

## Tutorial: Gauge graphics, Part 4

### Radial ticks

This is the final part of this tutorial. It will begin with a discussion about an effect that can be seen in at least one gauge in almost every aircraft available in flight simulator. These are the radial markings around the face of an instrument. When used in conjunction with a pointer of some sort, they relay information to the pilot. Because of the frequent use of radial ticks, their construction will be demonstrated using the tools of XaraX.

The gauge at right not only uses a dial with tick marks; it also has radial divisions that delineate areas of the gauge. It is this gauge that will be used to illustrate this technique. The outer band provides altitude, the center shows drift information. Both the altitude ticks and the drift markers (triangles) will be considered in this discussion.

Radio altitudes up to a maximum of 1000-feet are displayed. It does this using two scales. Between 1000-feet and 100-feet the ticks represent 100-foot divisions. Between 100-feet and zero, the divisions represent 10-foot segments. The two scales allow altitudes nearer the ground to be represented more accurately than higher altitudes. This assists the pilot in knowing when touchdown is about to occur or when a helicopter is taxiing a few feet above a surface.

If you study the placement of the radial lines on the gauge, three major properties of each become evident. They all have angle, they all have length, and they all have location. For this discussion, color and line width will play a minor roll. You are already familiar with those qualities.

As the lines rotate around the gauge, their angle constantly changes. These all have a common focal point in the center of the gauge. They vary in length because some lines need to be more prominent than others. For example, shorter ticks are used for most of the higher altitude markings giving them less importance than lower altitude markers. The location of tick marks is important to provide readability and uniformity to the gauge. For example, the distance between the 5 and 6 ticks will equal that between 6 and 7 ticks.

Let's begin the radial layout by first sketching a game plan showing how the gauge is grouped into areas. This will be the map to follow when drawing the graphics. The 360-degree circular gauge will be divided into sections. All values will be expressed in degrees using a compass rose; North is at 360-degrees (this is also zero-degrees), East is at 90-degrees, South is at 180-degrees, and West is at 270-degrees.

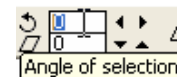
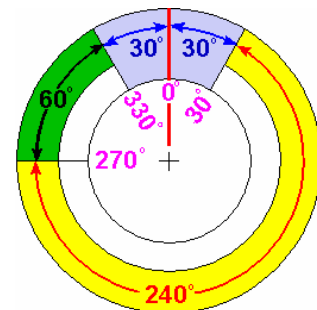
At right, the top of the gauge will contain the identifying text. The blue area will be reserved for that element and is given a 30-degree band on either side of the vertical centerline. This band extends from 330-degrees on the left, to 30-degrees on the right.

The higher altitudes (100' - 1000') will be allotted the green area. It covers a band containing 60-degrees. It extends from 330-degrees to 270-degrees. That area will be subdivided into nine ticks. The calculation for those ticks is:  $60 / 9 = 6.66$ -degrees per tick. That number is the **offset value of rotation** for each mark within that area starting at value 330°.

What is an offset value of rotation? That is the difference in rotation between any two adjacent tick marks. The number 6.66 above represents this value for each of the higher altitude ticks that will occupy the green zone.

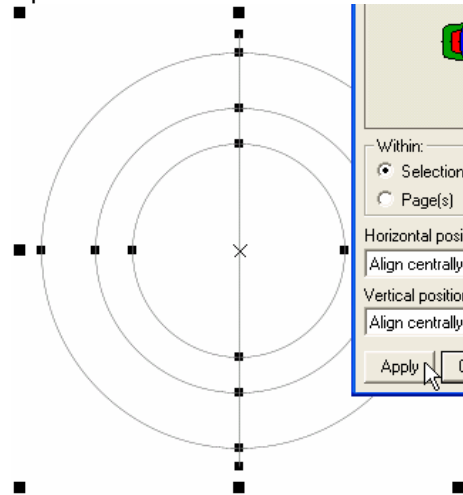
If you will remember from an earlier discussion regarding rotation, it was stated that objects may use the Angle of selection box illustrated at right. Input into that data box would rotate the arrow illustrated there relative to its current position. The current angle, even after a rotation, is always zero-degrees. Positive values rotate the selection counterclockwise, negative values rotate the selection clockwise. In effect, this box requires offset values, not compass rose values.

As you probably have already discovered if you are trying XaraX for yourself, all data windows will in reality accept values to two decimal places (6.66), not just one decimal place that has been used up to now. While such accuracy is overkill for pixel and angle values, it makes entry a tad easier because no thought is given to rounding-off calculations.



The lower altitudes (100' - 0') will be allotted the yellow area. It contains a band having 240-degrees and extends from 270-degrees to 30-degrees. That area will be subdivided into ten ticks. The calculation is:  $240 / 10 = 24$ -degrees per tick. That provides the offset value of rotation for each mark within that area.

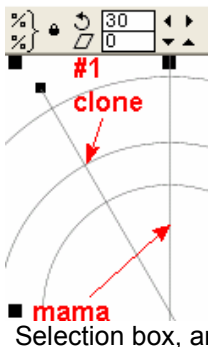
Having calculated all necessary offset values, the drawing phase can begin. It starts with the four objects at right. The three circles represent the circular bands visible on the face of the gauge. The vertical line will become the mother of all tick marks. All objects are shown selected, then centrally aligned using the Object Alignment box.



The size and spacing between circles evolved over time. That was a product of design decisions. Why those locations were chosen will not be detailed. Instead, this demonstration will focus only on how the tick marks were created using XaraX.

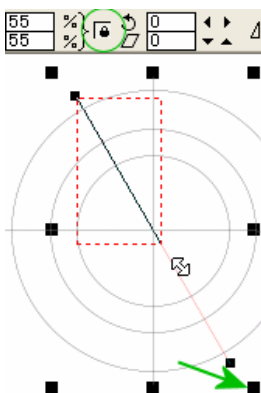
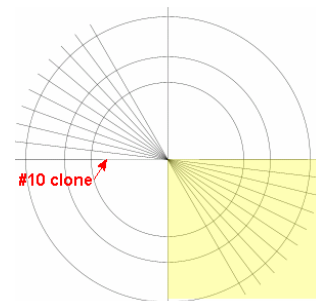
Because all objects in this illustration are centered, the pivot point for the vertical line will be located in the exact center of the concentric circles. The small X-mark seen in the center of the illustration is the method XaraX uses to indicate the center of selections. Having a pivot point centrally located will allow cloned versions of the vertical line to rotate about the same pivot point as each is supplied with the calculated offset angle of rotation.

The first area to receive ticking will be the green area, from 330-degrees to 270-degrees. A brief summary of steps is: a #1 clone will be made from the vertical line and given an offset angle of 30. This will rotate the clone counterclockwise (ccw). That places it at the starting point for the high altitude tick marks. After rotation, the clone will remain selected. A #2 clone will be made from the first. It will be given an offset angle of 6.66-degrees. It will then rotate ccw by this amount. The process of clone-rotate-clone-rotate will be repeated until the tenth clone is rotated. At that time the clone will lie horizontally across the center of the circles. That location is equivalent to the 270-degree point on the compass rose. This clone will become the 100-foot altitude tick mark.



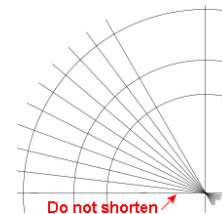
In the illustration at left, the first clone has been rotated 30-degrees counterclockwise. As you can see, it remains selected after the rotate. That makes it easy to clone a second line (CTRL + K), type 6.66 into the Angle of Selection box, and then hit Enter.

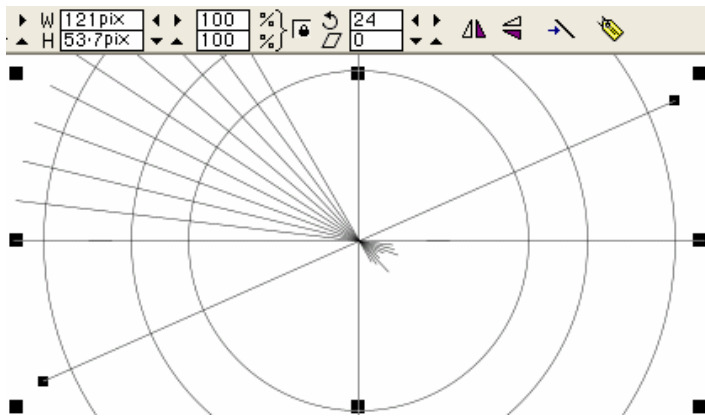
At right, the ten clones are in place. Half of each line extends to the opposite side of the circle. Those inside the yellow region will cause confusion later because that area will also receive its own tick marks. The lines can be shortened at this time.



If a diagonal line (at left) is selected, it can be shortened (or lengthened) by adjusting a corner selection handle. In order to maintain the diagonal angle, the "lock" inside the green circle at left must be active. The selection handle pointed to by the green arrow will adjust the line length without interfering with the angle. If the lock is off, both length and angle are changeable.

At right, all clones have been reduced in length except the #10 clone. That line will be left untouched so additional clones can be made from it. Changing its length would also change its pivot point. That would affect the rotation of the new clones.



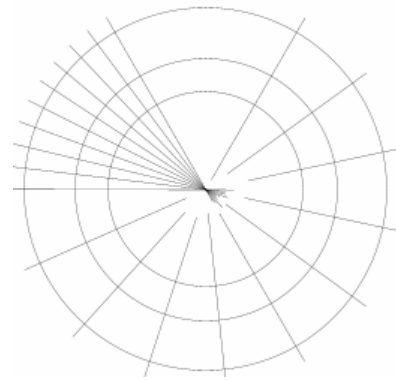


In this illustration, the #10 clone has been copied and rotated 24-degrees counterclockwise. The left half of this line will become the 90-foot low altitude tick mark. The remaining low altitude ticks will be made using the clone-rotate process until reaching the zero altitude marker. That will be positioned at 30-degrees on the compass rose.

