock at a time, but a clock can control more than one space. To have a clock control another space, drag its icon into the visualization corral of that space. As with all other controllers, you can make a shared clock local to a space by selecting it and choosing Make Local Copy from the Object menu.

7 Dressing Up Visualizations

Once a complete 3-D visualization has been produced, it is sometimes useful to dress up the visualization with additional information, such as titles, annotations, and legends. This chapter describes a variety of 2-D tools for dressing up visualizations within SciAn.

Space panels

Every 3-D space in SciAn has two 2-D panels associated with it, a front panel in front of the space, and a back panel behind it. These panels are used to store 2-D drawing objects such as annotations and clock displays.

The panels are strictly 2-D and do not use the Z-buffer of the graphics workstation. When the space needs to be redrawn, the back panel is drawn, then the 3-D space using the Z-buffer, then the front panel. Objects in panels are drawn in their stacking order. Normally, more recently created objects appear on top, but the stacking order can be changed using menu items described later.

Panel controls

Both front and back panels have control windows, which can be shown using Show Front Panel Controls and Show Back Panel Controls from the Window menu. The front panel controls are shown in Figure 7-1.

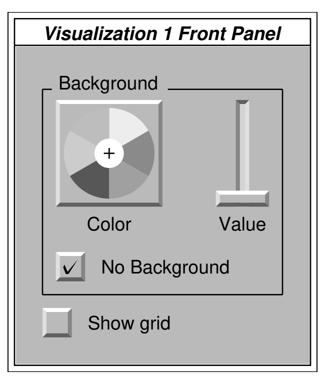

Figure 7-1. *Space Front Panel controls*

The color wheel and brightness slider control the color of the background. The back panel always has a background, which by default gives the black background of the space. Black seems to work well for most visualizations, but you may want to set it to some other neutral color in particular cases. The front panel normally does not have a background so that the space is visible behind it. If you want to obscure the space, such as to have titles only, you can give it a background with the check box.

Hint *When the front panel has a background, SciAn does not need to redraw the space, which can save a lot of time. This is handy when you want to set up a few titles but don't want to wait for redraws every time you make a change. Just temporarily set the front panel to have a background and the drawing will speed up.*

Drawings

The front and back space panels are mainly there to hold 2-D drawings, which you draw by hand. Drawings are represented by drawing objects, which you can select and manipulate after you have drawn them.

With the exception of color palette displays, most drawing objects are created using the space tools at the left of each space, as shown in Figure 7-2. Which control is chosen determines the action of the mouse in the space or space panel. Choose a space tool by pressing its icon button with the left mouse button.

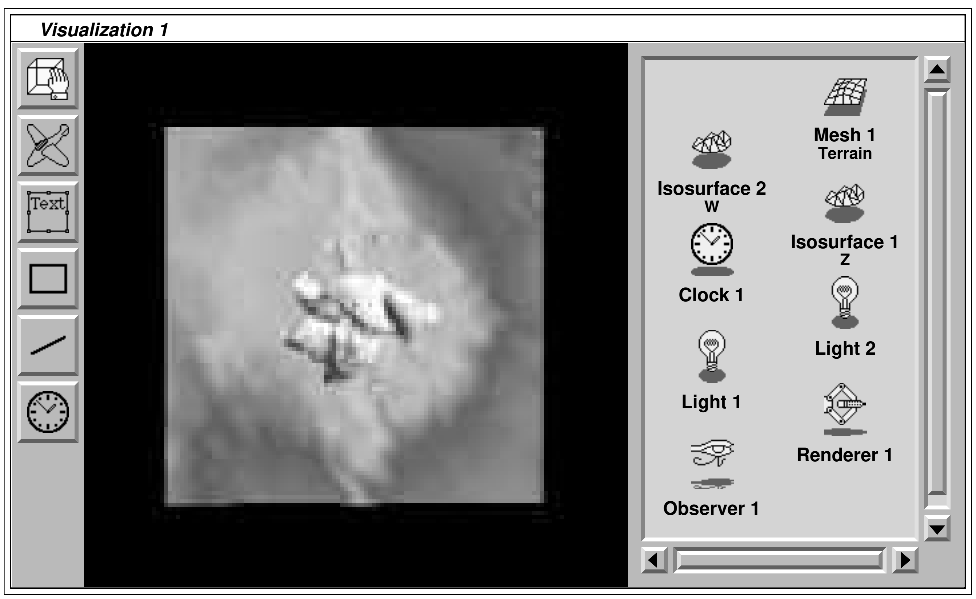

***Figure 7-2**. Space tools*

The tools below the flight simulator tool are all for making drawings on space panels. They are all operated the same way. First press the tool for the kind of drawing you want to make. Then move the cursor to the place inside the space where you want one corner or endpoint to start. Press down the left mouse button and drag the mouse to the opposite corner or endpoint. As you drag, a red outline of the drawing will appear. Release the mouse button to create the object.

