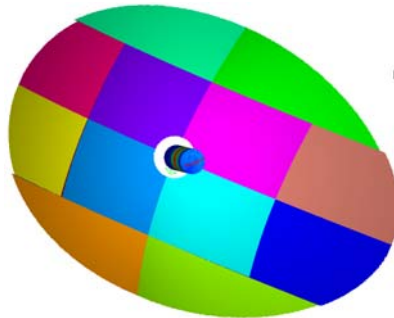
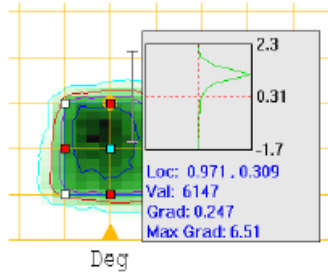
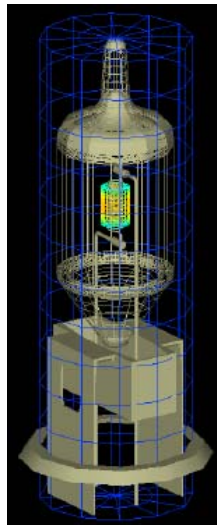


REFLECTORCAD

segmented reflector design software



User's Guide

**BREault RESEARCH ORGANIZATION, INC.
ISO 9001 CERTIFIED**



This manual is for use with ReflectorCAD® 1.5.

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Chapter 1

A Quick Tour

This chapter introduces ReflectorCAD™ by way of example. It provides step-by-step instructions and illustrations for building a simple reflector. By following through this example, and the chapter that follows, you will be exposed to most of the principles required for using ReflectorCAD effectively.

1.1 Typical Reflector Design Steps

The typical steps involved in designing a reflector with ReflectorCAD are as follows.

Choose a base surface All segments are initially created on the base surface. Vertex and segment heights are measured relative to it. Typically, this surface approximates the desired shape of the finished reflector. Simple built-in base surfaces are provided. Alternatively, virtually arbitrary surfaces can be imported from an IGES file.

Select a light source One or two light sources (bulbs) can be used. Only one source can be on at a time. The source is used for calculating the reflector's approximate output and aiming segments.

Create and aim segments Segments are created graphically using the mouse. Each segment is directed to illuminate a specific region by moving and reshaping its aim box in the Output view. Approximate reflector output (either positional or directional) can be quickly calculated at any time to aid in making aiming decisions.

Adjust intersegment discontinuities For both performance and manufacturability reasons it is generally best to minimize height discontinuities between segments. Where such discontinuities are necessary they should normally be hidden from the source (in other words, shadowed) to prevent undesired stray reflections. This can be done by adjusting segment aims and/or starting point heights. A simple method for checking edge shadowing is provided in ReflectorCAD.

Export the reflector design Reflector designs can be exported to ASAP™ (via an INR file) or a CAD package (via an IGES file). Other geometric elements (for example, the bulb holder or shelves) can then be added. With this additional geometry in place,

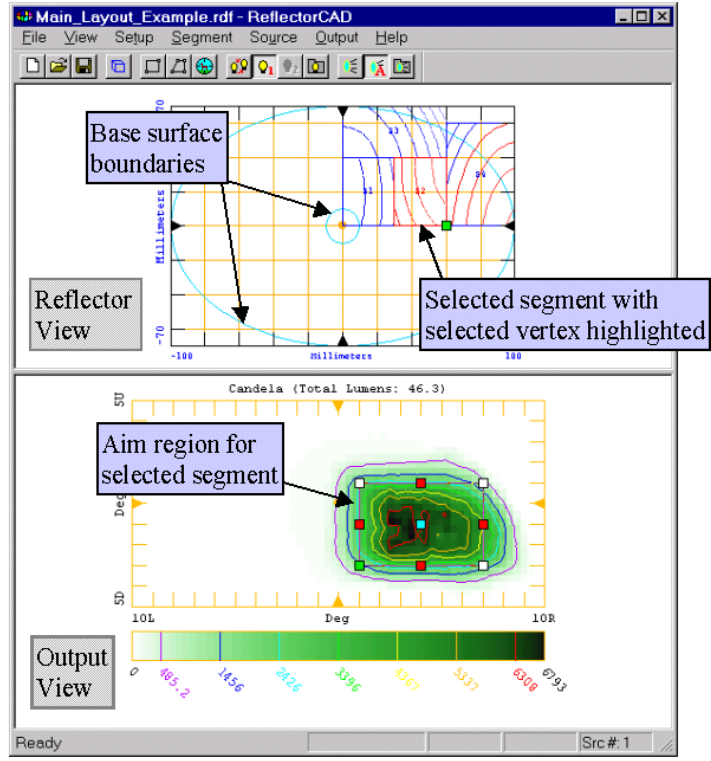


Figure 1.1: The main ReflectorCAD window is shown with key features delineated. In this case the window is shown with the Reflector view above the Output view in a vertical layout. This can be changed to a horizontal layout on the **View** menu.

further analysis should be performed using an optical analysis package, like BRO's ASAP.

1.2 Main Window Layout

Figure 1.1 shows features of the main ReflectorCAD window. The reflector faces in the +Z-direction and is viewed looking in the -Z-direction. In otherwords, if the reflector were a headlamp we would be viewing it from in front of the car. The output is viewed looking in the +Z-direction, as if we were in the car looking at the output on a wall in front of the car. See figure 1.2.

1.3 Design Goal

Our design goal in this quick tour is to create a reflector that produces an output pattern qualitatively similar to that shown in figure 1.3. We want a square hotspot at 2° below the center and a relatively even spread from -15° to 15° horizontal and 0° to -6° vertical.

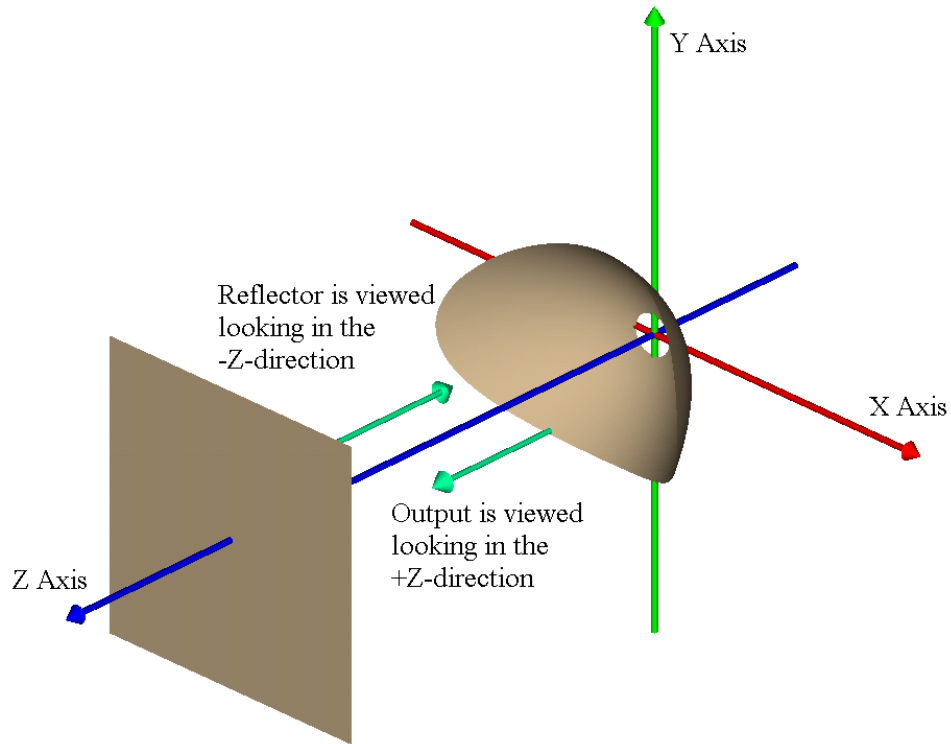


Figure 1.2: Viewpoint orientation for the Reflector and Output views.

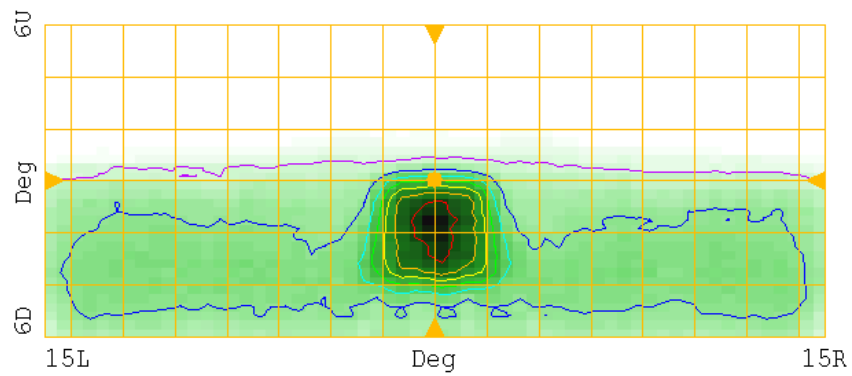


Figure 1.3: The desired output pattern for the quick tour reflector.

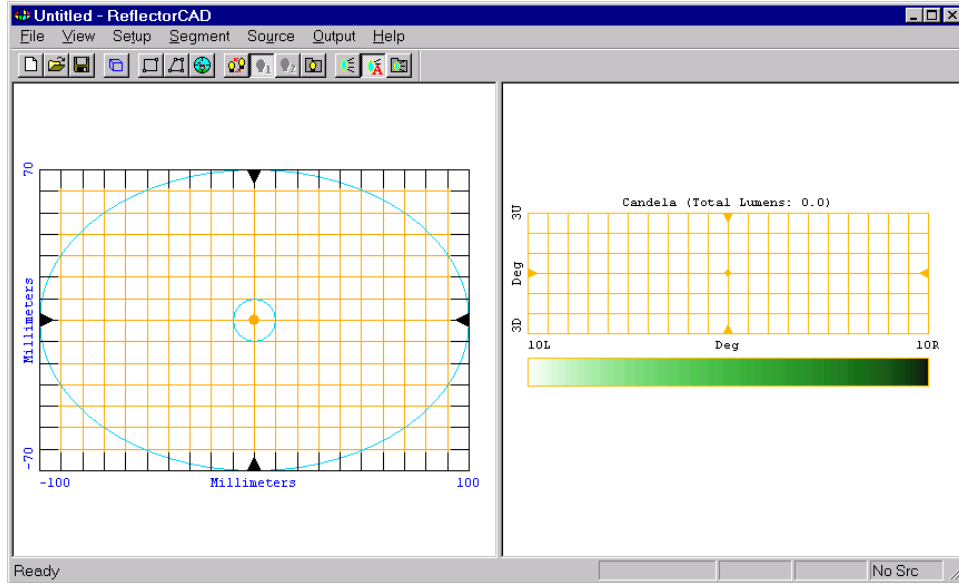


Figure 1.4: Initial appearance.



Figure 1.5: Setting the system units.

1.4 Preliminary Steps

Start ReflectoCAD, if you have not already done so. The main window opens with an initial appearance similar to that shown in figure 1.4. Before we can create our first segment, there are some preliminary steps we must go through. These include setting units, choosing a base surface, selecting a light source, and specifying the output properties.

1.4.1 Set the System Units

Set the system units by selecting **System Units** on the **Setup** menu (for the rest of this tour a menu operation like this will be denoted as **Setup > System Units**). Set the units to 'millimeters' as shown in figure 1.5.

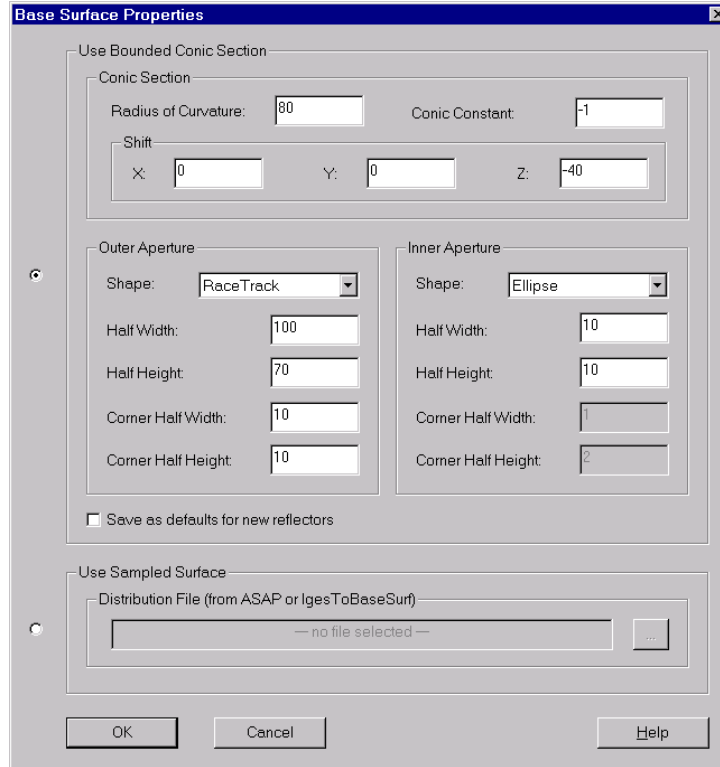




Figure 1.6: Setting the base surface properties.

1.4.2 Choose a Base Surface

The base surface defines the height (Z coordinate) for the starting point of new segments. It also specifies the reflector's boundaries (in the X-Y plane). Select **Setup > Base Surface Properties** and fill in the dialog as shown in figure 1.6. This will make the base surface a parabola (because the **Conic Constant** is -1) with a focal length of 40 mm (because the **Radius of Curvature** is 80 mm). By shifting the base surface -40 mm along Z, we place the focus at the origin. The outer boundary is rectangular with rounded corners (this is called a **Racetrack**). The circular inner boundary serves as the bulb hole.

1.4.3 Choose a Light Source

Choose a light source (bulb) by selecting **Source > Properties** (or by pressing the  button on the toolbar) and filling in the dialog as shown in figure 1.7. Press the  button to select the **HB3** bulb from the **Head&FogLamps** source directory. Once the bulb is selected, click the **View Model** button to get details on the source model. Note that the filament for this source is 31.5 mm above the reference point. We are positioning the reference point at (0,0,-48), which will place the filament 16.5 mm inside the base surface's focus at the origin.