Take a closer look at the graphic at left. Potential confusion will develop as more low altitude ticks are rotated around the circles. Even the original vertical centerline will contribute to this disorder. Since it was needed only to produce the first clone, it can be removed. To prevent a tangle of lines, each low altitude tick will be shortened after a clone has been produced from it and rotated. Otherwise, it will be nearly impossible to identify what line goes where if allowed to remain across both halves of the circles.

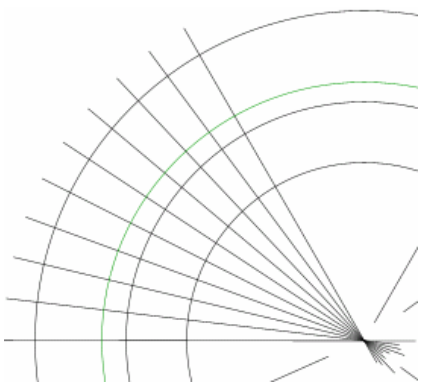
At right, all low altitude tick marks are in position.

Because each line was shortened after rotation, it is clear whether a mark represents a low or high altitude. The last task is to reduce each line until it has a length appropriate to its function. Some lines will be longer than others. The final length chosen for each line was made during the design phase of this gauge. Here, only the length-editing process will be discussed.



The high altitude ticks will run from the middle circle outward a short distance toward the edge of the gauge. The two exceptions are the 1000-foot tick and the 100-foot tick. Those two lines are extended until they touch the inner circle.

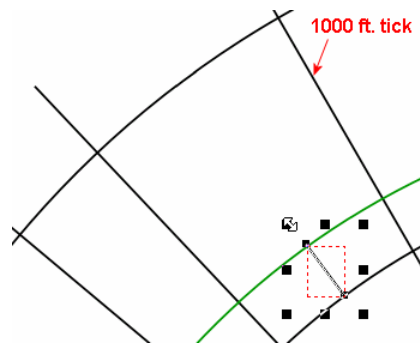
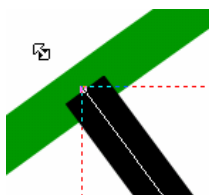
All low altitude marks will run from the inner circle to the middle circle. Illustrating how this is accurately done is the last stage of the ticking process. What about numbers that identify the ticks? Putting labels on ticks is a textual procedure using the tools discussed under the Text topic.

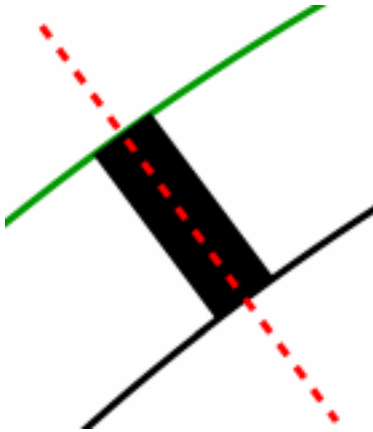


To set the length of each high altitude tick, an additional circle was drawn and centered. It is shown at left in green. That object will set the outer boundary for each of these tick marks. After that is accomplished, the circle will no longer be needed and will be deleted.

Each mark will be edited until it touches the green circle on one end and the middle circle on the other. This is a manual procedure done by eye. There are no snaps available to speed up this task such as those found in CAD software. But, only a few lines are involved, so it's no big deal.

At right, the 900-foot marker has been shortened to fit within the two circles defining the boundary. The end point of each tick should stop in the center of the circular lines. A zoom will be needed to do that properly. With a zoom level high enough, the center of lines can easily be seen. The zoom at left is over 25,000-percent. With such accurate placement, the ticks will look identical when the gauge is installed, even at larger sizes.

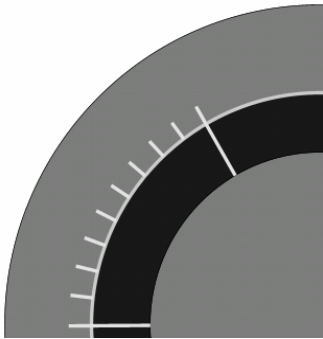




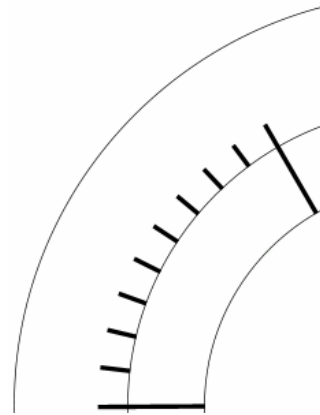
After editing the length of ticks, they can be increased from the 0.1 initial width to a final value. This value should be determined by viewing the lines at a zoom of around 100%. This magnification will give an idea how the lines will display when the gauge is viewed at its operational size. If needed, readjust the width until it looks correct, not too fat, not so thin they can barely be seen.

XaraX increases the line width proportionately around the selection center of the object. At left, the red, dashed line lies along the original angle for that tick. The wider black line is the actual tick mark that has been increased in width. You can see that the tick remained the same length, still has the correct angle of rotation, and only increased to a more useable width.

At right, the ticks have been given a width of 0.5 pixels. The 1000-foot and 100-foot ticks have been set to their proper lengths. With these marks lengthened, the green circle was deleted.



One final edit on the ticks will be performed when the interior of the gauge has been given color. At left, color has been applied to the three circles. You will also see that the center circle was given a border of light gray. The tick marks were colored to match this line. The remainder of line ticks used on this gauge was done in a similar manner as just discussed. As you can see, line colors and widths are design decisions.

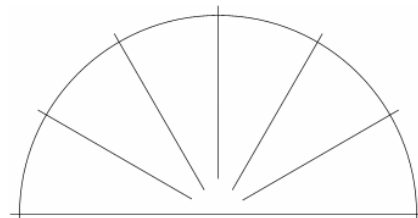


At left, there is another type of tick that was used on this gauge. Those are triangular ticks. Even though they are a different shape, the basic technique remains the same.

First, it can be seen the dial uses an arc spanning 180-degrees. The arc is divided into 6 areas representing angles of drift ranging from zero to 30-degrees left and right.

At right, temporary lines have been placed around

the circle. These were rotated to form the six divisions. The offset angle to which they were rotated was derived from the calculation,  $(180 / 6 = 30)$ . These lines will act as guides for the placement of the triangular ticks.

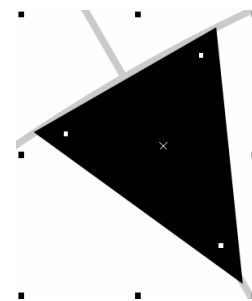


Each tick mark is made from a small triangle. The initial triangle represented zero-drift. By default, XaraX drew this triangles facing downward. That is the direction needed for the zero-drift tick mark. That triangle can be seen at left occupying center position.



This triangle was cloned and given an offset angle of rotation of positive 30-degrees and negative 30-degrees. Positive values rotated the triangle counterclockwise, negative values rotated the triangle clockwise. The clone-rotation step was repeated for each of the remaining ticks.

To achieve alignment, each triangle was positioned by eye. The tip of the triangle was centered along the appropriate temporary line. The base of the triangle occupies the center of the border line of the inner circle. One tick position is shown at right. The color of the triangular ticks was later edited to gray to match the altitude tick marks.



A word from pilots Tail Wheel and Sweet Pea



### Miscellaneous techniques

This topic will round out the final section of this tutorial. Covered are three techniques that can be used to make objects associated with gauges. The first is a cutout graphic (a hole) within the panel of an aircraft. Gauges are commonly installed into these cutouts. They provide a smooth transition between a gauge and its panel. Cutouts may also have adjoining holes used for mounting screws. These secure the gauge in place.

The second technique is the mounting screws or bolts. These fasteners will contain the familiar Phillip's head slot.

The last topic will illustrate how

to make needles. These pointing devices are an essential part of mechanical gauges and are likely found on most panels. The tools within XaraX helps to construct these graphics so they display more realistically as they rotate within an instrument.

For each of these topics, XaraX will play the primary roll. Many of the illustration that will be shown could have been produced with Paint Shop Pro as well. However, I favor vectors for most drawings and effects because of its superior curving and shading abilities. And, if you are wondering, XaraX also produced the cartoon above. By now, you may recognize beveled noses.

### Cutouts

The job of a cutout is to hold a gauge. Many gauges are round at the body but may have bezels of other shapes such as an octagon. In reality, the body would fit into a panel hole and be covered by the bezel. In flight simulator, both body and bezel normally fit into the cutout. To what size should the cutout be made? Most round gauges fit into holes that are either 3 1/8-inches in diameter, or 2 1/4-inches. The gauges themselves are a bit larger. For example, a common stock size is 3 1/2-inches.

But, in today's digital age, gauges can be all sorts of shapes, not just round. Just look at the GPS. Also, all gauges are not necessarily installed into panels. Some may use alternative mounting devices such as brackets or adjustable arms; however, duct tape is frowned upon.

The scale graphic at left is modeled after the spec sheet of a typical round gauge. In this example, the gauge has an octagon face, but it could be round or square. The red, dashed line shows the body of the gauge. This is the part that would fit into the cutout on the panel. The four black circles indicate the mounting hole locations.

The green ruler will give the relationship between elements of a 3 1/8" gauge. Divisions are in 1/8<sup>th</sup>-inches. The blue ruler does the same for a 2 1/4" gauge. Divisions are in 1/4-inches.

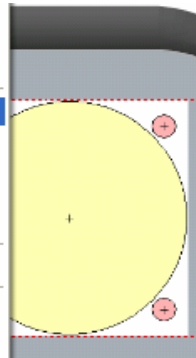
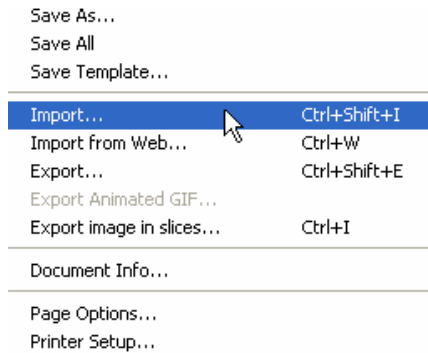
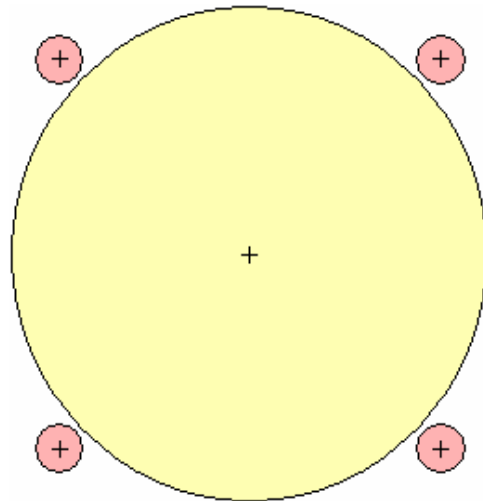
During this cutout demonstration, the primary objective will be to present techniques on how the hole is drawn, colored, feathered, and provided with holes for mounting screws. If you look at a panel you may find not all gauges use four screws. Sometimes there is not enough room because of space interference from nearby instruments and switches.