If you hold down the Shift key while dragging, the movement will be constrained to a regular grid on the screen. This grid is handy for lining up drawings. You can see the grid by turning on a check box in the panel's control window.

Normally, newly created drawings appear on the top of the front panel. To find out how to change the depth of a drawing object or send it to the back panel, see "Moving and reshaping" and "Changing depth" below.

Text annotations

The tool just below the flight simulator tool is the text annotation tool. It looks like a box with the word Text inside. When this tool is chosen, you can press in the panel and drag out a rectangular box to hold text. Once the text box is drawn, you can start typing. You can edit the text using the mouse and keyboard as described in Chapter 1.

The Tab key can be used to move the left margin over for a line or group of lines. Every time you press the Tab key, the left margin moves to the right a few spaces. Text typed after the tab starts at that point. If text is typed past the right of the text box, it is automatically wrapped around to this new margin. The Tab key does not work exactly like the Tab key on a typewriter, which moves to the next tab stop relative to the current position. In SciAn the Tab key moves to the next stop relative to the left margin or the previous tab stop.

You can change the font, font size, and alignment using the Text menu. Select the text box and choose Show Controls from the Object menu to edit other attributes of the annotation. A sample control panel is shown in Figure 7-3.

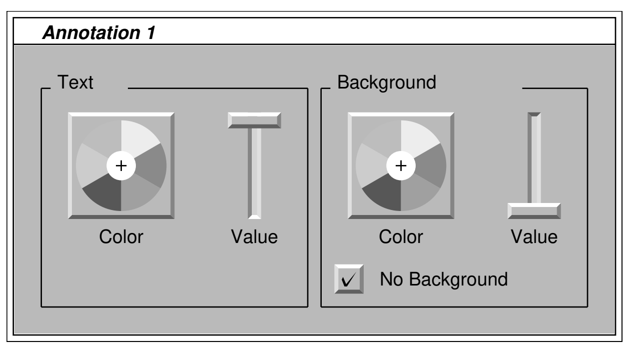

Figure 7-3. *Annotation control panel*

The Text group of hue/saturation and brightness controls allows you to change the color of the text. The Background group of hue/saturation and brightness controls allows you to change the color of the background. By default, text boxes have no background.

Note *When a renderer is in color map mode, the entire range of colors is not available. Instead, SciAn will try to find the closest predefined color to the color you request.*

Rectangles

The next tool down is the rectangle drawing tool, which looks like an outline of a rectangle. When this tool is chosen, you can press in the panel and drag out a rectangular box.

Select a rectangle and choose Show Controls from the Object menu to show its control panel. A typical control panel is shown in Figure 7-4.

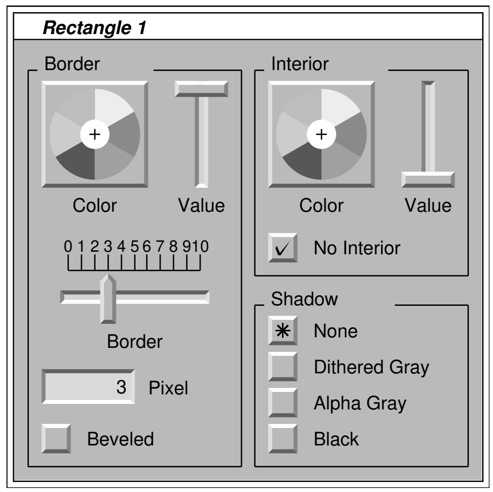

Figure 7-4. *Rectangle control panel*

The Outline and Center groups of color controls allow you to change the color of the outline around the edges and the center of the rectangle. The Line Width slider and check box allow you to change the width of the lines around the edges. If the Beveled check box is checked, the edges are displayed as beveled edges lit from the upper left instead of as solid lines.

The Shadow group of controls allow you to specify a shadow to the lower right of the rectangle. The None radio button specifies no shadow. The Black button specifies a solid black shadow which obscures everything behind it. The Dithered Gray and Alpha Gray buttons both specify gray shadows which do not entirely obscure the objects behind them.