The **Effective Filament Position** (EFP) is reported in the dialog's lower right corner when a valid source has been selected. This is usually the best focus of the rays used to create the source model. Notice that for this bulb, as would be expected, the EFP is very

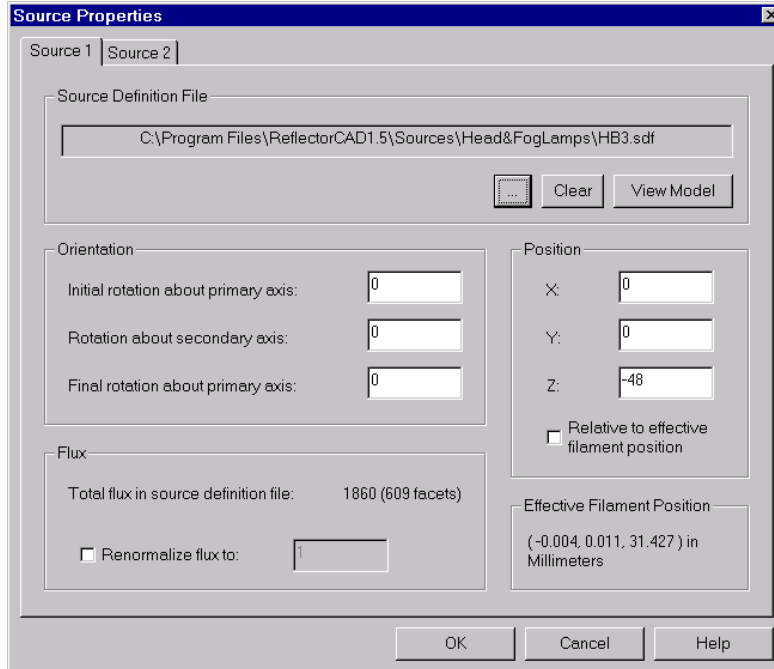



Figure 1.7: Setting source properties.

close to the bulb’s filament center. If the **Relative to effective filament position** box were checked (it shouldn’t be in this example) then the EFP would be used as the bulb’s reference point for positioning.

Only one source is needed in this example, so only the **Source 1** tab should be filled in.

1.4.4 Set Output Properties

Select **Output > Properties** (or click the  toolbar button) and fill in the dialog as shown in figure 1.8. For this example we want far-field directional output with a vertical range of -6° to 6° and a horizontal range of -15° to 15° . The vertical resolution is chosen to provide 3 pixels per degree, while the horizontal resolution provides half degree pixel spacing. The **Reflector reflectance** (85%) and **Lens transmittance** (90%) act as simple scaling factors on the calculated output.

1.4.5 Grid and Snap Settings

To aid in positioning segment vertices and aim points, ReflectorCAD provides grids that can be snapped to. In the Reflector view, right click and select **Grid/Snap Settings** from the popup menu that appears. Fill in the dialog as shown in figure 1.9 (left image). Following the same steps in the Output view, fill in the dialog as shown in figure 1.9 (right image). Finally, make sure the grid and snapping are enabled by checking the **Enable Grid and Snapping** item on the popup menu in each view.

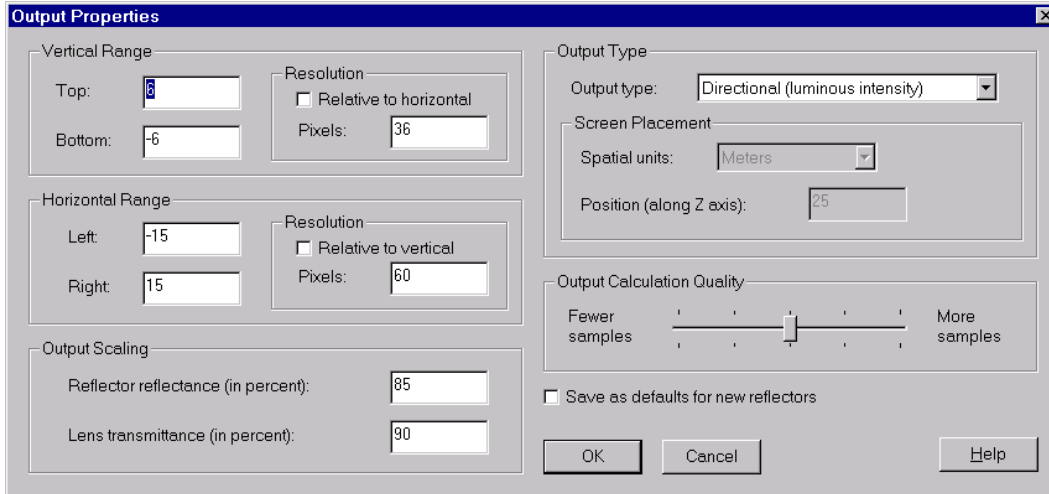


Figure 1.8: Setting output properties.

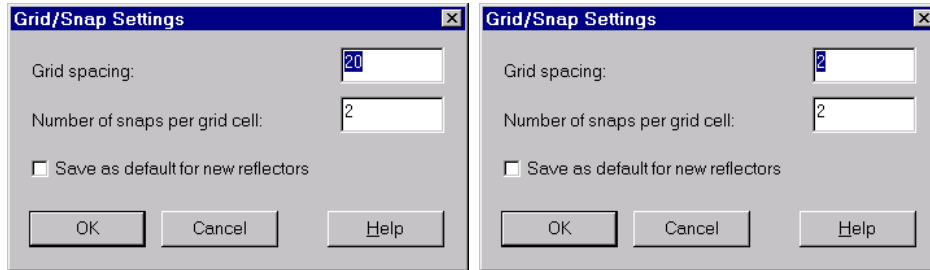




Figure 1.9: Reflector view (left) and Output view (right) grid/snap settings.

1.4.6 Set Default Segment Aiming

Set the default aim, which is assigned to new segments upon creation, by selecting **Segment > Default Aiming** and filling in the dialog as shown in figure 1.10. This will give new segments a 10° horizontal and 4° vertical spread. Checking the **Save as defaults for new reflectors** box makes these the defaults each time ReflectorCAD starts up.

1.4.7 Enable Automatic Output Recalculation

Enable automatic output recalculation by making sure the **Output > Auto Update** menu item is checked or the  toolbar button is pressed down. When this option is enabled reflector output is calculated automatically whenever a relevant change is made. Because output calculation can often take several seconds, it is sometimes quicker to work with this option disabled when making a series of changes. In such a case output can be calculated at any time by pressing the  button.

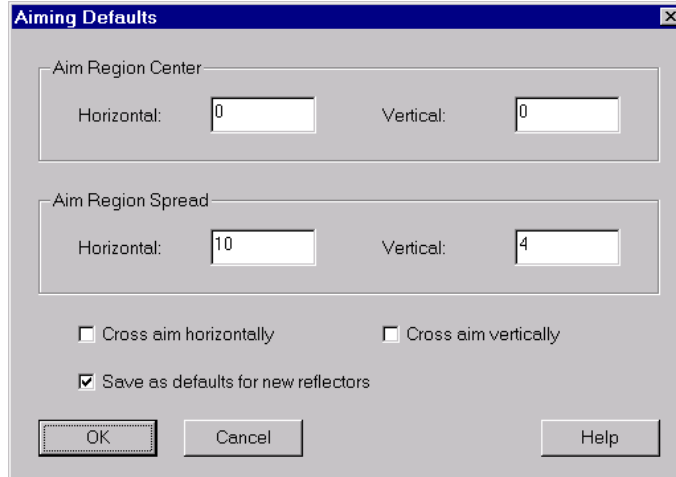



Figure 1.10: Setting defaults segment aiming.

1.5 Create and Aim the First Segment

Now that we're done with the preliminary steps, it's time to create the first segment. Begin by clicking the  button on the toolbar. In the Reflector view, place the cursor at (0,0) and click to define the first corner. Then move the mouse to (50,40) and click to define the opposite corner. Note that the current mouse coordinates are displayed in the status bar at the lower right corner.

If you make a mistake while creating the segment, pressing the **Esc** key will cancel the creation. Alternatively, after any segment change (including creation of a new segment), selecting **Segment > Undo Last Segment Change** or pressing **Ctrl-Z** will undo the last change.

At this point, the Reflector view should look similar to figure 1.11. The new segment, labeled **S1**, is automatically selected as the current segment following its creation. The output produced by this segment is shown in the Output view, and should look similar to figure 1.12.

When a segment is selected its aim box is shown with the output. Unselect the segment by clicking in the reflector view *outside* of the segment. Note that the aim box is no longer drawn in the Output view. When no segment is selected the combined output for all segments is displayed. Now, select the segment by clicking inside it. Note that the vertex closest to the cursor is highlighted with a green box when the segment is selected. If you click near another vertex inside the segment then it will be highlighted, instead. In the Output view, the corresponding aim point is also highlighted with a green box. This shows where on the output screen this particular vertex is to direct its light.

1.5.1 Change Segment Properties

With the segment **S1** selected, right-click in the reflector view and select **Segment Properties** from the popup menu that appears. Fill in the dialog as shown in figure 1.13. The **Save as defaults for new segments** box is checked so all other segments we create will

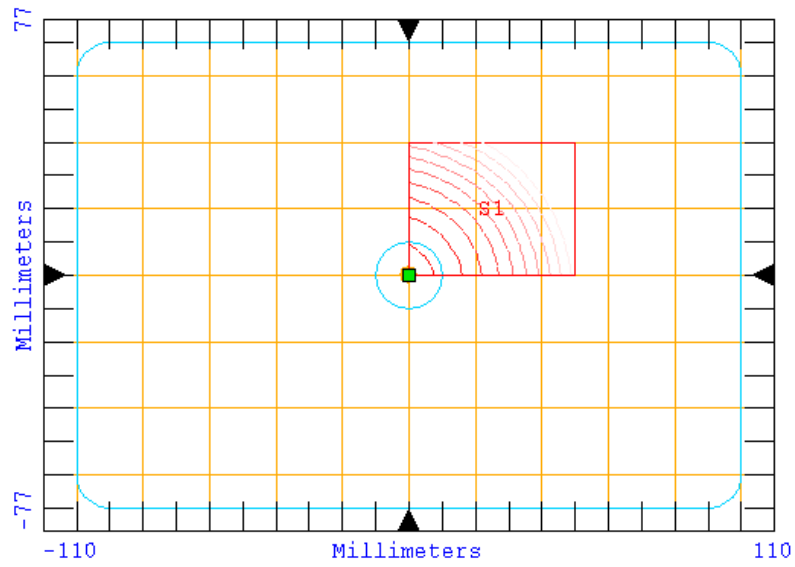


Figure 1.11: Reflector view after creation of first segment.

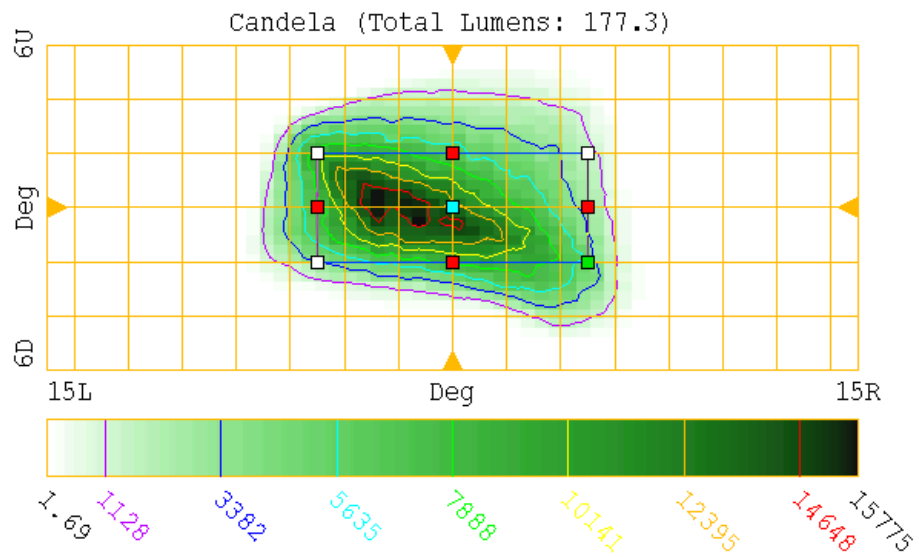


Figure 1.12: Output view after creation of first segment.

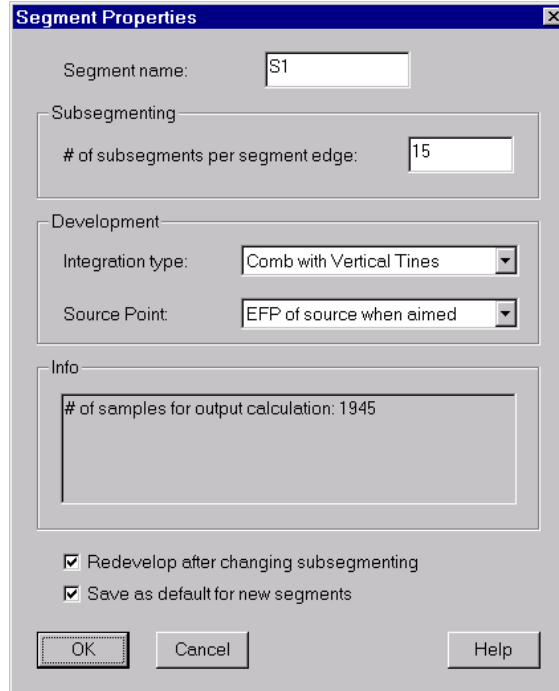


Figure 1.13: Setting segment properties.

have these same properties. Click the **Help** button for information on what the settings in this dialog mean.

1.5.2 Segment Contouring

Contours are drawn inside the segment in the Reflector view. They indicate height (along Z) measured relative to the base surface. Red contours denote a positive distance (e.g., the segment is above the base surface) and blue contours denote a negative distance. The contour colors fade as the height of the segment moves further from that of the base surface. Set the segment contouring properties by selecting the **Segment > Contouring** menu item and filling in the dialog as shown in figure 1.14. This sets the contours to range from -10 to 10 millimeters relative to the base surface with 10 contours on each side of 0. So one contour will be drawn for every 1 millimeter of deviation from the base surface.