To ease the design task, the graphic at left will be converted into a template. The template will serve to guide the development of both large and small round-body gauges and associated mounting holes. The number of mounting holes you use for a particular instrument is a design decision and may require compromise.

The template is shown at right. It is a bitmap included in this zip archive with the name of GauTemplate.bmp. The yellow circle represents the approximate size of the cutout including the feathered area. The red circles are the mounting holes.

Feathering with XaraX requires an object of solid color to be drawn at its maximum size. This includes the region to be feathered. XaraX first applies the greatest amount of feathering to the outermost pixels. As the process proceeds toward the center of the object, it begins to decrease. This continues for a pixel-distance that you stipulate. Upon reaching that value, feathering stops. From that point on, the remainder of the object will contain only solid color.

This method of feathering makes it very convenient to know exactly what the final size of the cutout will be, feathering and all, without calculations or trial and error drawings.

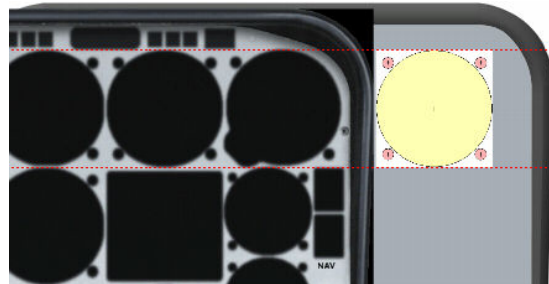


To begin, the template is imported into XaraX. It will be used to size elements and locate them in correct relationship to each other. This template will work for both large and small gauges.

The Import tool is found inside the File menu. At left, the imported template has been placed on a simple gray panel made for this demonstration. The light color will allow the dark feathering to be clearly seen.

After importing, the next step is to adjust the template until it is the size needed for the cutout. How is that determined? One method is to also import the bitmap of a panel from FS and use the size of those cutouts as a guide.

At right, the Bell bitmap has been imported and placed over the demo panel. Guides are set along the top and bottom of the desired cutouts on the Bell panel. Using these, the cutout template is proportionally re-sized to fit between the Guides.



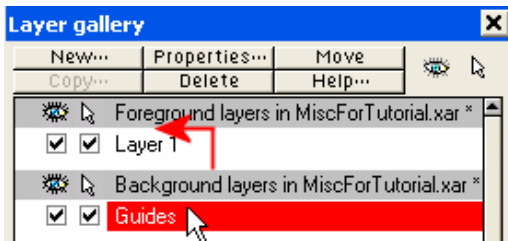
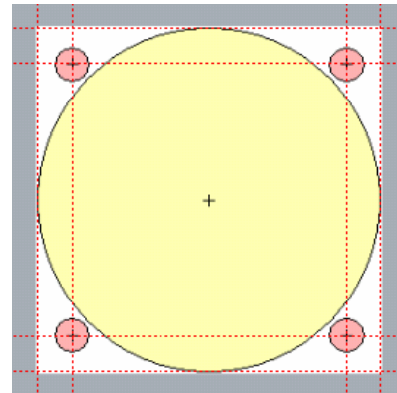
Before continuing with the cutout, let's look at a default gauge installed on the panel of the Bell helicopter. That will give us a clue on how MS develops their cutouts. We will follow their lead when making our own.

A couple of factors appear after scrutinizing the gauge at left. The first is that the rim of the gauge does not touch the exterior of the cutout. It sits away from that edge by a distance of several pixels. This allows the border of the gauge to blend into the blackness of the cutout. That prevents the jagged edge that is often apparent around a gauge when it is placed on top of a light colored panel without the intervening cutout. There is also an interesting element that can be seen near the left side of the cutout. It is a lighter circular band that is not the rim of the gauge. That element projects the thickness of the metal in which the cutout is drilled. Panel material has physical depth and MS gauge designers are simulating that property.

The outer edge of the cutout is rather indistinct. It is solid in color near the gauge but becomes blurred as it moves further away. That is the feathering technique that will be used in this demonstration. Also, the gauge is not centered perfectly in the hole. Looking closely, the instrument can be seen favoring the right side of the cutout. This adds to perspective because the gauge is not located directly in front of the pilot. However, the pilot in a Bell sits on the right side of the gauge console so centering should favor the left side of the cutout, but who cares? The bolts also slightly favor the right side of their respective holes to keep the perspective intact.

One additional fact not readily apparent is the shade of black used in the cutout. Measuring the value at various points in the graphic found that no single percent of black was evident. However, a value around 80-percent showed up frequently and could be considered an average value. Neither of the two reserved shades of black was found.

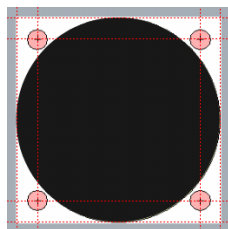
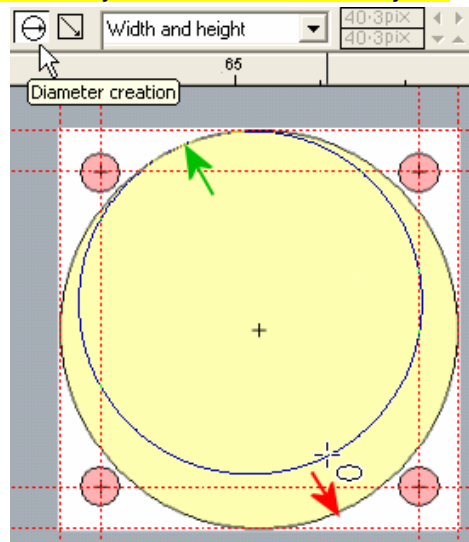
Let's begin this demo by using the imported (and sized) template to locate the various elements. Guides are positioned along each side of the cutout as shown at right. Those will set the outer boundary where feathering will begin. As you can see, Guides have also been used to locate the centers of each mounting hole.



**Tip:** If Guides are covered by a graphic, it is because the layer they occupy is below that of the graphic. The drawing order can be changed inside a box activated in the Utilities/Galleries/Layer Gallery menu. The Guides layer is selected, and then moved upward using the mouse. Place it directly above Layer 1. That will make the Guide visible along its entire length. Then, select Layer 1 so that all future objects will be drawn on that layer; otherwise, they will be created with the properties of a Guide (red dots).

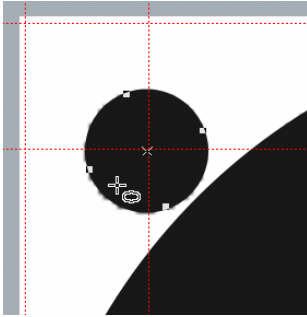
A solid circle representing the cutout will be the first object to be drawn. In the illustration at right, the circle was begun by first choosing the Diameter creation tool at the top of the XaraX screen. This instructs the software that you intent to draw a circle by using two points, the beginning point (green arrow) and the ending point (red arrow). Both points lie atop the template and are determined by eye.

The blue outline is a visual indicator XaraX provides so you can see how the circle is being developed at any given moment. The circle grows larger as the cursor nears the ending point. It can be adjusted in size and positioned until it fits perfectly over the template. A mouse click finalizes the operation.



At left, the 90% black circle is complete. It has a border because that was drawn by default. This is not necessary but it does not interfere with feathering if allowed to remain.

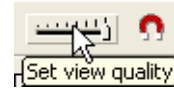
The next task is a reasonably accurate placement of the four mounting holes. One circle object will be drawn to size following the template. It will be centered at the intersection of two red Guides. From that circle, the other three mounting holes will be cloned and positioned. These steps are illustrated next.



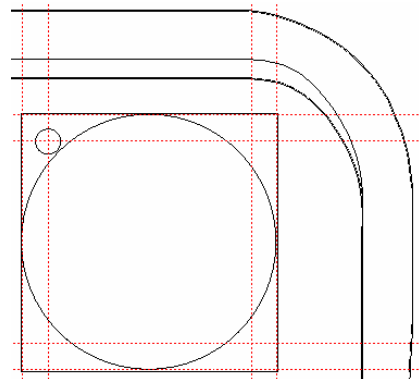
At left, the first mounting hole has been drawn. Working in a small area such as this requires a large amount of zoom. This circle was drawn using the same technique as the cutout. It lies directly over the mounting hole on the template. The remaining three circles will be cloned from it. This will keep all screw holes identical.

In this graphic, you are viewing a stack of objects. First, the demo panel (gray) occupies the bottom. Next comes the template graphic (white). Above that are the two circles (black). Sometimes you may wish for a better way of selecting an object that is part of a stack. XaraX has such a tool.

**Tip:** Selecting objects that are stacked can sometimes be difficult if they are displayed in solid colors. To make selection easier, turn down the slider on the "Set view quality" tool (beside the horseshoe). This will reduce all graphics to their most basic line form.