The difference between alpha gray and dithered gray is subtle, much like the difference between transparency and translucency. Dithered gray shadows are drawn in black using a screen door pattern which only draws every other pixel. The advantage of dithered shadows is that they always work, regardless of the hardware capabilities of the computer or the color mode of the window. The disadvantages are that they entirely obscure translucent objects and may look funny on video depending on the recording hardware. Alpha shadows use the alpha blending capabilities of the workstation. The advantage of alpha shadows is that they appear smoother and gently obscure all objects, translucent or not. The disadvantages are that they only work on workstations with alpha plane hardware and they do not work in color map mode.

Hmmm *When more than one object casts an alpha shadow on an area, the area is darkened more than when a single object casts a shadow. This isn't physically accurate, but strangely enough, it looks very realistic.*

Lines

The next tool below the rectangle tool is the line drawing tool. The tool looks like a short diagonal line. When this tool is chosen, you can press in the panel and drag out a straight line.

Select a line and choose Show Controls from the Object menu to show the controls of the line. A typical control panel is shown in Figure 7-5.

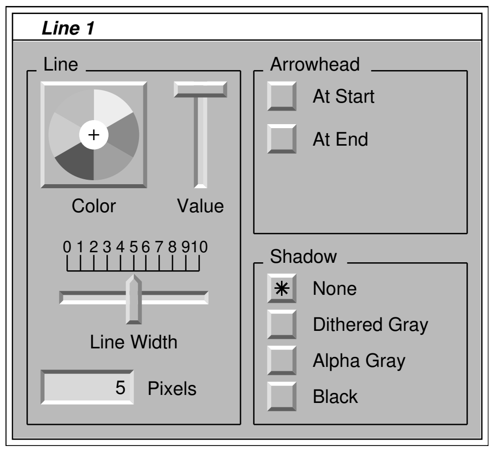

Figure 7-5. *Line control panel*

The Line Color and Line Width controls control the color and width of the line. They work like the Outline controls in the rectangle control panel. The Shadow controls work the same way as the Shadow controls in the rectangle control panel.

The Arrowhead controls allow you to put an arrowhead on one or both ends of the line. (The size and shape of these arrowheads are not editable.)

Clock display

Below the Line drawing tool is the Clock tool. To display the time given by the clock in the space itself, choose the Clock tool and drag out a rectangle in the space panel. The current time will be displayed in a text box similar to the text boxes used to display annotations. The text font, size, and color as well as the shape and position of the text box can be changed. The text in the box, however, is not edited directly. Instead it comes from the current time of the clock.

The control panel of a clock display object looks very much like the control panel of an annotation object with one addition: an editable Format box at the bottom which gives the format used to print the time.

The format used is very much like the format required by the C `printf` function. (In fact, the actual printing of individual numbers is implemented using a modified string passed to `printf`.) The main differences are the conversions used. This description will only give a general overview of the formatting, concentrating on the differences between the time format and `printf`. It should be sufficient for most uses, but more details on `printf` are available by entering `man printf` on the console of your workstation.

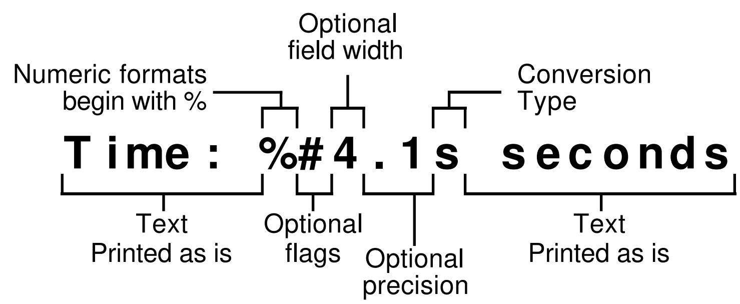

Figure 7-6. *Example time format*

An example of a typical time format is given in Figure 7-6. Most characters are simply printed as they appear. Embedded in the string are numeric formats, which begin with a percent sign (`%`). There can be several numeric formats within one time format, and they all refer to the same time. (If you want to print a percent sign as is, include `%%` in the string.)

Following the `%` are optional flags:

#	Causes any zeroes following the decimal point to be printed. Normally, trailing zeroes are truncated.
−	Causes the result to be left justified within the field.
+	Always prints a sign (+ or –).
blank	Always prints a minus (–) sign or a blank

Following the optional flags is an optional field width. The field width is the minimum number of characters used to print the number. The number may be printed using more characters than this width, but this will only happen when absolutely necessary when the given field width is too small. If this number begins with a zero, the result will be padded with zeroes.