1.5.3 Change the Segment's Aim

The next step is to change the segment's aim. To begin, ensure the segment is selected by clicking inside of it, in the reflector view. Next, in the Output view, right click and select **Move** from the popup menu that appears. Then move the aim box to the new location shown in figure 1.15, and click. Next move the aim box's top edge to a new location by dragging the corresponding red square as shown in figure 1.16. Finally, drag the left edge as shown in figure 1.17.

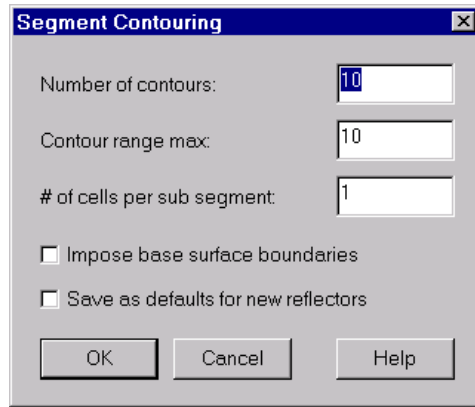


Figure 1.14: Setting segment contouring.

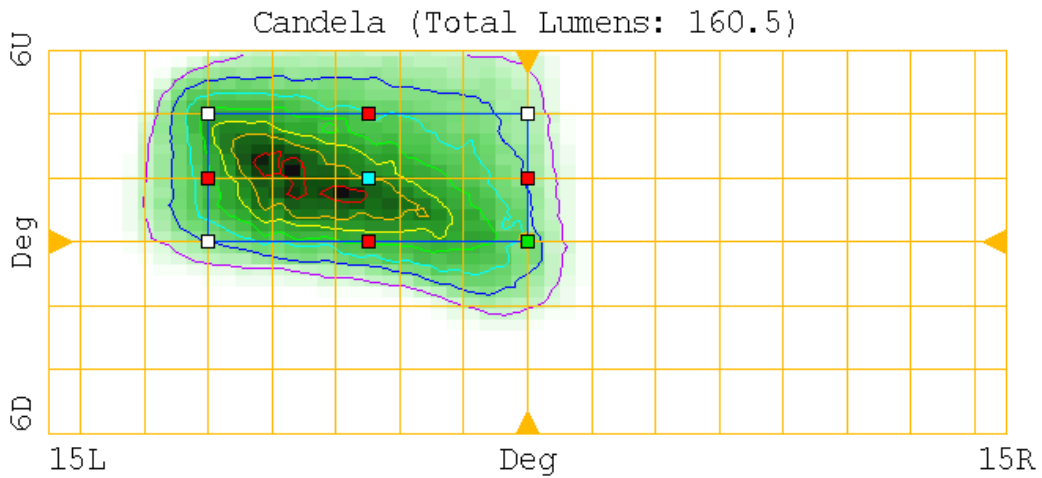


Figure 1.15: New location of segment's aim box after move.

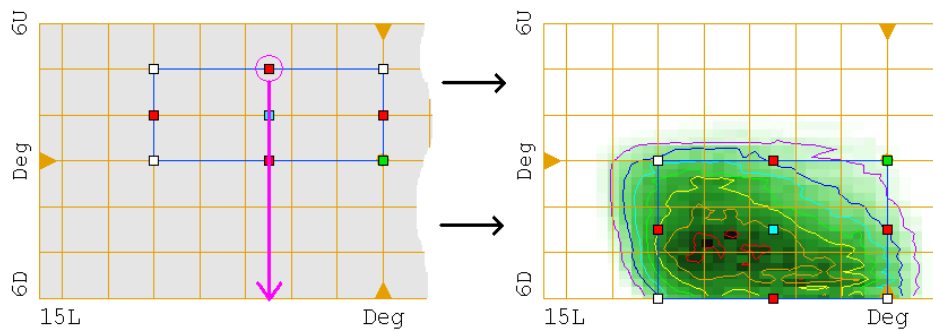


Figure 1.16: Dragging top edge of aim box.

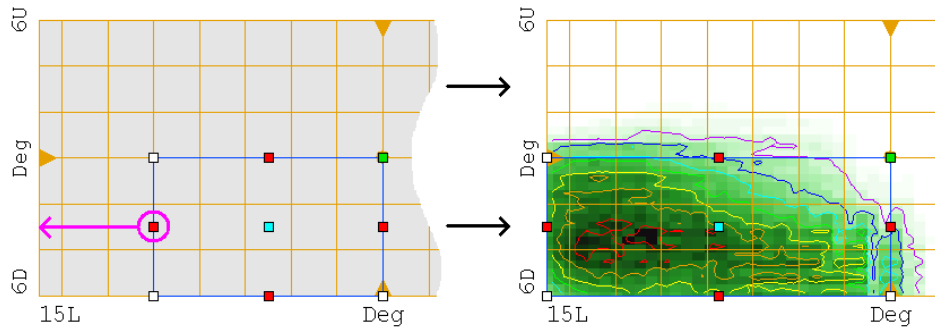



Figure 1.17: Dragging left edge of aim box.

1.5.4 Redevelop the Segment



Each time a segment's aim changes, ReflectorCAD automatically reshapes the segment to achieve the desired aim. This is called **developing** the segment. The aim is used, along with the specified source point, to determine the necessary surface normals. These normals are in turn integrated, starting from the specified vertex (called the **starting point**), to form the segment's new shape. By default, the starting point is the first vertex laid down when a segment is created. For our segment **S1** this is the lower left corner.

During integration, the segment's prior shape is used as an approximation for its new shape to help evenly balance flux across the aim region. To the extent that the prior and new shapes are similar, this approximation is good. If a segment's shape changes substantially its performance can often be improved by redeveloping it after the last aim change.

To redevelop segment **S1**, first ensure it is selected. Then right click in the Reflector view and select **Redevelop** from the popup menu. In this case, because the segment aim changes were small, the segment's output pattern should change only slightly.

At this point, it's a good idea to save your work by selecting **File > Save** or by clicking the  button on the toolbar.

1.5.5 3D Preview

To see what the segment looks like in three dimensions, select **View > Generate 3D View** or click on the  toolbar button. After a few seconds a separate 3D Viewer window should appear, similar to that in figure 1.18. The segment and a cylinder representing the source model are shown in the viewer. The view can be rotated by moving the mouse while holding down the right mouse button. See the 3D Viewer help for information on the other manipulations available. When done with the 3D Viewer window, close it by clicking the  button in the upper right corner.

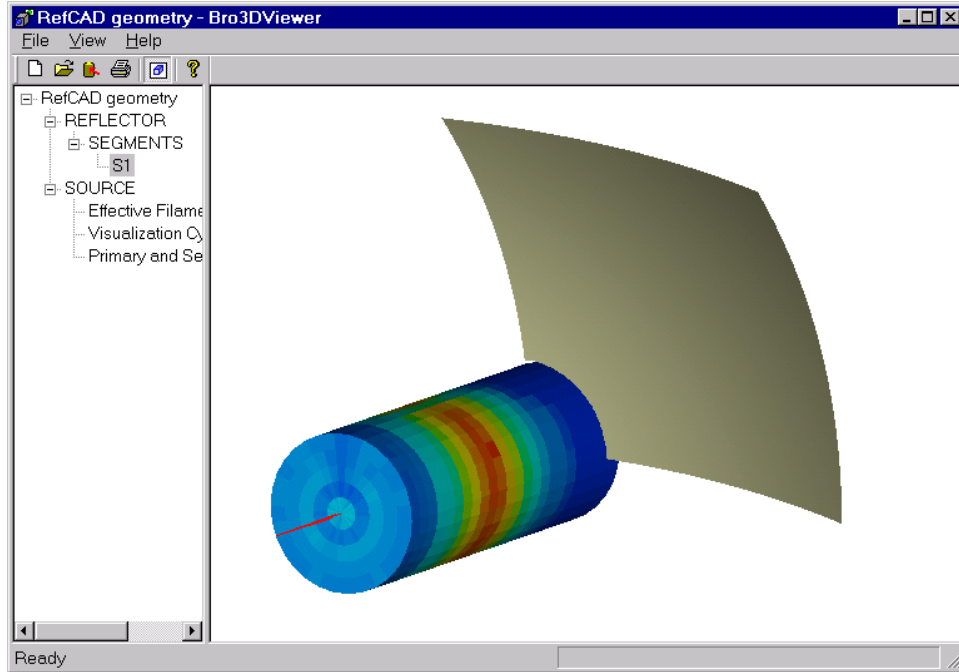


Figure 1.18: 3D view of reflector with one segment created and aimed.

1.6 Create and Aim More Segments

1.6.1 Segment S2

Create a second rectangular segment, starting at (0,40) with the opposite corner at (50,70). The Reflector view should now look like figure 1.19. Change the aim of the new segment as shown in figure 1.20.


1.6.2 Segment S3

Create a third rectangular segment, starting at (50,0) with the opposite corner at (100,70). The Reflector view should now look like figure 1.21. Move and change the width of the segment's aim box to match that shown in figure 1.22.

Try selecting the different segments with the mouse. Notice that only the selected segment's output is shown in the Output view. If no segment is selected, the combined output from all segments is shown.

1.7 Intersegment Discontinuities

1.7.1 Checking Intersegment Discontinuities

Generate a three-dimensional view of the reflector, by clicking the  button. Rotate the view by moving the mouse while holding down the right button and note the discontinuities between adjacent segments, as shown in figure 1.23. It is generally a good idea to minimize

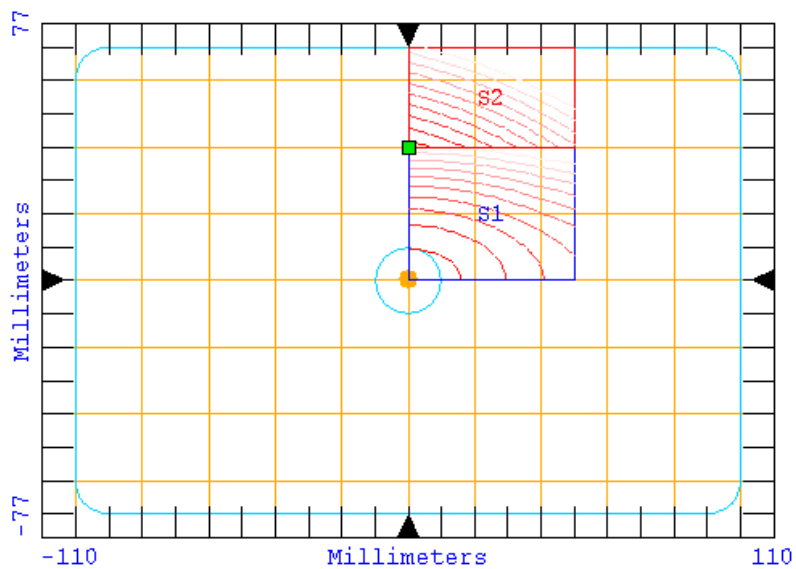


Figure 1.19: Reflector view following creation of second segment.

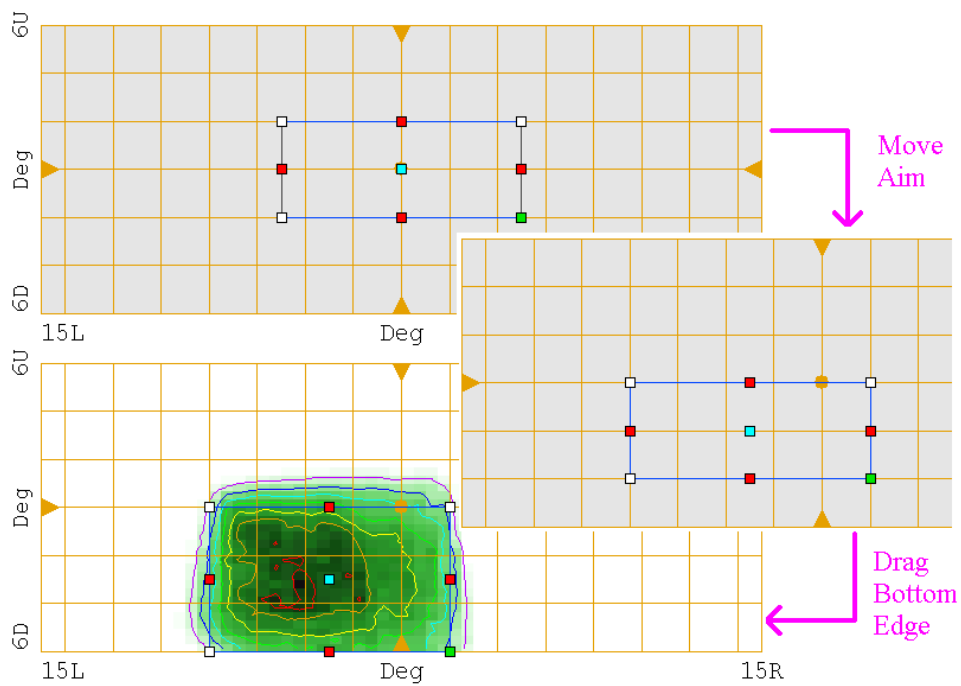


Figure 1.20: Changing aim of segment **S2** .