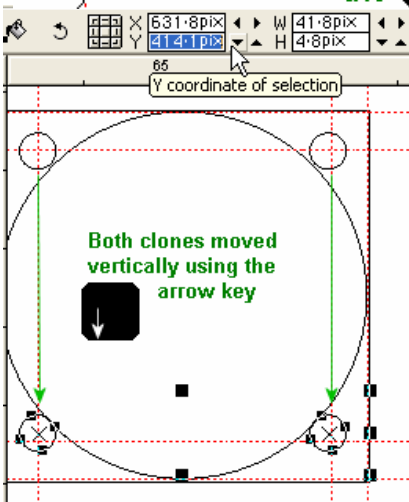
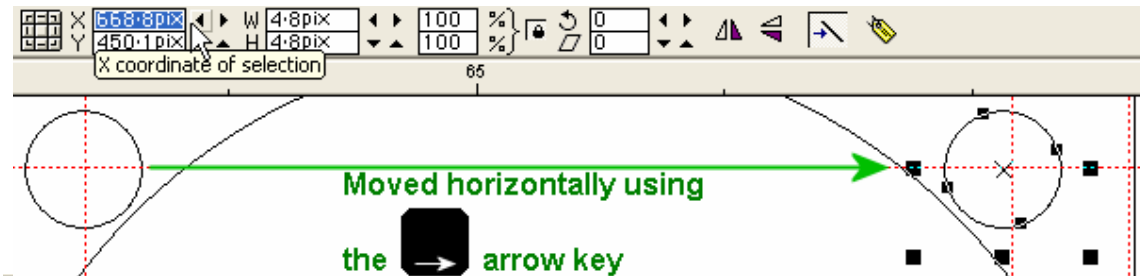
The drawing at right has been stripped to the bare bones. This is a view quality at the lowest setting. Parts of the demo panel are visible and the square template. This template is a bitmap and its outline can be seen but none of the images contained on the graphic. Also seen at right are the two circles that were just drawn.



This minimum setting has another application that can be used to advantage at this time. The first mounting hole can be centered over the intersection of the Guides.

In the graphic below, the mounting hole was cloned. The clone was moved horizontally using the arrow key. This insures the Y-value does not change.

The selected clone contains a small X showing the center of the circle. An increase in the "X coordinate of selection" at the top of the XaraX screen will move the clone to the right. The value is increased in steps of 0.1-pixels until the center of the circle straddles the intersection of the two Guides.

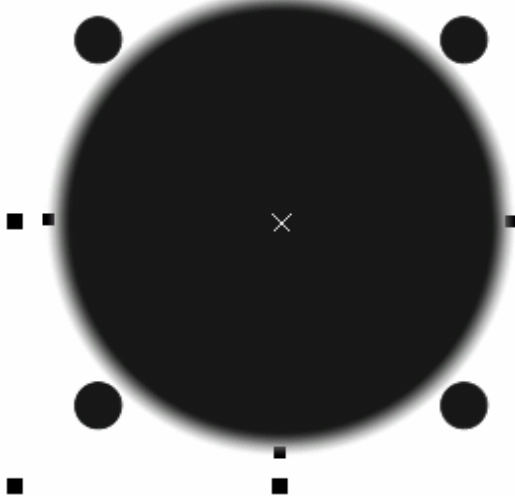
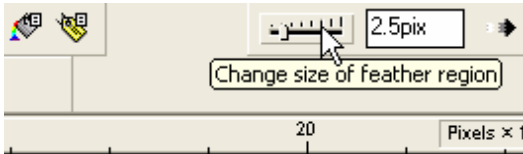
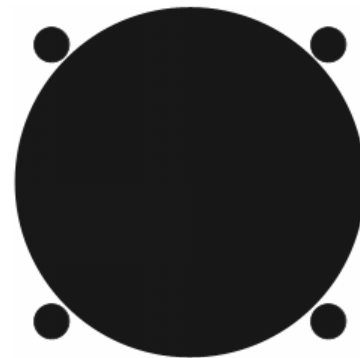


With the first clone in position, both it and the original mounting hole are selected. They can then be cloned at the same time. The pair of new clones is moved down using the down-arrow key. A final adjustment of the "Y coordinate of selection" will center the clones over the intersections at the bottom of the template.

Using arrow keys to move objects horizontally or vertically is a helpful technique when alignments are needed. The arrow keys will keep either the X-value or the Y-value intact during the move. That reduces the amount of time needed for the alignments.



At right, the five circular objects are now in their final position and have been returned to the highest view quality setting. For the feathering task, the cutout and the mounting holes will be worked separately because they will receive different amounts of feathering. The four mounting holes can be feathered as a unit.



At left, the cutout is selected, and given a feathering value of 2.5-pixels. The "Change size of feather region" is found at the top of the XaraX screen to the far right side. The feathering effect blurs the edge of the circle without changing the overall size.

The four mounting holes are feathered using a value of 1-pixel. The effect of this is seen in the next illustration.



It was mentioned earlier that borders around these circles had no effect on feathering. But borders can be used to control the final way these five circles relate. That is a design decision over which you have full control. By increasing or decreasing the border width around these feathered circles, the space between the blurred regions will change. If you prefer these regions to overlap (as MS seems to), then experiment with various border widths. As their widths are changed, the number of feathered pixels remains the same and the circles stay centered in the same positions. The only change is in the diameter of the circles.



The graphic at left shows the cutout using a border of 2 pts. The two mounting holes have a border of 1 pt. You can see how those changes moved the feathered regions closer together.

The last step in cutouts is grouping. All five circles are locked together. From this point forward, one completed cutout with mounting holes can be cloned as many times as needed to fill an entire panel. The one cutout can also be changed in size (proportionally) to match that of any circular gauge, large or small.

Square cutouts are also possible. These begin with a black square. Feathering techniques would then be applied. Most square gauges have no mounting holes.

One final technique; this will simulate cutouts for gauges with extra protrusions such as a VOR or ADF. Those have knobs used to rotate various elements of a gauge. To add the extra space to a cutout that will accommodate these gauges, draw two circles as shown at right. The red (for clarity) is the cutout; the larger black circle is the added area. These are permanently joined using the Arrange/Combine Shapes/Add Shapes menu. That forms a single object, which can be feathered. This effect is shown at left.



**Screws and bolts**

These two words will be used interchangeably throughout this discussion.

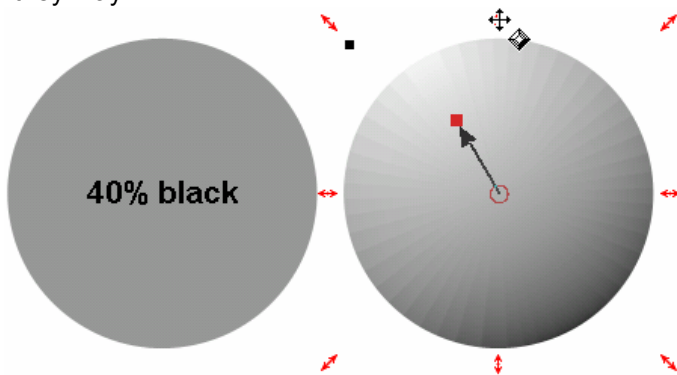
Cutouts and mounting holes are useless without an instrument of some type and a few bolts in the proper areas. Gauges and cutouts have already been covered. Now it's time to discuss the fasteners, or more properly, the heads of these devices. Fortunately, threads are not needed.

Only the type of bolt that has a Phillip's head is demonstrated. That is the one with the cross-shaped slot. Other types would employ similar techniques.

The heads of the bolts are round. The top surface may be flat or slightly rounded. And, of course, they must have slots to provide grip for the screwdriver.

Aircraft screws are not the fancy, chrome-plated fasteners used in a restored '57 Chevy. An aircraft panel is no place for glitter. Aircraft screws should have no mirrored surface but should reflect light. But reflections are kept to a minimum. Screws may or may not cast shadows depending on the screw type and what you think is appropriate.

Because screws will probably appear at rather insignificant sizes in an operational panel, a lot of detailing would be diminished. Details such as those seen inside the slots of the above illustration may fade from view when these screws are reduced to their final size. But, these details are so easily made that there is little point in avoiding them. Then, the chips can fall where they may.

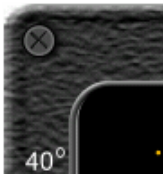


This demo bolt begins life as a 40-percent black circle. The size is drawn relative to the mounting hole it will occupy. It is made a bit smaller than that hole. The dark hole adds to the contrast around the screw.

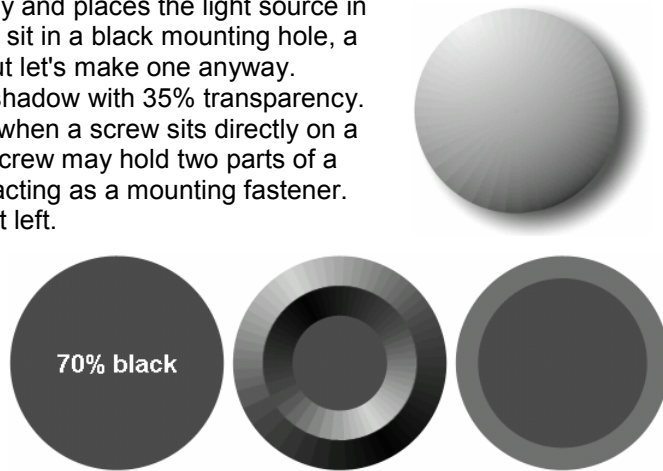
The second graphic at left has been given a "Rounded 2" bevel type. This bevel covers the entire interior of the circle. It is pulled toward the center. That process is underway at left. The tiny red circle indicates that the tip of the bevel has almost

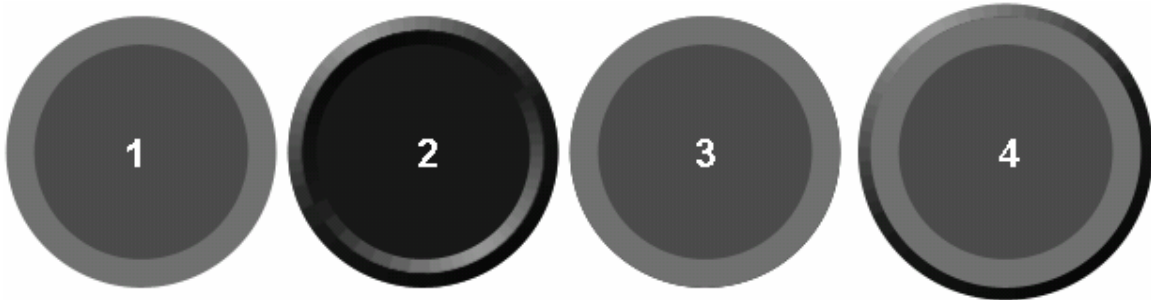
reached the center. When it does, the tip will disappear into the roundness of the bevel. You can see default shading is applied automatically and places the light source in the correct location. Because most screws sit in a black mounting hole, a cast shadow is probably not necessary. But let's make one anyway.