Following the optional field width is an optional precision. This consists of a decimal point and the number of digits to print following the decimal point. If the precision is omitted, the decimal point must be omitted as well.

Following the optional precision is the conversion type. This is where the time format most differs from `printf`. The conversion type assumes that the time is stored as a number of seconds or timesteps and prints according to this table:

`t`	The number of the current timestep.
`T`	The number of the current timestep.
`s`	The integral number of seconds, restricted to lie between 0 and 59. This is useful for hours, minutes, seconds format.
`S`	The real number of seconds, unrestricted.
`m`	The integral number of minutes, restricted to lie between 0 and 59. This is useful for hours, minutes, seconds format.
`M`	The real number of minutes, unrestricted.
`h`	The integral number of hours, restricted to lie between 1 and 12. This is useful for hours, minutes, seconds format.
`H`	The real number of hours, unrestricted.
`i`	The integral number of hours, restricted to lie between 0 and 23. This is useful for hours, minutes, seconds format.
`a`	"am" or "pm" depending on the value of the clock.
`A`	"AM" or "PM" depending on the value of the clock.

For example, a time of 43440 seconds past midnight, or 12:04 PM, would be printed with various formats like this:

Format	Result	Explanation
`%.0`	43440	Seconds with no decimal places
`%2.0h:%02.0m %a`	12:04 pm	12-hour format with lower case am/pm.
`%.2M`	724.00	Minutes with 2 decimal places

Color palette legends

You can display color palette legends in any space by dragging the palette icon into the space. The icon is available from the control panel of the dataset. The palette legend appears with a border and handles similar to an annotation object.

To show the controls of a palette legend, select the palette legend and choose Show Controls from the Object menu. A window like the one in Figure 7-7 will appear.

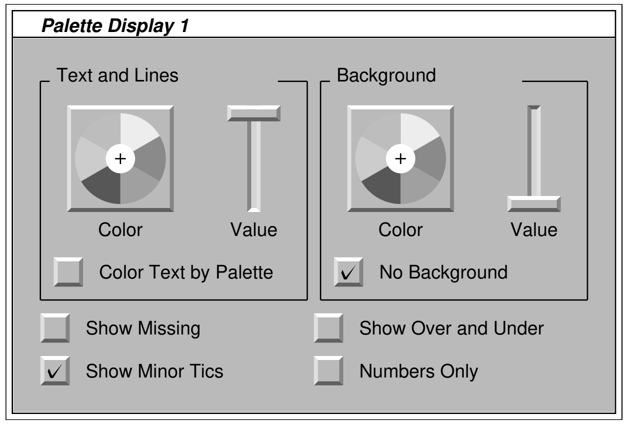

Figure 7-7. *Palette Display control panel*

Two color wheels and sliders allow you to set the color for the background and for the text and lines of the legend. If you check the Color text by palette check box, the text will be colored by the actual values each number represents.

Four check boxes at the bottom of the control panel set other options of the legend. The Show Over and Under and Show Missing check boxes allow you to show or hide missing or over and under entries. The Show Minor Tics check box allows you to show or hide the minor tic marks. The Show Numbers Only check box is useful in conjunction with the Color Text by Palette check box to show a palette consisting only of colored numbers.

Palette displays which are taller than they are wide are displayed vertically. Displays wider than tall are displayed horizontally.

Moving and reshaping

When you select a drawing using the space selection tool, a number of square handles will appear over the object. Lines have two handles, one on each end. Rectangular objects have an outline box with eight handles. Press and drag a corner handle to move a corner of the drawing. Press and drag a handle in the middle of an edge to resize in one dimension only. Press and drag on the outline box between handles or on the body of a line to move the entire object without resizing. Press and drag an endpoint of a line to move just that endpoint.

There is a regular grid overlaying the space panels which can help you line up objects. When you hold down the Shift key, mouse motions will be constrained to the grid points. To show the grid, bring up the controls for the front panel and turn the Show Grid check box on.

Changing depth

Objects within the space are drawn in order from back to front, with the closer ones obscuring farther ones. If an object has a shadow, it will partially obscure the objects below it. Each new object is created on top of all the other objects in the front panel.

Which panel an object is on and the order of objects on that panel can be changed using items from the Arrange submenu in the Object menu.

To move a drawing from the front to the back panel, select it and choose Move to Back Panel from the Arrange submenu. To move from the back panel to the front panel, choose Move to Front Panel instead.

To change the stacking depth of drawings within one of the panels, select them and use Bring to Top and Push to Bottom from the Arrange menu.