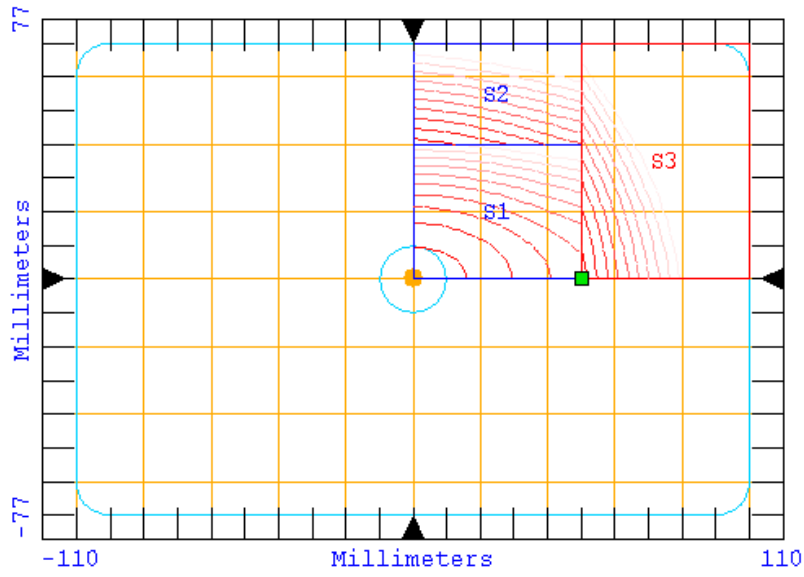


Figure 1.21: Reflector view following creation of third segment.

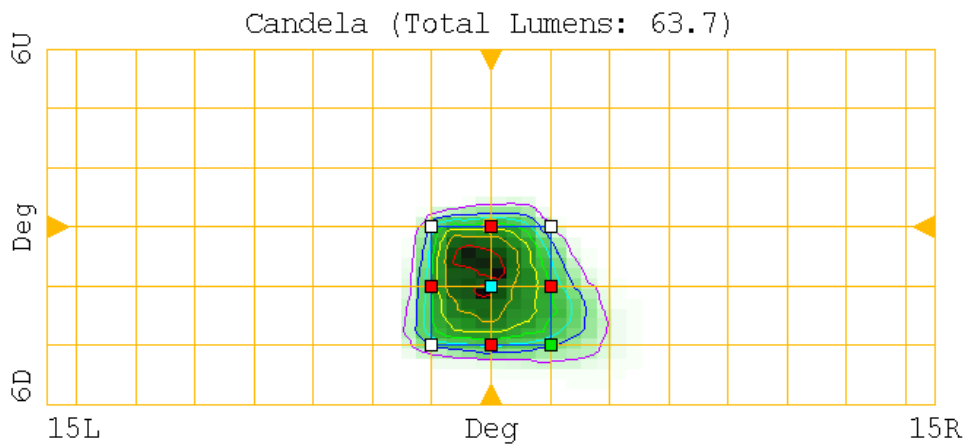


Figure 1.22: Output view showing desired aim for segment **S3**.

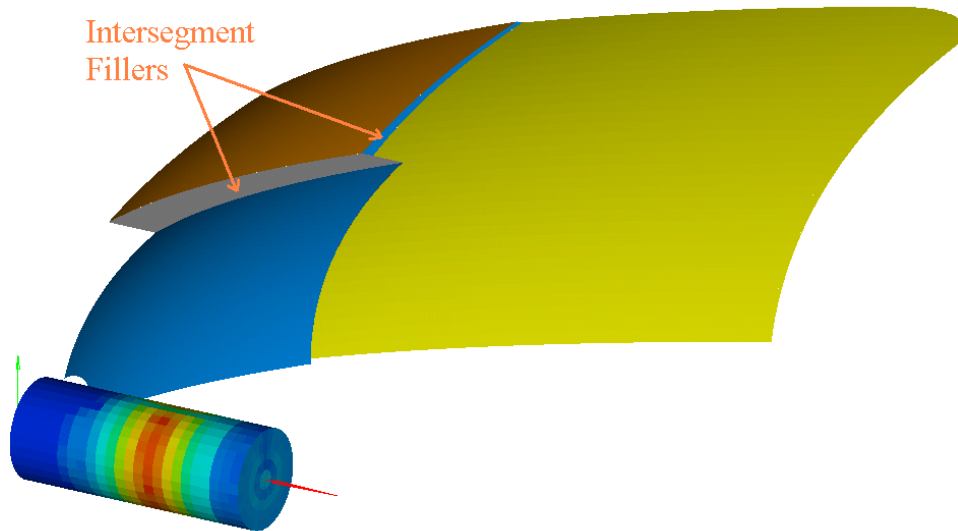


Figure 1.23: 3D preview of reflector highlighting intersegment fillers.

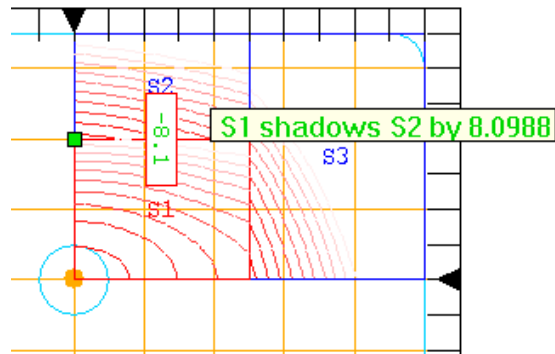


Figure 1.24: Checking edge shadowing between segments **S1** and **S2** .

such discontinuities and ensure they are hidden from the source (shadowed) to avoid stray reflections. In this case the discontinuity between segments **S2** and **S3** is exposed to the source. The other two discontinuities, while shadowed, are large.

ReflectorCAD also provides a more quantitative method for checking edge shadowing. To check the edge between segments **S1** and **S2** , first select **S1**. Then, with the cursor in **S2** , hold down the shift key and left mouse button simultaneously (note this will also work with **S1** and **S2** reversed). A titletip similar to that shown in figure 1.24 will appear. It indicates that **S1** shadows the edge of **S2** by at least 8.09 mm along their common edge. Since the edge is shadowed, the message is colored green. If the edge had not been shadowed it would instead be colored red. The box containing '-8.1' is conveying the same information as the titletip, and indicates which edge is being checked.

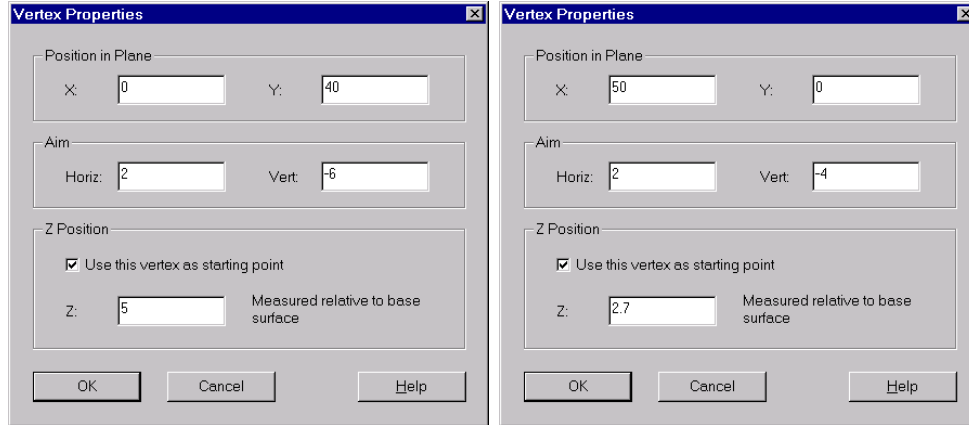


Figure 1.25: Changing height (Z position) of starting point for **S2** (left) and **S3** (right).

1.7.2 Reducing Intersegment Discontinuities

The discontinuities can be reduced by adjusting the relative segment heights. First select **S2** and its lower left vertex, by clicking inside **S2** near this vertex (the lower left vertex is chosen because it's the segment's starting point). Then right click and select **Vertex Properties** from the popup menu. Change the **Z Position** to be 5 mm above the base surface as shown in figure 1.25 (left side). Note that the discontinuity between **S1** and **S2** is now greatly reduced. Further, the discontinuity between **S2** and **S3** is now shadowed. Proceeding in a similar fashion, change the lower left vertex (starting point) of **S3** to have a **Z Position** of 2.7 as shown in figure 1.25 (right side)

1.7.3 Redevelop All Segments

Since the segment height changes were fairly large it's a good idea to redevelop the affected segments (**S2** and **S3**). Since there's only one unaffected segment it's easiest to redevelop them all by selecting **Segment > Redevelop All Segments**. After developing, save your work and then generate a three-dimensional preview to check the discontinuities.

1.8 Finishing the Reflector

1.8.1 Mirror Segments

At this point, the total output from the reflector, with only one quadrant complete should look similar to figure 1.26. This is essentially one half of the pattern we are looking for. The next step is to mirror the segments about the Y axis to produce the other half. Select **Segment > Mirror Existing Segments** and fill in the dialog as shown in figure 1.27 (left side). This will create 3 additional segments with mirrored vertices and aiming (because the **Mirror aim points** box is checked).

With the top half finished, next create the bottom half by mirroring about the X axis. Because we only want output on the lower half, the **Mirror aim points** box should not be checked this time, as shown in figure 1.27 (right side).

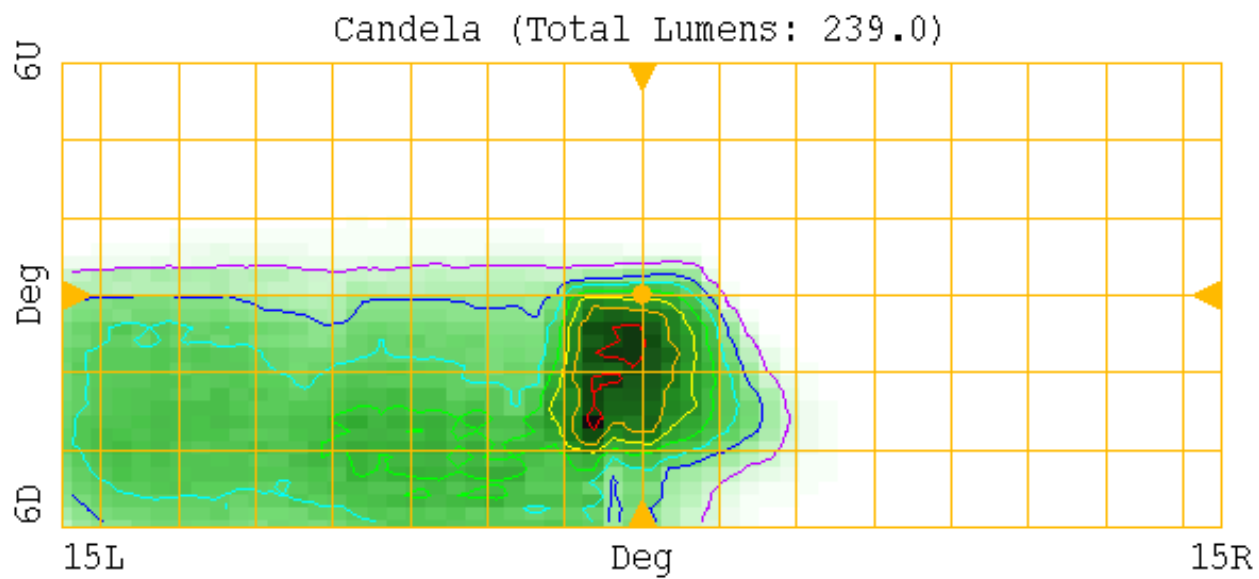


Figure 1.26: Total output from first quadrant

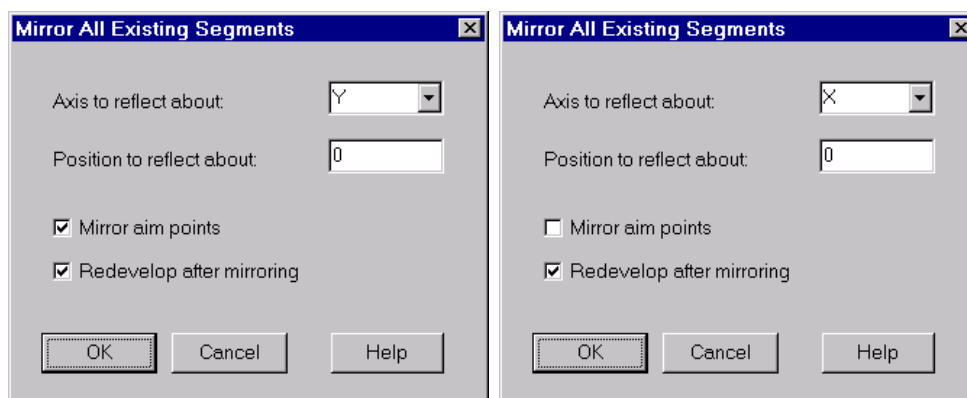


Figure 1.27: Mirroring about the Y axis (left) and then X axis (right).

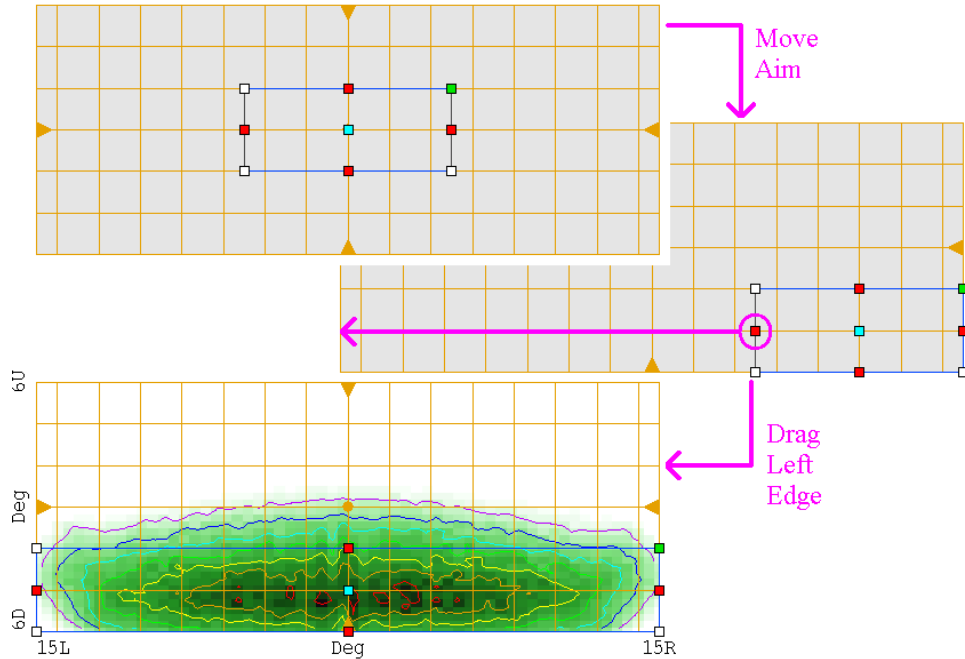


Figure 1.28: Adjusting aim of segment **S13**.