At right, the circle is given a Wall shadow with 35% transparency. Such shadows play a more prominent roll when a screw sits directly on a gauge. Used as such, the screw may hold two parts of a gauge together rather than acting as a mounting fastener. That function is illustrated at left.

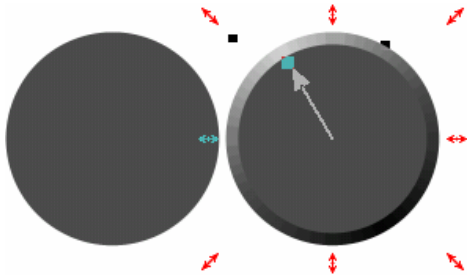


Screws with flat heads are also possible. At right, the screw begins with a circle at 70% black. The middle graphic shows the circle given a "Point Frame 1" interior bevel. The far right graphic is the same bevel adjusted so the light elevation is at 90-degrees (overhead). This flattens the bevel. And the size of the beveled edge was reduced to 1.5-pixels.





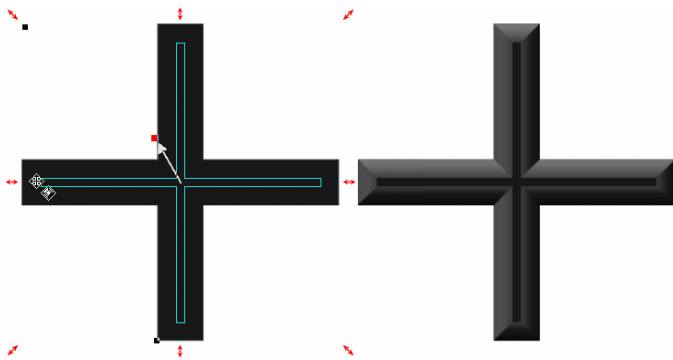
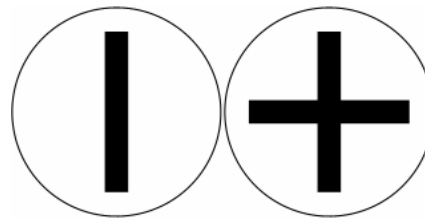
There are endless ways to modify circles to give different bolt effects. Above, the original flat bolt (#1) was cloned (#2). The clone was colored 90% black, then placed behind the original bolt using the "Put to Back" Tool inside the Arrange menu. This gives view #3. While the clone is still selected, it is given a border with a width of 1-pt and a light elevation of 50-degrees. These last two steps increased the size of the clone until it shows from behind the original circle (view #4). And altering the elevation of the light sources gives the clone shading and highlights around its beveled edge. Now, the screw head has a bit of depth.



Don't like the gray band around the above screw? The screw at left was given a flat interior bevel of a few pixels. It still has depth but no outlining band of gray.

What good are bolts or screws if they have no slots? These shallow cuts are easily simulated using two small, skinny rectangles set at 90-degrees to each other. The head of the screw will determine the size of the grooves.

The first groove is shown at right. It is placed inside a circle representing the head of the screw. The black slot is a rectangle, not a line. It uses no border. The color used is 90-percent black. The second graphic shows a clone from the rectangle rotated 90-degrees. The two rectangles are selected, then added together to form one slot having two arms. When the slot is one object, it can be beveled in such a way the bevel will affect all 12 sides of the slot in a continuous fashion.



In the first graphic at left, the slot is receiving a Rounded 2 bevel type applied to the interior of the object. The bevel size is about 0.9 pixels. The second graphic shows the result of that application.

Notice the default location of the light source. For the slot, it should be just the opposite that of the screw head. The walls of the slot nearest the light source would be in shadow since they are indentations

in the screw. The direction of the light source is edited and the contrast is adjusted to secure greater variance in the highlights and shadows of the slot. The effects of these edits are shown at right.

The groove effect has increased in realism, but still does not look like its real-life counterpart. Grooves are not flat across their span. The tip on a screwdriver goes further down into the slot than the outer perimeter. That means the slot is deeper in the center, and then slopes upward to the surface of the head. Let's simulate that effect next.





The image, above left, is first cloned. The clone is allowed to remain over the original image, but is stripped of its beveled edge. This produces the center image. The clone is then given a circular transparency. That process is shown in the graphic at right. The transparency allows outer areas of the underlying bevel to show through while retaining the opaque center of the clone. This darkens the central area of the slot simulating more depth in that region.

For the final graphic below, slots were centrally aligned above a screw head. All elements were then grouped. The graphic shows various screws placed into mounting holes. The dark outline allows the full effect of the shading and highlights on the screws to display to their best advantage.

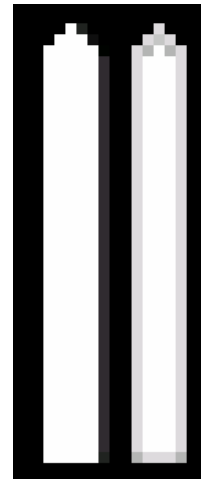


What do you suppose the last step for these bolts would be? Grouping? No, they are already grouped. Rotation is the correct answer. Unless you want a panel to look as though Mr. Perfect installed every gauge, the slots of the screws should be randomly rotated. This will showcase another of XaraX's features. Once the direction of the light source is set, it stays constant even when objects are rotated. That includes objects that have received bevel effects, transparency, or have been grouped together. To rotate an object, click it twice to activate the rotation handles, shown at left, and then spin the object. XaraX calculates the new highlight and shadow locations automatically.

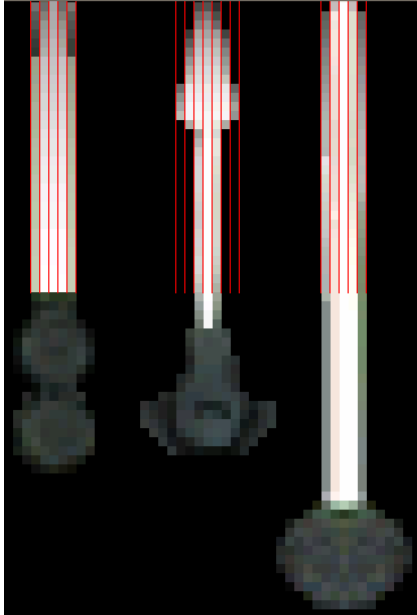
### Needles

This mechanical equivalent of a pointing finger has a history in aviation design. Shapes have ranged from clock-like ornamental hands to a rather mundane appearance. The needles in today's gauges are purely functional. But that doesn't mean they have to look like sharpened sticks. Although shapes will be discussed, the primary focus for this topic is producing needles that can rotate while minimizing jagged edges.

At right, two needles are shown. They are the same size; however, the image to the right is different. The gray outline around that needle helps to lessen the stair-step effect that occurs when bitmaps are rotated. It does this by making the effect less obvious. Most gauges in flight simulator that use needles will display them in fairly small sizes. That, too, contributes to smoothing the edges as the BMP is angled.



The previous illustration showed a needle that had a width of 5-pixels. Two of the five pixels were used for feathering. Stated another way, 40% of the width was devoted to feathering.

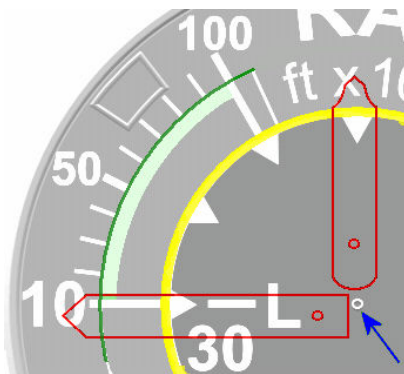


Feathering is a term that was discussed a few pages back, so you understand the concept. But feathering with XaraX is only one technique that can be used on needles. A new tool will be introduced that produces results equal to or better than feathering. This new procedure will be referred to as "contours/contouring"

The three needles at left were taken from the Baron. You can see the percentage of feathering remains around 40-percent. While adherence to a formula is frowned upon for most design work, it does provide a place to start. But, bear in mind, satisfactory performance from a needle can

only be determined by having a working gauge. Under those conditions, a clearer judgment can be made on whether to modify needle graphics. If a needle appears smooth along its edge as it rotates, then that is acceptable performance.

Since the demo gauge and all the miscellaneous components have been drawn in XaraX, so too will the needles. They will be designed to a size that will fit within the gauge to which they are assigned. Once sized, feathering or contouring can then be applied.



For this illustration, I will return to the gauge used for the radial tick demonstration. That gauge requires two needles. Let's design those two elements and see what steps are needed for both feathering and contouring.

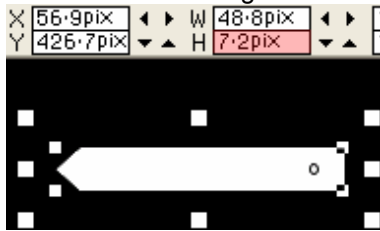
At left, the body of the Radio Altitude gauge has two circular scales. The horizontal needle (outlined in red) will use the outer scale (dark green). The vertical needle will use the inner scale (yellow). The two red circles near the end of each needle indicate the rotation points for both pointers. The blue arrow indicates the center of the gauge. The two needles will have their pivots placed directly over the center of the gauge. When in that position, the point of both needles will barely touch their respective scale. The distance from pivot point to

scale determined the length of these needles. Width is a matter of taste. Some may prefer skinny needles, some big mamas.

The two needles above were given a red outline for demonstration purposes. In actuality, they are created in solid form like the two at right. For the color, 100-percent white was chosen. Feathering and contouring will decrease the white value around the perimeter causing it to become more blended into the black background on the face of the gauge. For now, forget the rounded and pointed ends on these needles. We will focus on those shaping techniques shortly.