1.8.2 Replace Two Segments

Generate a three-dimensional preview of the reflector. Note that the two segments in the center at the bottom (**S8** and **S11**) have large discontinuities with their neighboring segments. Rather than adjust these segments we're going to replace them with a single segment. Select segment **S8** and delete it by pressing the **Delete** key (or selecting **Delete Segment** from the popup menu). Do the same for segment **S11**. Next create a new segment in their place, starting at $(-50,-40)$ (the upper left corner), with the opposite corner at $(50,-70)$. Adjust the aim for the new segment as shown in figure 1.28.

Finally, adjust the starting point height of the new segment. Select **S13** by clicking inside it, near the upper left vertex (the segment's starting point). Adjust its **Z Position** to 5mm above the base surface. Because the height change is significant redevelop **S13**, by selecting **Redevelop** from the popup menu.

1.8.3 The Reflector's Finished

The reflector should now be finished. This is a good time to save your work. The Reflector view should look similar to figure 1.29. Figure 1.30 shows the total output for the reflector, which achieves our initial output goal. This completes the basic quick tour of ReflectorCAD.

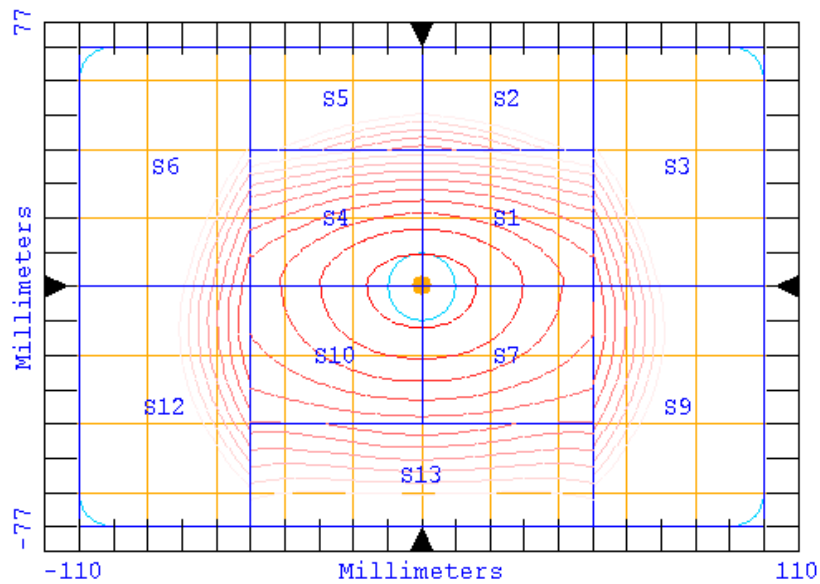


Figure 1.29: View of finished reflector.

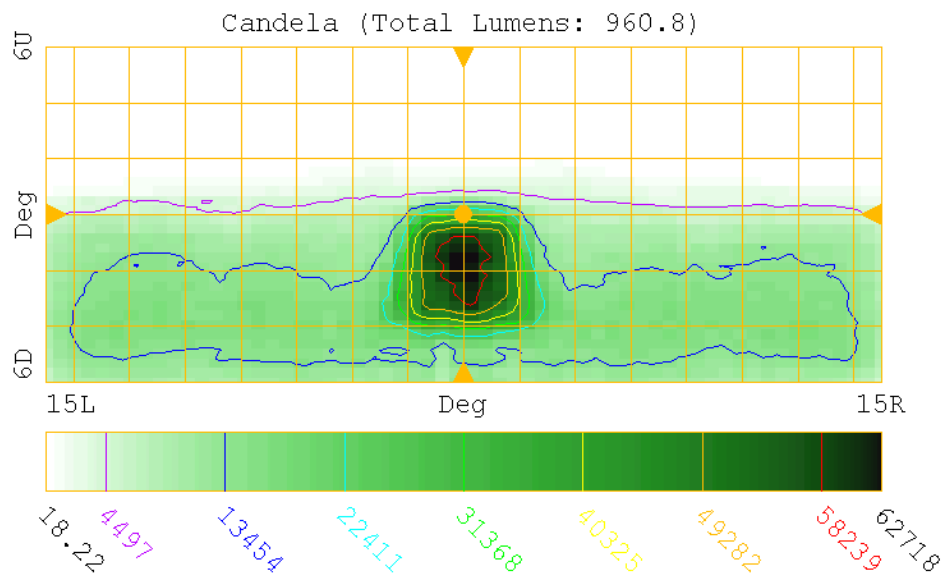


Figure 1.30: Total output of finished reflector.

Chapter 2

Further Exploration

This chapter explores some aspects of using ReflectorCAD that weren't touched on in the basic quick tour. To follow along, use the reflector created in the quick tour above.

2.1 Setting Output Contour Levels

It is often useful to have output contours drawn for specific levels. Change the contour levels by selecting **Output > Contouring**. Delete any existing contour set(s) by selecting them and clicking the **Delete** button. Then, by clicking the **Add** button, add the single value contours for the levels shown in figure 2.1. Whether contours are displayed is controlled via the **Show** setting on the **Output Appearance** dialog (accessed by selecting **Output > Appearance**).

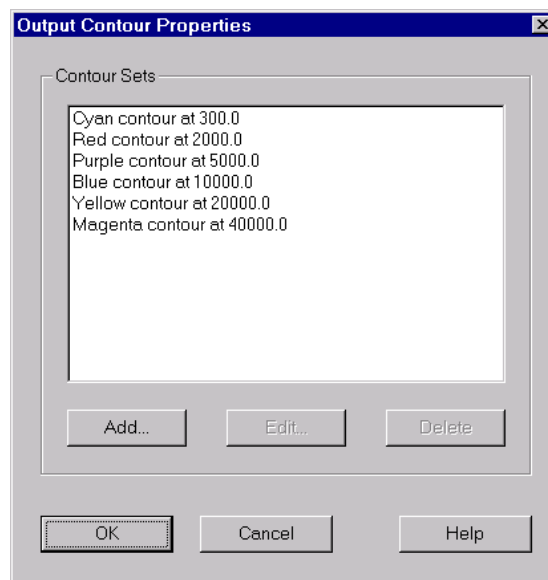


Figure 2.1: Setting fixed contour levels.

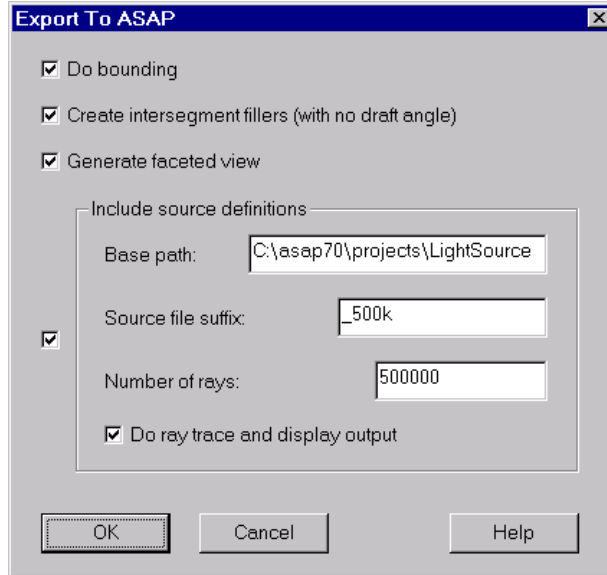


Figure 2.2: Exporting to ASAP.

2.2 Exporting to ASAP for Further Analysis

It is always important to remember that ReflectorCAD's output calculations are approximate (see section 3.4.1 (page 36) for more details). A more thorough evaluation of the reflector should be performed using an optical analysis package, like BRO's ASAP. Generally this should be done after completing the design in ReflectorCAD and then, again, after all remaining geometric elements (e.g., the bulb holder, lens, and shelves) have been added to the design.

To export the reflector design to an ASAP input file, select **File > Export > To ASAP** and fill in the dialog as shown in figure 2.2. Note that a stored rayset for the **HB3** bulb, which our reflector design uses, will have to be downloaded (or generated) before the exported file is run in ASAP. Also, note that the **Base path** should be the directory where your ASAP light source files are stored and may differ from that shown in the figure. The **Source file suffix** entry shown assumes that the 500,000 ray version of the source is used. The **Base path** and **Source file suffix**, are combined with the source's name (HB3) to form the complete source file name used with the **EMIT DATA** command in the ASAP input file.

When run in ASAP, the resulting output resembles that shown in figure 2.3. The corresponding output calculated in ReflectorCAD is also shown for comparison.

2.3 Measuring Vertical Gradients

ReflectorCAD provides a convenient method for measuring vertical gradients in the reflector's output. In the Output view, right click and select **Gradient Query Settings** from the popup menu. Fill in the dialog as shown in figure 2.4.

To measure the vertical gradient at a location in the output, hold down the left mouse

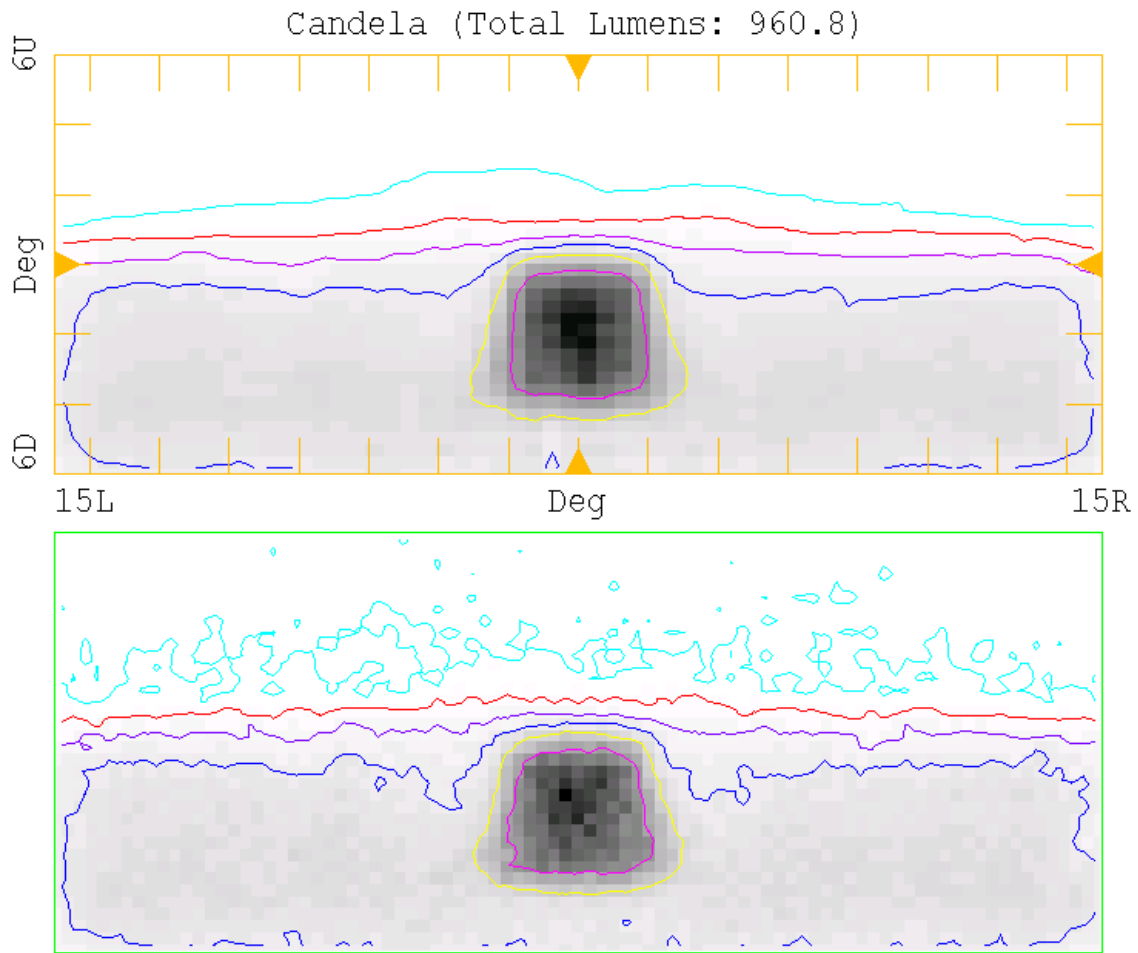


Figure 2.3: Comparison of output calculated in ReflectorCAD (top) and ASAP (bottom). The ASAP calculation used 500,000 source rays and yielded a total flux of 957 lumens. Contours were added manually in ASAP's display window.

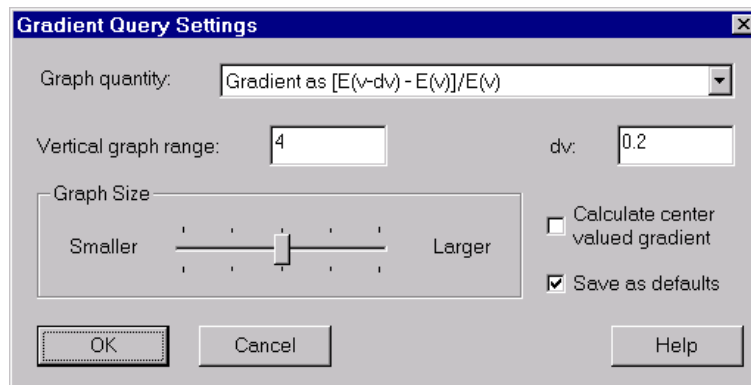


Figure 2.4: Gradient measurement settings.

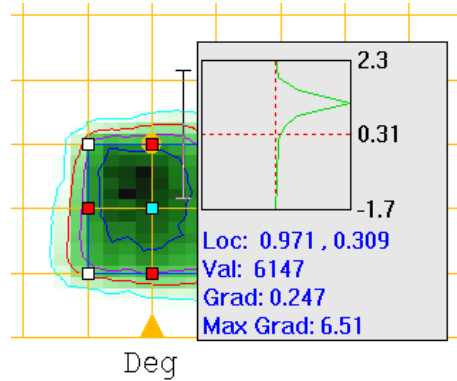


Figure 2.5: Measuring vertical gradient for output of segment **S3**.