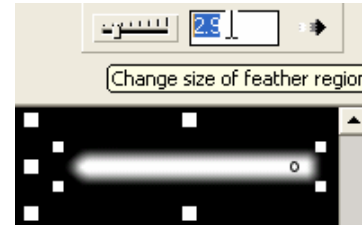


Needles are constructed either horizontally or vertically. Which direction hardly matters. When the gauge is first activated, the initial angle of rotation will be determined by the XML code instructing FS how to draw the needle.



A bit of math; the diagram at left shows the horizontal needle selected. At the top of the XaraX screen the "H" data box (red) indicates the needle is 7.2-pixels in height. Forty-percent of that value is 2.9 pixels.

Using that value to produce feathering around the needle, the illustration at right is the result.

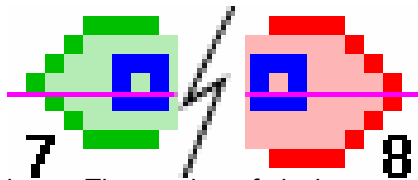


Did I hear, "Hum, not bad"? Yes, I agree. However, this is a vector image, not a bitmap image. Let's export it into Paint Shop Pro (using true color) while transforming it into a BMP at the same time. The result of that task is shown below.



This image contains many of the desired characteristics needed for a needle in flight simulator. The solid color (100% white) has been retained in the center. The bands radiating outward progressively get darker, finally dropping away to black. The bands are symmetrical with three on either side of the centerline. And opposite bands contain color values that are nearly identical. But there is one thing wrong.

The pivot point is not centered. As you can see, it favors the lower half of the needle. While this may be barely detectable when the needle is used at its operational size, it is a good place to pause and briefly discuss the centers of bitmap graphics.



At left, the green needle has a width of 7 pixels, an odd number. The red needle uses 8 pixels, an even number. The magenta lines attempt to define the centerlines of both needles. Since it cannot occupy half a pixel, it may fall to one side or the other of the center pixel.

In the green needle, a true centerline cannot be drawn. The number of pixels on one side of its centerline will never equal the pixel count on the opposite side. In this example, the centerline could also have been placed above the center pixel. Although a true centerline cannot be drawn, the graphic does have a center point (inside blue circle). Having an off number of pixels in this graphic may be an advantage for two reasons.

First, the needle can be created with a sharp point at its tip. This example shows a single pixel. Second, a pivot point (blue circle) is located in the same plane as the tip of the needle. That allows the point to rotate evenly around the pivot.

In the red needle, a true centerline can be drawn. It divides the graphic with an equal count of pixels on either side of the line. However, this may be disadvantageous for two reasons.

First, the tip of these needles will be blunter. In this example it consists of two pixels. Second, a pivot point (blue circle) cannot be located so that it has an equal number of pixels on either side. A pivot that is offset may prevent the tip of the needle from rotating evenly.

Remember that we are discussing a difference in the centers of these two graphics of one-pixel. In practice, this may be meaningless if gauge graphics are small when used on an aircraft panel. At larger sizes, it possibly could play a factor.

For my money, I prefer to keep needle graphics at an odd number of pixels. That suits my psychological need for having a design that is balanced. But this balance also requires ignoring Xara's ability to work in decimal sizes. We should not use this degree of accuracy when constructing needles. In fact, constructing a needle with a width of 7.2 pixels, and then feathering it by 2.9 pixels contributed to the white needle above having an off-center pivot point.

Now that we know a little about the centers of graphics, let's redo the white needle using only whole numbers. We will make the needle seven-pixels wide, 7.2 rounded-off, and feather it with a value of 3-pixels, 2.9 rounded-off.



Redoing the graphic using the values just mentioned produced the above results. Now the pivot is centered and color symmetry has been maintained to an acceptable degree. When this needle is reduced to gauge size, any variation in pixel color for the different rows will not be distinguishable. A needle at operations size will resemble the smaller image at right. As you can see it is not necessary to be overly fussy about color symmetry.

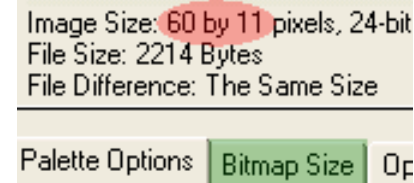
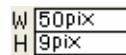


In the above illustration, various shades of gray occupy corner areas and around the tip. Paint Shop Pros states there are 56 unique colors in that graphic. If you wish to edit the color of any pixel/s in PSP, you will not be breaking any laws. In fact, that is one reason for giving graphics a final polish using a program that can work at the pixel level like Paint Shop Pro. We have the freedom to modify images until they are suitable to our needs and our tastes. This is not fast-food imagery where we have to consume whatever is tossed at us. We can "hold" the onions, graphically speaking.

The finished version of the vertical needle is shown at left. It was modified in size to a width of 7-pixels before receiving a 3-pixel feathering. The results are as satisfactory as the horizontal needle. You can see the four-sided tip (at right) did not survive the conversion too well. Was creating such a tip a waste of time? Perhaps, but that is for you to judge. However, nothing ventured, nothing gained.



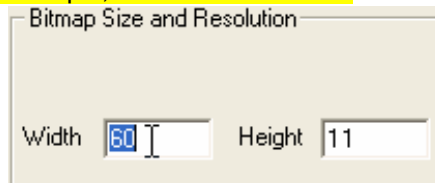
**Tip:** Consider this safeguard regarding graphic sizes when exporting to PSP. At right, the selected black rectangle was drawn with a width/height of 50 x 9 pixels. After exporting, we want the bitmap image to equal these values.



As this rectangle is exported into PSP, double check its size (red area) inside the Export box shown at left. In this example, the two sizes do not match.



If that is the case, then open the Bitmap Size tab (green area). Inside, you will see the Bitmap Size and Resolution values in the illustration at right. The width value can be changed to 50; the height value will change automatically to a proportional value, in this case, to 9. Reset these values, when needed, before completing an export.



Sometimes the size parameter in the Export box gets out of sync with actual drawn size and must be reset. This is usually caused by having reset the size of a bitmap during a past export and forgotten about it. However, XaraX did forget. It still remembers the percentage of change and applies that size change to new objects as they are exported.



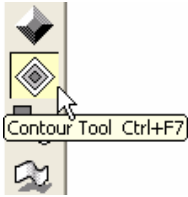
Checking the exported size is important because it not only affects the size of the bitmap image in PSP, but also the size of feathered regions, if any.

At left, the black 50 x 9 rectangle received a 3-pixel feathered edge. It is exported into PSP. That



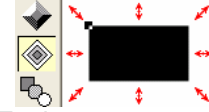
bitmap is seen at right. The red V helps to distinguish each line of pixels across the width. You can see from this illustration the feathered edge of the bitmap image still retains the three pixel value across the 9-pixel rectangle.

## Contouring

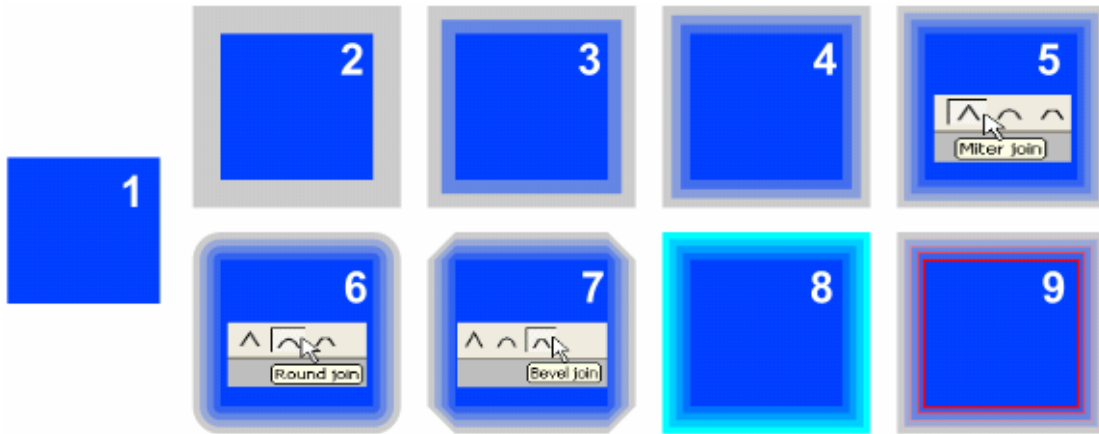


The second method used to smooth edges around a graphic employs the Contour Tool. This tool is located along the left side of the XaraX screen. It is directly below the Bevel Tool. As you will see, in many respects it functions like the Bevel Tool although it produces entirely different results.

At right, a black rectangle is shown selected. When the Contour Tool is chosen, double-ended arrows appear around the object. These indicate that contours can be drawn to the exterior or the interior. This is a characteristic similar to that of the Bevel Tool.



A tool description would state that the Contour Tool draws one or more lines around a selected object. These are the contours. There are many options on how those lines are drawn. One of those effects is especially desirable for needles. But before demonstrating that, let's have a visual demonstration of this tool and see a few of the options that will lend variety to contours.



- Number 1** is the original object to be contoured. All contours will be exterior.
- Number 2** has one contour. It has a width of 8-pixels. The contour is colored gray.
- Number 3** contains two contours. The gray contour has begun blending with the blue.
- Number 4** contains three contours. Even more blending has taken place.
- Number 5** contains four contours, the default value. Square corners denote Miter joins.
- Number 6** has four contours with Round join. This is very similar to Curvature of objects.
- Number 7** uses the Bevel join.
- Number 8** has the contours colored cyan instead of gray.
- Number 9** shows the rectangle with a red border at 1-pt.



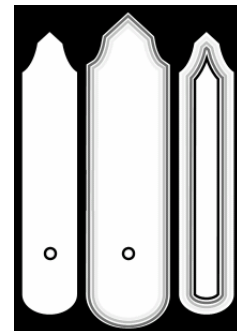
There can be two borders when contours are involved. The object can have a border, but the contour can also receive a border independent of the object.

At left, the blue object has a red border. The gray contour was turned black for better viewing, and then the contour was given a blue border. The blue and red borders begin to blend about midway.

Contours cannot be beveled with the Bevel Tool. Not to be outdone, neither will a beveled object allow contours.