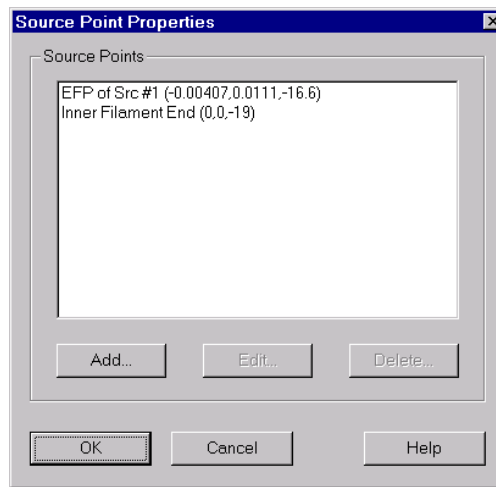


Figure 2.6: Adding a source point at the inner filament end.

button while also pressing the control key. A small graph tip, similar to that in figure 2.5, will popup. As the mouse is moved the graph and values update. The plot shows the vertical gradient calculated along the I-shaped cursor. The gradient at the cursor location and the max gradient along the cursor bar are amongst the values displayed. The **Gradient Query Settings** dialog controls the method used for gradient calculations (see that dialog’s help for more information).

2.4 Defining and Assigning Source Points

When trying to achieve sharp vertical cutoffs, it often helps to use a filament end as the source point for developing a segment. While the present example reflector doesn’t try to produce sharp cutoffs, we can still use it to see how this feature works.

First, add a new source point at the inner end of the filament: (0,0,-19). Select **Source > Source Point Properties**, and add the new point with the name “Inner Filament End”. The dialog should look similar to figure 2.6.

Next, select segment **S2** and change its aim to a horizontal line by dragging the bottom

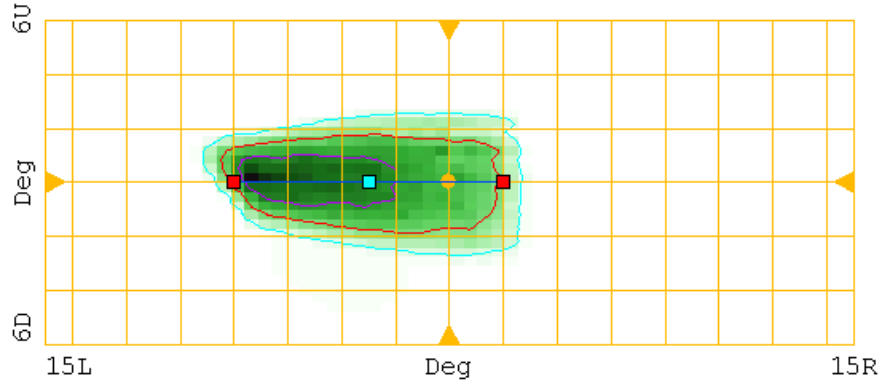


Figure 2.7: **S2's New Aim.**

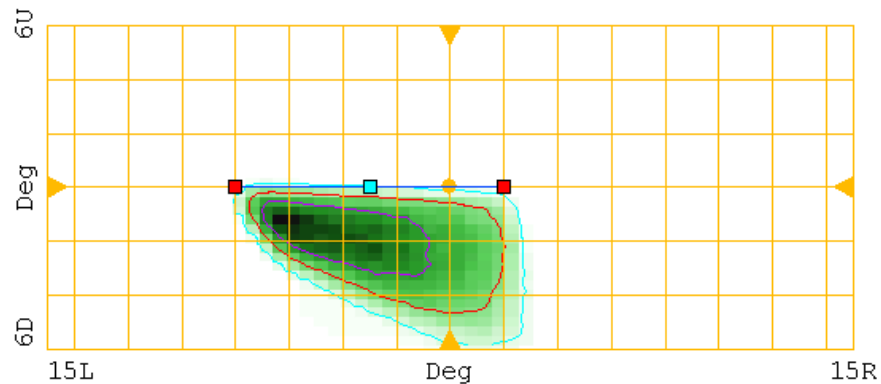


Figure 2.8: Output pattern for segment **S2's** with filament end used as source point.

edge up. The resulting aim should look like figure 2.7. Due to the filament's size, the output pattern has significant flux up to 2° on either side of the horizontal. Note that the peak vertical gradients (measured with the settings used in section 2.3) vary between 2 and 7.

Finally, with **S2** selected, right click in the Reflector view and select **Segment Properties** from the popup menu. Change the segment's source point to the 'Inner Filament End'. The output pattern should now resemble figure 2.8. Notice that the output essentially cutoffs at the horizontal. Peak vertical gradients now range between 4 and 15.

2.5 Aim Balance

In addition to the vertex aim points, ReflectorCAD provides an aim balance point that allows flux to be directed preferentially to one region of the aim box. Select segment **S5**. Its aim balance point (the small cyan square) is currently centered, so its aim balance is neutral. In this case ReflectorCAD will attempt to spread light evenly throughout the aim region. Dragging the balance point to one side of the aim region will direct more flux to that side. Figure 2.9 shows the resulting output patterns for several aim balance positions.

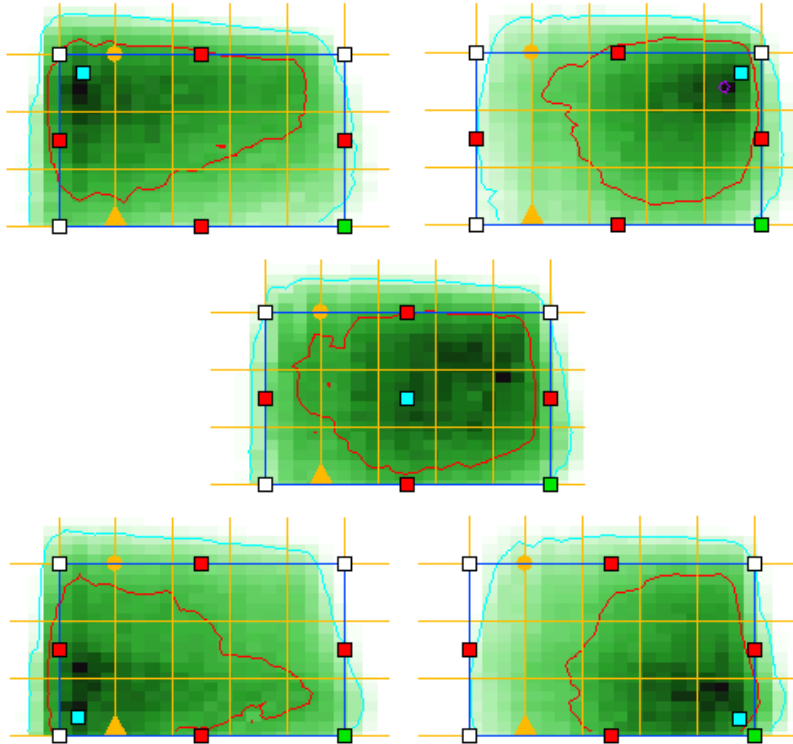



Figure 2.9: Impact of different aim balance settings on output pattern for segment **S5**.

2.6 Output Calculation Quality

ReflectorCAD provides a control for output calculation quality in the **Output Properties** dialog box. To see the effect of this control on output for a specific segment, first select the segment **S7**. Next, select **Output > Properties** on the menu or press the  button. Vary the **Output Calculation Quality** setting, noticing that as quality increases the output becomes smoother and that calculation time increases. Figure 2.10 shows **S7**'s output for three quality settings. See section 3.4.1 (page 36) for information on the limitations of ReflectorCAD's output calculation method.

2.7 Subsegmenting

In ReflectorCAD a segment's surface is defined as a grid of second-order bezier patches. The grid resolution (subsegmenting) for a given segment can be set in its **Segment Properties** dialog box. To see how subsegmenting affects output beam performance, first select segment **S13**. Next, right click in the Reflector view and select **Segment Properties** from the popup menu. Change the subsegmenting, **# of subsegments per segment edge**, to 3 and click **Ok**. Note that the output pattern for **S13** now has two prominent hot spots, instead of the relatively even pattern it produced before. Figure 2.11 shows the output produced by **S13** for different levels of subsegmenting. In each case, the hot spots in the output pattern correspond to output from a single subsegment, or column of subsegments.

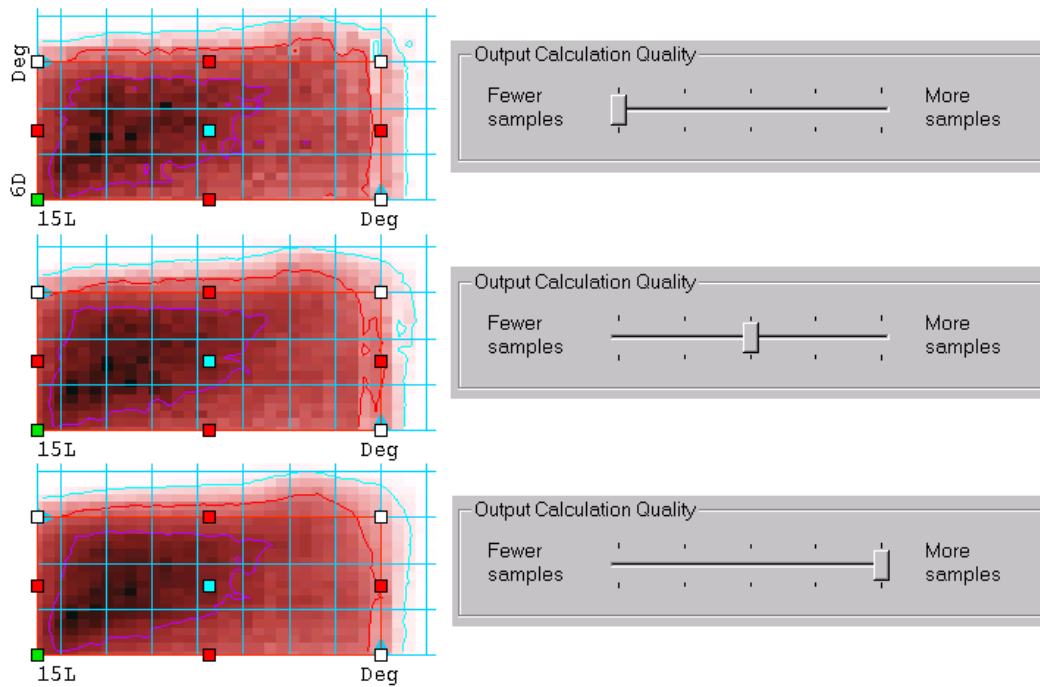


Figure 2.10: Calculated output for segment **S7** at three quality settings.

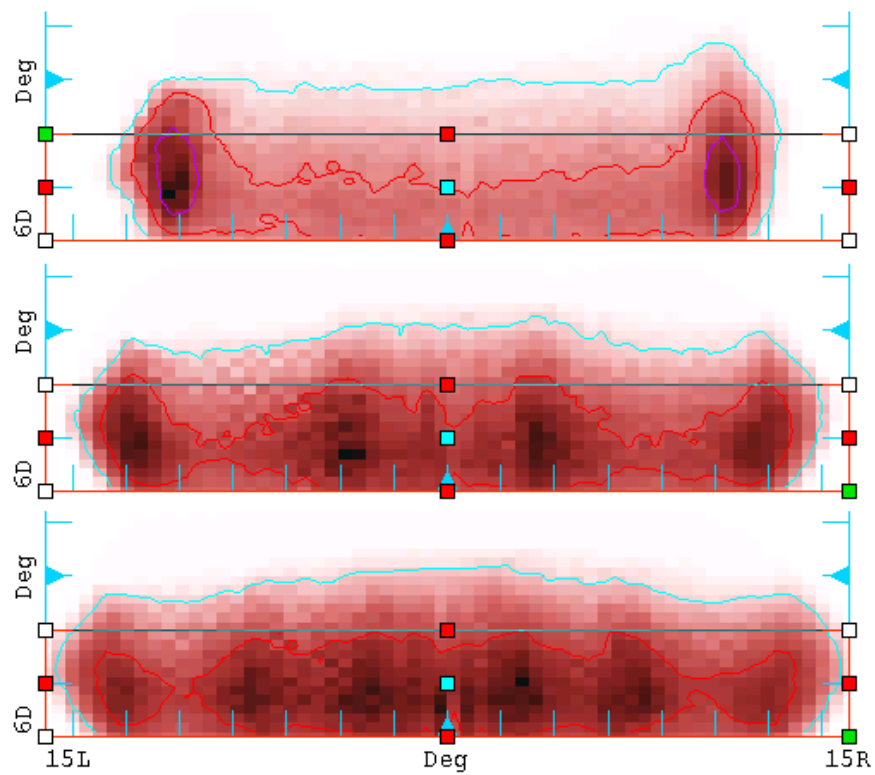


Figure 2.11: Calculated output for segment **S13** with subsegmenting of 3 (top), 5 (middle), and 7 (bottom).