As stated, contours can be either interior or exterior. While interior bevels are useable on gauge graphics, interior contours are not. The illustration at right shows both types of contours.

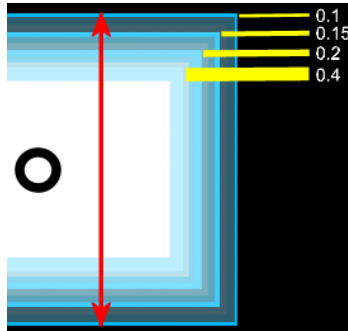
The image on the left is the original needle. The center image is an exterior contour. And at the right is an interior contour. The interior version retains the size of the original image but draws lines in reverse color. The darks are nearest the center and grow progressively lighter near the perimeter. This is exactly the opposite effect needed for needles. While the exterior contour produces color lines correctly, it also grows the image. As you can see the center graphic is larger than the original needle





For needles, only exterior contours will produce acceptable results. But, because that effect increases the size of the original image, some adjustment will be necessary to prevent having a needle with a weight problem.

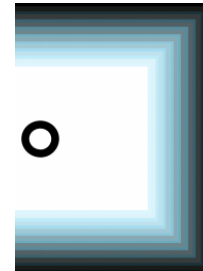
By default, contours are drawn using lines in shades of black, but all colors are possible. For needle graphics, the default color is used because we want a blending from the white needle to the black background. XaraX provides that effect automatically. Think of contouring as objects having multiple borders with each border having a separate width.



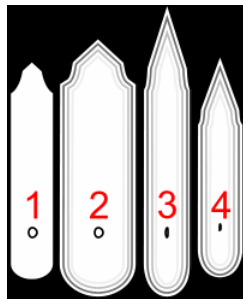
At left, the contours have been given a blue color for clarity. The yellow lines mirror the width of the four contours. Four is the default number of lines. As seen here, the wider contour lines are nearer the center of the graphic and contain the lightest shade of color. The lines decrease in width as they approach the edge of the object while becoming darker.

At left, the original white needle measured 7-pixels in width. A contour value of 3-pixels was applied. That number is a carry-over from the feathering technique. The red arrow indicates that the contours increased the needle to a width of 12.3-pixels.

At right, the number of contours has been increased from four lines to eight lines.

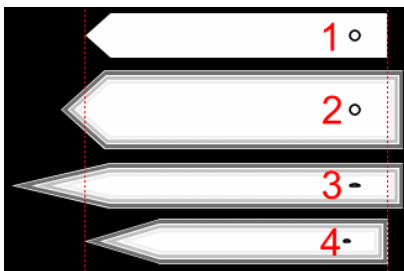


The contour value remained at 3-pixels so the width of the needle is again 12.3-pixels. Smoother shading is the obvious result. But is that an advantage? Perhaps you are beginning to see how contours give a vector image a bitmap appearance. That is definitely an advantage as will be shown.



The Contour Tool can sometimes produce unexpected results. The only way to know the final effect of an applied edit is by experimentation. For example, the vertical needle 1 at left was given a default contour of 3-pixels producing image 2. Image 2 was then selected and decreased in width using the mouse. That operation also elongated the needle producing image 3. In image 4, the needle was shortened back to the original dimension.

Let's see how the fourth image would look if exported into PSP. At right, the exported BMP is seen. Folks, it doesn't get any better than that! But, was it a fluke? Let's try the horizontal needle to see if a second home run is in the cards.



At left, the same four steps have been applied to the horizontal needle 1. The red Guides are used for length reference. Again, image 4 is exported into Paint Shop Pro. The result is seen below; perfect color symmetry again. Although hard to see in this illustration, the top and bottom pixels are not black; they are a dark gray.

Count 'em. Both the vertical and horizontal needles used a width containing an odd number of pixels, 7 and 9.



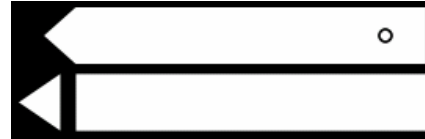
As you may have noticed, pulling and tugging on contoured objects to reestablish the original dimensions creates distortion

in circular pivots. Why are these points needed, anyway? Most needles have no visible point of rotation. They are used mainly to set rotation coordinates for XML code although circles are not required for that task. Instead, a single dark pixel can be used. After obtaining coordinates and checking for correct rotation, the points can be removed from the needle graphic before finalizing the gauge. Should you want a point to be visible on a needle, then a non-distorted pivot can be exported to PSP. Then, a copy/paste operation would cover the malformed circular pivot.

The demo needles are not very stimulating as far as shapes are concerned. But, by using the tools available in XaraX, almost any outline is possible. Although exotic shapes are not suggested, a bit of flair may be. Many of the tools needed to form needles have already been covered. But a few new techniques will be introduced.

Let's begin by making the two simple demo needles.

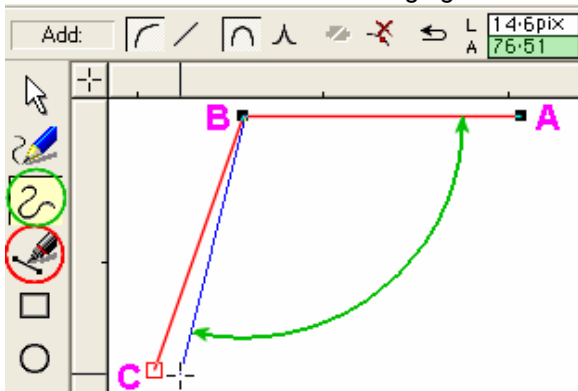
At first glance, it may appear the horizontal needle was constructed by combining a rectangle with a triangle. One may think that by grouping or adding the two objects together, the desired needle shape would result. At right, if the two polygons on the lower graphic were combined, they would produce the original shape shown at the top of the illustration. But that is not a finished needle. There is also feathering or contouring (not both) that must be applied.



Grouping or adding two objects will allow feathering, but not contours. As mentioned before, this tool often has its own ideas regarding shapes. For example, if the two objects were combined, then contoured, the graphic at right would be the result. Both objects have become enlarged giving an unusable needle. This is the result even when the two objects are grouped or added together prior to contouring.

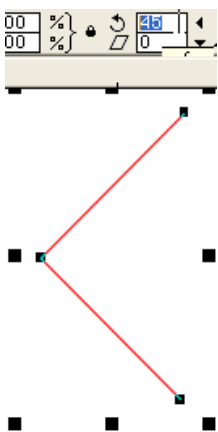


To produce a sharp point for this needle and retain the ability to contour, the Combine Shapes/Slice Shapes tool inside the Arrange menu is used. Two objects are required for slicing, the slicer, and the slicee. The slicee is a plain rectangle drawn to the dimensions of the desired needle. For ease of viewing, a black rectangle will be used for this illustration. It stands 7-pixels high and 49-pixels wide, the rounded-off dimensions of the horizontal needle. The object used to cut a point on the needle will be a custom-made dogleg line containing a 90-degree angle.



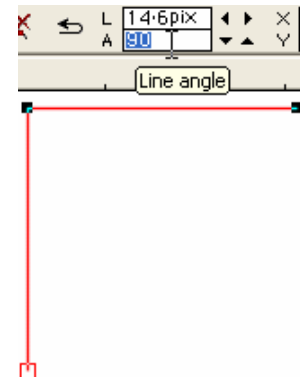
At left, the Pen Tool (red circle) was activated. Points **A**, **B**, and **C** were plotted to form the red line with a width of 0.1 pts. The angle at point **B**, between the green arrows, should be about 90-degrees. A right-angle will slice a suitable point on the needle.

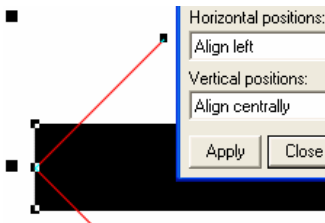
To check this angle, the Shape Editor Tool (green circle) is activated. This in turn activates the information bar at the top of the XaraX screen. Point **C** is selected. The angle data is then displayed inside the Line Angle box (green, above). In this case, the angle reads 76.51-degrees.



If Point **C** is moved slightly, XaraX will create the blue line, seen above, as a visual indicator of this movement. And, as point **C** is shifted, the value in the Line Angle box will constantly change. Values can also be typed directly into the box. At right, the value of 90-degrees has been entered. This forces the dogleg lines to form a right angle at point **C**.

These lines must now be rotated 45-degrees to position them correctly for the slicing operation. Rotation is done using the Angle of Selection box shown at left. The 45-degree value is entered. The graphic at left shows this rotation. When in this position, the lines can now be used to slice the black rectangle.



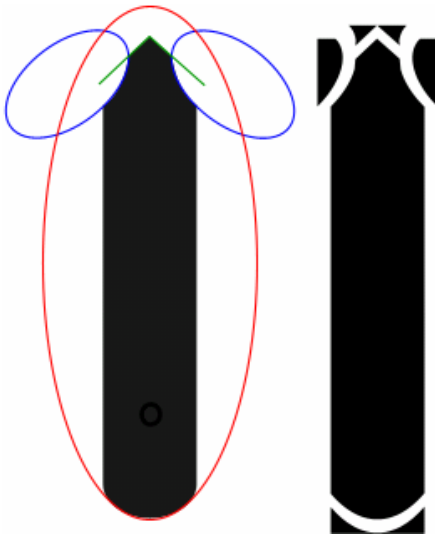


At left, the lines are aligned with the rectangle using the Object Alignment box. The values shown inside the two windows will position the objects as shown. The angle of the dogleg sits directly along the left edge of the rectangle. Vertically, it occupies the center of the rectangle. When the two objects are in this position, the Slice Shapes tool can do its work.

The result of the slicing operation is seen at right. The two sliced parts have been separated for this illustration. The section on the left is discarded leaving the horizontal needle containing a pointed tip.



The vertical needle will begin with a rectangle drawn to the desired needle size. This will also be shaped using the slicing technique, but given a bit more pizzazz. The setup is shown at left. The slicers included three ovals and one dogleg line (green).

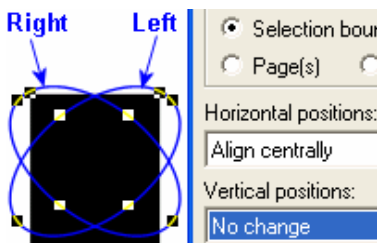
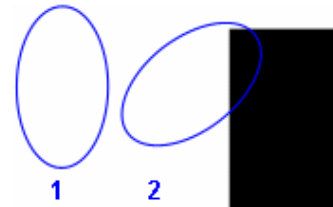


The red ellipse produced the first cut. It was important this object be taller than the black rectangle so only the lower end would be sliced.

The two blue ovals were worked one at a time. You cannot select both plus the black rectangle and make two slices concurrently. The tip of this needle is formed by the dogleg line and is very similar to the one produced for the horizontal needle.

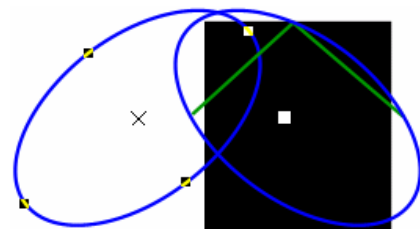
In every case, the Object Alignment box was used to position all objects, at least partially. The positioning of the two blue ovals was a special case because they were required to cut symmetrical slices from both sides of the rectangle. How they achieved these cuts is described next.

An oval was drawn to the approximate size needed for the slice. That is figure 1 at right. The oval was rotated clockwise and positioned near the end of the black rectangle. That is figure 2. The position chosen was a judgment call. The location needed was one that would slice a suitable arc from the side of the rectangle. This location determined the vertical alignment or Y-position for the oval.



The oval was cloned, and the clone was flipped horizontally. Those two ovals can be seen at left. They were aligned centrally in the horizontal to the black rectangle. This positioned both ovals at a known beginning X-value. In this illustration, they have been marked Right and Left. If the right oval is moved a set number of pixels to the right, and the left oval is moved an equal number of pixels to the left, symmetrical alignment will be achieved.

At right, the left oval was selected and moved six-pixels to the left using the left-arrow key. The process will be repeated by moving the right oval six-pixels to the right. This will position both slicing objects at equal but opposite positions atop the rectangle. From this point forward, slicing the circular parts from the rectangle follow the same steps illustrated for the horizontal needle.



At right, the green dogleg is shown centered above the rectangle. Both objects were then aligned vertically using the "Align tops" tool inside the Alignment Box. That positions that slicing object for the final cut.

Shapes for needles are limited only by how much time you wish to devote to experimenting with objects and their slicing partners. Using custom lines, slices can be made into rectangular objects to produce a needle of almost any shape. But, remember, too much detailing will likely be lost when needles are feathered or contoured and reduced to operational size.

To wind down this tutorial, a few miscellaneous loose ends will be covered. These are techniques used to create special objects that may be found to be helpful on certain gauges. For the finale, an exploded view of a gauge will show objects comprising a complex design. Viewing a gauge in that manner reinforces the fact that a moon shot begins with someone filling a gas tank.

### Trimming

There may be times you wish to modify bitmaps to make them more suitable for a particular need. This could involve removing the background of a graphic while retaining an item pictured on the graphic. This demonstration will illustrate how to import a toggle switch, and then trim away the background clutter. This is the switch from the Radar gauge shown at the beginning of this tutorial.

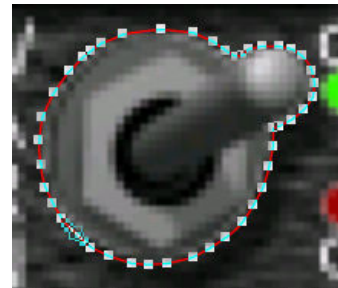


of this tutorial.

At left, the toggle is surrounded by the texture of the gauge, plus text on either side. As shown, this switch would probably not be suitable in a gauge of your design. But if the clutter around the switch was removed, then it may be useable.

A trimming operation is simply the slicing technique using a custom-shaped slicer. The slicer is fashioned using the Pen Tool to outline the part of the image to be retained.

At right, the pen has plotted the points shown selected. The line was set to a border width of .01-pts and colored red. The object color is transparent. Because this line will begin and end at the same point it will produce a closed object. That is why the transparency is necessary. Otherwise, when the loop is closed, the object would automatically fill with default black. This would cover the switch.



With the line selected as shown, it can be adjusted with the Shape Editor tool until it fits perfectly around the switch. The slicing operation requires the bitmap and the line to be selected. The Arrange/Combine Shapes/Slice shapes tool can then be used to separate the image into two parts.



At left, the switch is trimmed away from the background. They have been moved apart for illustration. The background can now be deleted. This switch is a XaraX object with all the privileges that implies, including the Wall shadow seen at right.

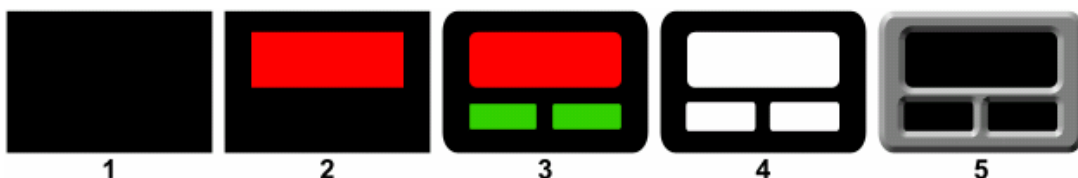


What about the switch in an OFF position? That requires another bitmap showing that position. XaraX cannot flip switches for you.

### Multiple Combine Shapes

As demonstrated earlier with the vertical needle, an object can receive more than one slice. In that demonstration, the rectangle used for the needle received a total of four slices. Multiple operations also apply to subtractions, additions, and intersections.

Here, a rectangle (1) received three subtractions from the smaller rectangles. Curved corners (3) were applied to all objects before the subtraction. A color change to gray, and then a Flat bevel was applied (5). Finally, another black rectangle on bottom finished this gauge body.



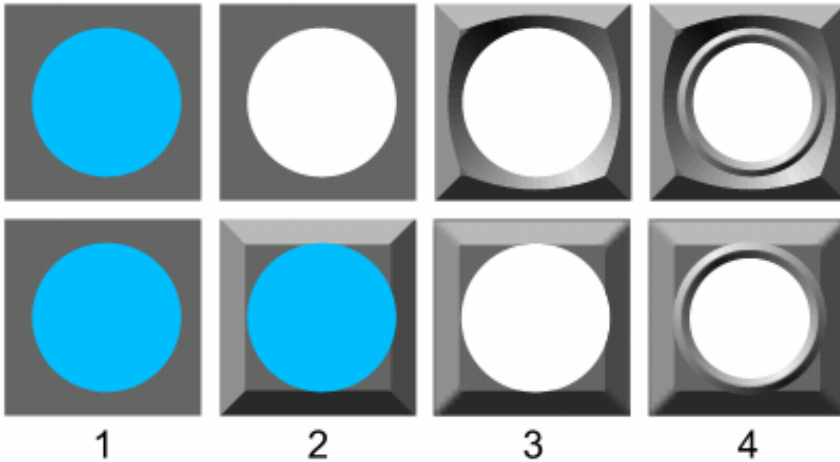
## Rings

A ring is a great way to spruce up a gauge and give it a face. They are easily made from two circles of different diameters (gray 1 and blue 2). The circles are subtracted leaving a hole in the larger circle (3).

The size difference between the circles determines the width of the ring. Once made, the ring can receive bevels, shadows, etc (4).



Different styles of bevels will produce rings having a surface shaped to almost any profile.



What could you do with a ring? Let me give a simple illustration while demonstrating two ways to bevel an object that was created by subtraction.

Top row: In diagram (1) a circle is centered atop a square. (2) The hole was created in the square by subtraction. (3) The object received a bevel. Note that this action produced a bevel along

both the interior and exterior edges. (4) A round-beveled ring was added for effect.

Bottom row: In diagram (1) we have the identical setup as the top row. (2) In this step no subtraction takes place; instead, the square is given a bevel. (3) The subtraction has been performed. Note that the square has a bevel on the exterior edge only. (4) A ring was again placed for to give shape to the circular hole.

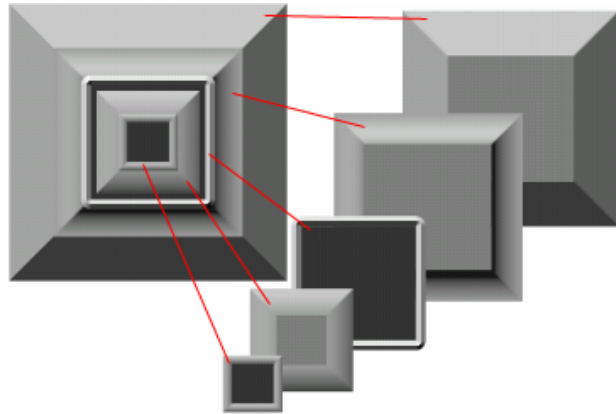
## More effects



Subtracting (or adding, intersecting, and slicing) two objects can produce countless effects not illustrated in this tutorial. One example of subtraction is shown above. The dark blue circle was cloned. The clone (seen here in light blue) was shrunk in diameter. The two circles were subtracted leaving a wide ring. This ring was then subtracted from a gray square. The square was beveled and given a shadow. The center part of that graphic is perfect for housing a needle. Appropriate marking in the white face would complete the gauge.

The point of the last few illustrations is to prompt experimentation. A tutorial cannot cover every nook and cranny of XaraX. It can only serve to introduce the reader to some of the more common features. With experimentation, it will be discovered that the most complex objects are usually those that are constructed in layers, or stacks. Examples of such objects are shown next.

At right, a molded button has been built by stacking five different bevels. Perhaps this will stimulate ideas.



This tutorial ends with the two graphics below. By now, you will recognize many of the effects shown on the radar gauge. It may have looked complicated and outside your abilities when shown on page 2, but now the mystery has waned. This gauge, any gauge, is nothing more than a series of techniques that are applied to multiple objects. When arranged in a logical order those objects simulate what is, or what could be, reality.

This concludes the Gauge graphic tutorial.