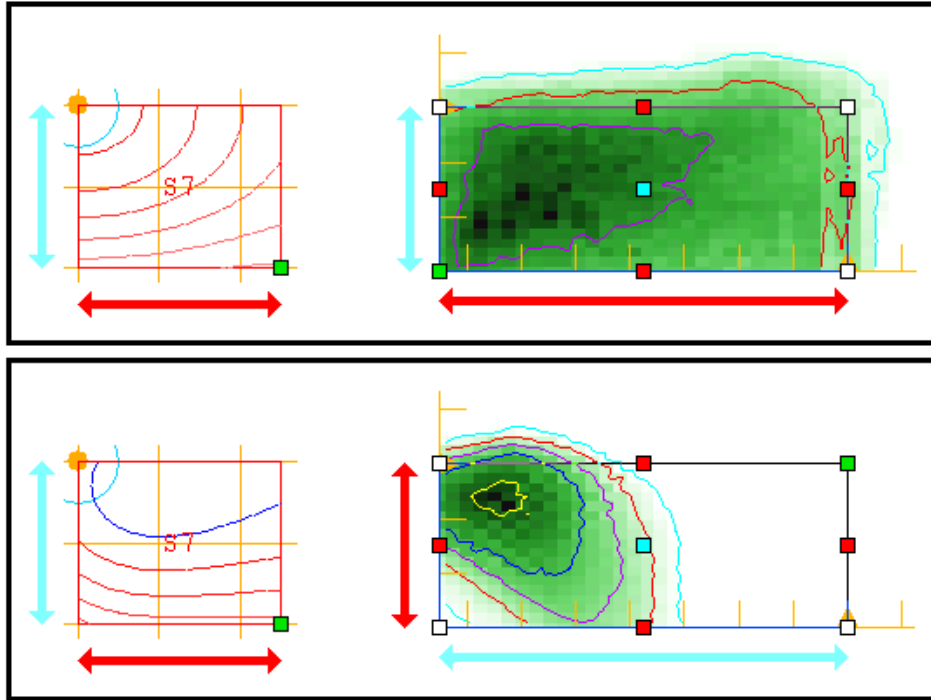


Figure 2.12: The top frame shows segment **S7** aimed such that horizontal and vertical aim differences correspond to horizontal (red arrows) and vertical (cyan arrows) spatial differences, respectively. The bottom frame shows the same segment with horizontal/vertical aim and spatial differences mismatched.

2.8 Aiming Mismatches

Sometimes ReflectorCAD cannot produce a segment that will achieve the specified aim. Each aim, when combined with the specified source point, corresponds to a field of surface normals. ReflectorCAD essentially integrates these surface normals to form the segment's surface. But not all normal fields correspond to an actual surface. In such cases, the segment that's produced by the integration process may fail to achieve the desired aim.

To illustrate this, consider segment **S7**. By selecting its various vertices, and noting their associated aim points, notice that horizontal variations in its aim correspond to horizontal spatial variations across the segment. Similarly, vertical aim variations correspond to vertical spatial variations. This is shown in the top frame of figure 2.12. To see what happens when this correspondance is flipped, select **S7** and its lower right vertex in the Reflector view. Next, in the Output view right click and choose **Swap Corners** from the popup menu. This exchanges the aim points of the current vertex with that diagonally opposite it. The segment's horizontal/vertical aim and spatial differences are now mismatched and the output pattern no longer achieves the desired aim, as shown in the bottom frame of figure 2.12. In general, segments with such mismatches rarely produce the desired pattern.

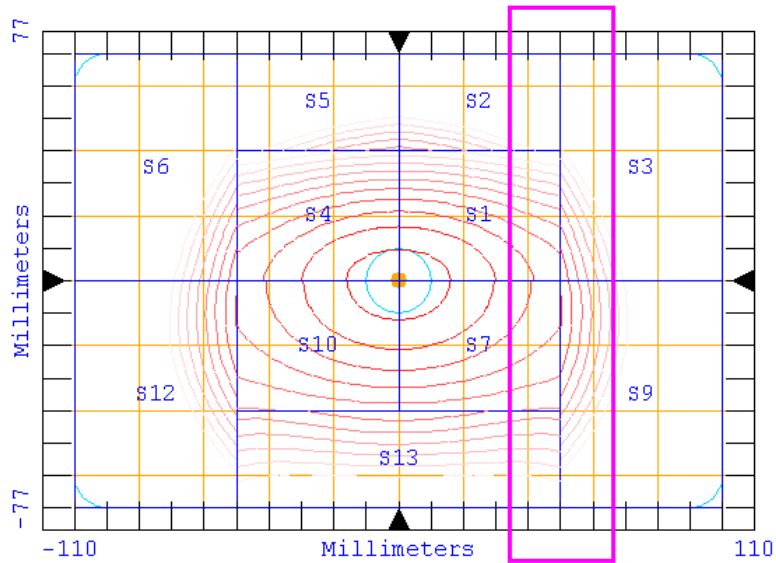


Figure 2.13: Shifting a group of vertices. The rectangle shows the vertices to enclose for shifting.

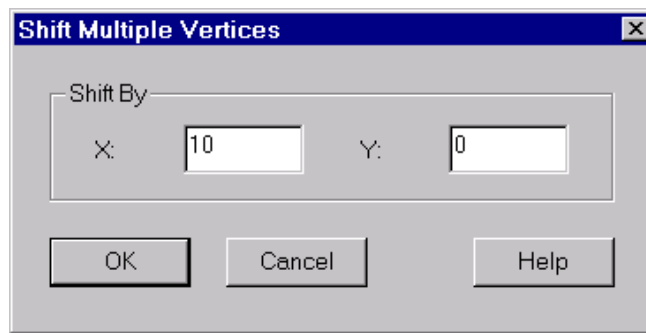


Figure 2.14: Shifting a group of vertices.

2.9 Moving Groups of Vertices

ReflectorCAD provides an easy way to shift a group of segment vertices by a specific distance in the X-Y plane. Let's try out this feature by shifting the vertices that lie along a particular line in our current reflector. In the Reflector view, while pressing the **Control** key, hold down the left mouse button and drag the mouse to enclose the vertices shown in figure 2.13. After releasing the mouse button, enter the desired shift in the dialog box, as shown in figure 2.14. This shifts all of the enclosed vertices 10 units to the right. After the shift is performed all of the affected segments are first reset to the base surface and then redeveloped according to their aiming. This has the side-effect of undoing any starting point offsets that the affected segments may have had. As with other segment changes, this change can be undone by pressing **Ctrl-Z** or selecting **Segment > Undo Last Segment Change** from the menu.

Chapter 3

Overview

This chapter provides an overview of ReflectorCAD.

3.1 Base Surfaces

The base surface serves two purposes in ReflectorCAD. First, it defines the height (Z coordinate) at which the starting point of newly created segments is placed. Second, it specifies the boundaries of the reflector (in the X-Y plane) that are used for output calculations and exported with the reflector's geometry (to an IGES file, for example).

Two types of base surfaces can be used: conic sections with elliptical or racetrack boundaries, and sampled surfaces with arbitrary boundaries. A utility (IgesToBaseSurf) is provided for sampling geometry in an IGES file so that it can be used as a base surface.

The base surface is set in the **Base Surface Properties** dialog (**Setup > Base Surface Properties** on the main menu).

3.1.1 Conic Section Base Surfaces

The conic section base surface is defined as follows:

$$z = f(x, y) = \frac{C(x^2 + y^2)}{1 + \sqrt{1 - (1 + K)C^2(x^2 + y^2)}}$$

where C is the curvature ($C = 1/R_c$, where R_c is the radius of curvature) and K is the conic constant. For values of x and y where the argument of the square root is negative, $f(x, y) = C(x^2 + y^2)$ is used. A parabolic base surface, for example, would have a conic constant of $K = -1$ and a focal length of $R_c/2$.

The outer and inner boundaries of the surface can be either ellipses or racetracks (rectangular with rounded corners).

3.1.2 Sampled Base Surfaces

The sampled base surface is defined as an evenly spaced grid of height (Z) values, which are read from a distribution (*.dis) file produced by either ASAP (using the **MAP** command) or

the IgesToBaseSurf utility (which ships with ReflectorCAD). Through sampling, essentially arbitrary geometry can be used as the base surface.

Sample heights that lie outside of the surface's boundary are marked in the distribution file when it is generated. The boundary of the base surface in ReflectorCAD is defined as the curve or curves that separate in-bounds and out-of-bounds samples. Therefore, the accuracy of the bounding curves is determined by the resolution at which the sampled surface was produced.

Sampling Geometry in ASAP

To height-sample geometry in ASAP for use as a base surface:




- Run whatever commands are necessary to define your geometry and system units.
- Make certain your geometry is oriented so that the desired surface faces along the Z-axis.
- Set your graphics window to look down the Z-axis using the command **WINDOW Y X**.
- Run the **MAP** command with the desired filename and resolution parameters. For example, the command, **MAP BASE.DIS PIXEL 201** creates a sampled surface with a side resolution of 201 pixels in the file, BASE.DIS.

Sampling Geometry in IGES Files

The IgesToBaseSurf utility, included with ReflectorCAD, height samples geometry in an IGES file so it can be used as a base surface. As with ASAP, the geometry should be oriented to face along the Z-axis. To achieve this alignment, up to three rotations can be applied within IgesToBaseSurf before sampling. See the online help in IgesToBaseSurf for more information.

3.2 Sources

Source models for several common bulbs are included with ReflectorCAD. Each is defined in its own binary **Source Definition** (SDF) file. In the case where a bulb has more than one operating mode (for example, a headlamp bulb might have a high and low-beam setting), there is an SDF file for each mode.

Sources are selected, positioned, and oriented in the **Source Properties** dialog, accessed by selecting **Source > Properties** on the main menu or by pressing the  button. Up to two sources can be chosen, but only one can be on at a time. For example, selecting **Source > Source 1 On** or clicking the  button will turn on source number one and turn off source number two. The  button toggles between sources one and two.

Each bulb model has primary and secondary axes. Typically, the primary lies along the bulb's long axis, or the axis of symmetry for the bulb's envelope (usually these are the same axis). The secondary axis is always perpendicular to the primary and usually is aligned

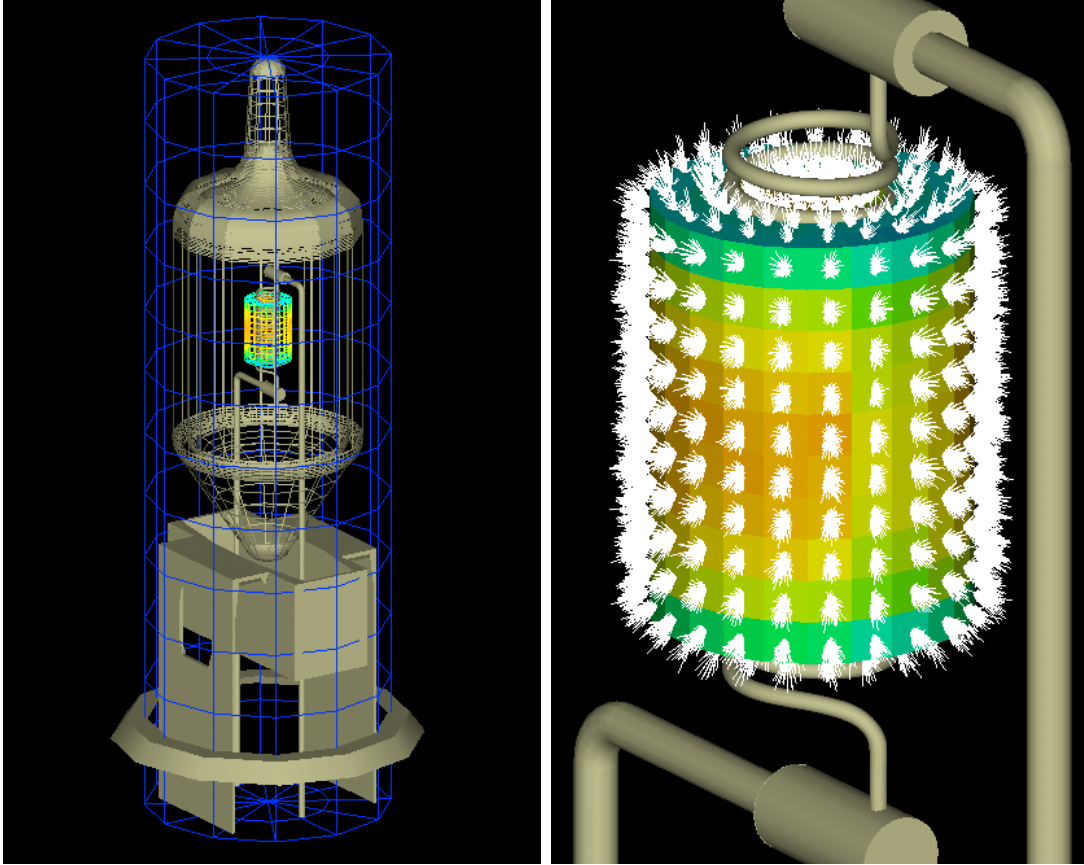


Figure 3.1: The ASAP geometric model for the 9005 headlamp bulb and the corresponding ReflectorCAD source model facets (left). The cylinder of facets near the filament (shown closeup in the right figure with directional apodization data included) carries roughly 90% of the model's flux. The remaining flux is captured on the cylinder that surrounds the bulb.

with some structural feature of the bulb. Clicking the **View Model** button in the **Source Properties** dialog displays information on how the primary and secondary axes are defined for the currently selected bulb.

Sources are modelled as collections of facets, each emitting light from its center according to its own directional apodization data. The models that ship with ReflectorCAD are created from the rays of their corresponding ASAP light sources. The rays are propagated to facets and then binned directionally. The best focus of the rays becomes the **Effective Filament Position** (EFP) for the source. The EFP is used, by default, as the source point during segment development. A source's EFP is displayed when it is selected in the **Source Properties** dialog. Figure 3.1 shows an example of an ASAP light source and its corresponding ReflectorCAD model facets.

3.2.1 Creating a Source

A ReflectorCAD source can be created from almost any collection of rays in an ASAP distribution (*.dis) file.

To create such a distribution file in ASAP:

- Make sure the **XMEMORY** setting is either **MIN** (preferably) or **NORM**.
- Execute whatever commands are necessary to define your source (making sure that system units are defined in the process).
- Orient your source so that its intended primary axis lies along the positive Z-axis and the secondary axis lies along the positive Y-axis.
- Execute the command **DUMP FILENAME.DIS** to dump the current rays to a distribution file.

Two equivalent source conversion programs, Dis2SdfGui and Dis2Sdf , are provided with the ReflectorCAD distribution. Dis2SdfGui has a wizard-based graphical interface and can be run from the **Start > Programs > ReflectorCAD** menu. Specific help for Dis2SdfGui is available via the **Help** button on its dialog boxes. Dis2Sdf has a simple command line interface. The **-h** command line option provides limited help for Dis2Sdf .

3.3 Segments


In ReflectorCAD, segments are the fundamental elements used to build a reflector. Each segment has four vertices. One vertex, called the *starting point*, is designated as the point from which the rest of the segment is developed. Each vertex has an aim point associated with it. From these aim points, and a chosen source point, surface normals for the segment are determined. The normals are then integrated from the starting point to form the segment's surface.

The starting point is the only vertex of a segment whose height can be changed. By default, it is the first vertex laid down when a segment is created. Following segment creation, any vertex can be specified as the starting point on its **Vertex Properties** dialog (accessed by selecting **Vertex Properties** on the pop-up menu in the Reflector view).


This section describes the various segment-related operations available in ReflectorCAD.

3.3.1 Creating Segments

To create a rectangular segment:

- Select the **Segment > Create (rectangular)** menu item or click the  button.
- Move the mouse to the desired location of the segment's first vertex and click.
- Move the mouse to the segment's opposite vertex and click.

The first vertex will be placed at the height of the base surface and serve as the segment's starting point (the starting point can be switched to another vertex later). If desired, segment creation can be terminated prematurely by pressing the **Esc** key. To create an arbitrary four-sided segment:

- Select the **Segment > Create (arbitrary 4-sided)** menu item or click the  button.
- Move the mouse to the desired location of the segment's first vertex and click.
- Similarly place the segment's second, third, and fourth vertices.

During segment creation, snapping is available. To toggle this feature on or off, right-click in the Reflector view and select **Enable Grid and Snapping** from the popup menu. The grid and snap settings can be changed by selecting **Grid/Snap Settings** from the same popup menu.

3.3.2 Selecting Segments and Vertices

A segment is selected by clicking anywhere inside its boundaries. Only one segment can be selected at a time. The selected segment is drawn in red to distinguish it from the others. Its corresponding output (if available) and aim points are displayed in the Output view.

Additionally, the vertex that was closest to the cursor is also selected and drawn with a small green box in both the Reflector and Output views. A different vertex can be selected by pressing the **Tab** or **Shift-Tab** keys, or by clicking near it within the segment. A vertex can also be selected by clicking near its aim point in the Output view.

Once a segment is selected, the keyboard arrow keys can be used to move to and select adjacent segments.

3.3.3 Aiming Segments

Segments are initially assigned a default aim when they are created. This default aim can be changed by selecting the **Segment > Default Aiming** menu item. A segment can be set to the default aim at any time by selecting **Aim to Defaults** on the popup menu in the Reflector view.

Once a segment is selected, there are several ways to alter its aim. A single aim point can be moved by dragging it with the left mouse button down. Similarly, an adjacent pair of aim points can be moved simultaneously by dragging the red box that's between them. All four aim points can be moved together by selecting **Move** on the popup menu in the Output view.

In addition to the vertex aim points, ReflectorCAD provides an aim balance point that allows flux to be directed preferentially to one region of the aim box. By default a segment's aim balance point (drawn as a small cyan square) is centered, so its aim balance is neutral. Dragging the balance point to one side of the aim box directs more flux to that side. Neutral aim balance can be restored by selecting **Make Aim Balance Neutral** from the popup menu in the Output view.

3.3.4 Redeveloping Segments

Each time a segment's aim changes, ReflectorCAD automatically reshapes the segment to achieve the desired aim. This is called *developing* the segment. The aim is used, along with the specified source point, to determine the necessary surface normals. These normals are in turn integrated, beginning at the starting point, to form the segment's new shape.

During integration, the segment's prior shape is used as an approximation for its new shape to help evenly balance flux across the aim region. To the extent that the prior and new shapes are similar, this approximation is good. If a segment's shape changes substantially its performance can often be improved by redeveloping it after the last aim change.

To redevelop a segment, first ensure it is selected. Then right click in the Reflector view and select **Redevelop** from the popup menu. All segments can be redeveloped by selecting **Segment > Redevelop All Segments** from the main menu.

3.3.5 Mirroring Segments

It is common for a segmented reflector to be essentially symmetric across one or both axes. To make creating such reflectors easier, ReflectorCAD can mirror a single segment or all segments.

To mirror the currently selected segment, select **Mirror Selected Segment** from the popup menu in the Reflector view. To mirror all segments select **Segment > Mirror Existing Segments** from the main menu.

3.3.6 Shifting Groups of Vertices

Groups of vertices can be shifted simultaneously in the X and Y directions. While holding down both the **Ctrl** key and left mouse button, drag the mouse to select a rectangular region that encloses the vertices of interest. When the mouse button is released enter the desired shift in the **Shift Multiple Vertices** dialog that appears. After being reset to the base surface, all affected segments will be redeveloped according their assigned aim points.

3.3.7 Checking Edge Shadowing

For both performance and manufacturability reasons it is generally desirable to minimize height discontinuities between adjacent segments. Where such discontinuities are necessary they should normally be hidden from the source (in otherwords, shadowed) to prevent undesired stray reflections. This can be done by adjusting segment aims and/or starting point heights. ReflectorCAD provides a simple method for checking whether a discontinuity is hidden from the source.

- First select one of the two segments that share the edge of interest.
- Then move the mouse to the other segment that shares this same edge and hold down the **Shift** key and left mouse button simultaneously.


While the buttons are depressed, a titletip will display the maximum height of the more-distant segment's edge relative to the closer segment's edge. If the discontinuity is shadowed

then the titletip message will be green, if not then it will be red. If the edge of interest lines up with the current source's effective filament position, no height value is reported because neither segment can shadow the filler


3.3.8 Undoing Segments Changes

Changes made to segments, including the creation of new segments by mirroring or other methods, can be undone by selecting **Segment > Undo Last Segment Change** from the main menu or by pressing **Ctrl-Z**. Up to the last five changes can be undone.

3.4 Calculating Output

ReflectorCAD can quickly calculate the approximate output from the reflector. Select **Output > Calculate Output** from the menu or click the  button to calculate the output. If **Output > Auto Update** is checked, output is automatically calculated every time a change is made that effects the output.

If up-to-date output is available it is displayed in the Output view. When a segment is selected, only its output is displayed. Otherwise the total output of all segments is shown.

Either directional (luminous intensity) or positional (illuminance) output can be calculated. For directional output, angles are defined relative to a horizontal pole. Detector screen limits, resolution, and distance (for positional output) are all setable in the **Output Properties** dialog (which is accessed by selecting the **Output > Properties** menu item or clicking the  button). Output can be scaled, to account for the reflector's reflectivity or the transmissivity of a clear lens. Calculation quality can also be adjusted.

The **Output Appearance** dialog (accessed by selecting **Output > Appearance** from the menu) is used to control how output is drawn. The color palette, whether contours are displayed, and tick mark spacing are among the things that can be changed. Contour levels and colors are set in the **Output Contour Properties** dialog (**Output > Contouring** on the menu).

3.4.1 How Output is Calculated


Reflector output is calculated using BRO's Deterministic Specular Radiative Transfer (**DeSeRT**) algorithm. Using approximations applicable to typical reflector systems, this high-speed algorithm provides nearly immediate feedback on how a reflector is performing. The output calculation has the following limitations:

- It ignores shadowing effects. All in-bounds portions of a segment can contribute to the output, even though they may be in the shadow of an adjacent segment. For reflectors with large intersegment discontinuities, and correspondingly large shadows, this can be a significant effect. In practice the shadowed regions of a typical reflector are often very small and the resulting overestimate will be, at most, a few percent of the total flux.

- It ignores direct transfer from the source to the detector screen. This typically is a small effect and leads to an underestimate of the total output flux. For reflectors with bulbs that have blockers or blackened caps there would not be appreciable direct transfer.
- It ignores multiple bounces off of the reflector.
- It ignores interactions with intersegment fillers. Typically, effort is spent hiding intersegment discontinuities from the light source because they lead to spurious, unaimed, reflections. To the extent that they are hidden, ignoring fillers in the output calculation has no significant effect. Unfortunately, if a reflector has fillers that are visible to the light source, they can have serious deleterious effects on its performance that will NOT be seen in the approximate output calculation. In such cases further analysis with a high quality package, like ASAP, is especially important. Intersegment fillers are (optionally) included when reflector geometry is exported to ASAP or IGES, to make this task easier.

In the end it is important to keep in mind that ReflectorCAD provides a quick, but approximate, calculation of the reflector's output. While this approximate output can provide very useful feedback during the design process, performing final analyses with a high quality package, like ASAP, is still necessary.

3.5 Three-Dimensional Preview

A three-dimensional preview of the reflector can be generated by selecting **View > Generate 3D View** from the menu, clicking the  button, or by pressing the **P** accelerator key. A separate window will open with a faceted representation of the segments, intersegment fillers (optionally), and source model. The view can be rotated by moving the mouse while holding down the right mouse button. The 3D Viewer has help describing the other manipulations that are available.

Segment faceting, color, and filler creation are controlled in the **Segment 3D View Properties** dialog (accessed by selecting **Segment > 3D View Properties** on the menu). The method for displaying the source model is controlled in the **Source 3D View Properties** dialog (**Source > 3D View Properties** on the menu). Both dialogs have online help available for their detailed options.

The three-dimensional preview geometry can also be exported directly to an ASAP vector (VCR) file for later viewing. Select **File > Export > To VCR** on the menu to do this.

3.6 Exporting Geometry

A reflector design can be exported to an ASAP input (INR) file or an IGES file. In either case intersegment fillers can be (optionally) included. It is important to note that the fillers generated by ReflectorCAD do NOT have draft angles, and that segment edges are not radiused. So additional work will be required to produce the finished geometry for mold-making purposes.

3.6.1 Exporting to ASAP

Segment geometry can be exported to an INR file by selecting **File > Export > To ASAP** from the menu. Bounders, intersegment fillers, source definitions, and analysis commands can also be optionally included in the INR file.

INR files exported from ReflectorCAD use stored raysets as source models. To run the exported file in ASAP, the raysets corresponding to the sources used in ReflectorCAD need to be present. This may require downloading the relevant source files. Consult the documentation included with ASAP for more information.

3.6.2 Exporting to IGES

All reflector segments and, optionally, intersegment fillers and source points can be exported directly to an IGES file by selecting **File > Export > To IGES** on the menu. Any bounders associated with the base surface, while included in the IGES file, will not actually be imposed on the segments or fillers.

Appendix A

A Comparison of Output Calculated by ReflectorCAD and ASAP

This short note compares output calculated by ReflectorCAD and ASAP, for the ‘VisualAimLowBeam’ example that ships with ReflectorCAD 1.5. This reflector is not an actual headlamp – it is the first-pass at a conceptual design intended to meet the visual aim standard.

Figures A.1 and A.2 show the output calculated by ReflectorCAD and ASAP, respectively. Comparing contours, the results agree nicely. The peak output values are 31,637 for ReflectorCAD and 32,664 for ASAP, while total flux on the screen is 575.9 lumens for ReflectorCAD and 594 for ASAP. The approximate output calculated by ReflectorCAD does not include light that travels from the source directly to the screen, while the ray trace performed in ASAP includes everything. Consequently we would expect the numbers from ASAP to be slightly larger than those from ReflectorCAD. A separate ray trace, with just the source and detector screen, was performed to quantify this effect. The total flux due to direct illumination was found to be 16.5 lumens. Subtracting it from the total figure for ASAP, we now get 577.5 lumens for the total flux, which agrees very nicely with the value calculated by ReflectorCAD.

On a 500 Mhz Pentium-series processor, ReflectorCAD took 30 seconds to calculate output for the entire reflector. Since most design changes affect only a portion of the reflector, output can typically be updated in just a few seconds when working in ReflectorCAD. ASAP took a little more than 2 hours to perform the calculation, using 2 million rays (pretraced through the bulb’s geometry) for the source model. The bulb’s geometry was not present during the trace with the reflector. The ASAP results were averaged horizontally (using the **AVERAGE 0 2** command).

It is also interesting to compare vertical gradients in the region between 1 and 3 degrees right. Figure A.3 shows three screendumps of the interactive gradient-query tool in ReflectorCAD for this region. The gradient, in this case, is calculated as a partial derivative along the vertical direction. Peak values vary between 23,700 and 26,400. Figure A.4 shows the relevant results from ASAP. Peak derivative values vary between 23,300 and 25,600.

For purposes of headlamp testing, vertical gradients are typically not defined as derivatives. For example, SAE J1735 of January 1995 (*Harmonized Vehicle Headlamp Performance Requirements*) defines the vertical gradient as $G(v) = [I(v - 0.2) - I(v)]/I(v)$, where $I(v)$ is

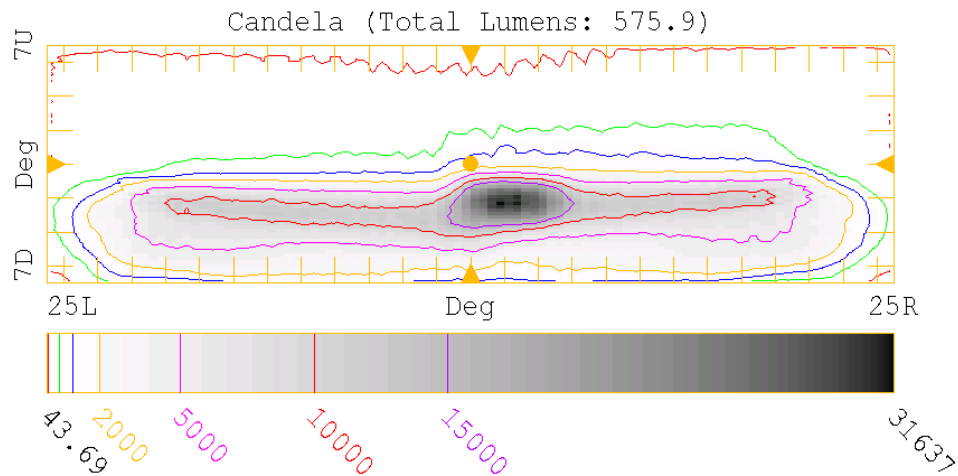


Figure A.1: Output calculated by ReflectorCAD. Resolution is 70 pixels vertical and 100 pixels horizontal. Calculation quality was at the middle (default) setting. The standard ReflectorCAD source model for the 9005 bulb (with roughly 600 facets) was used.

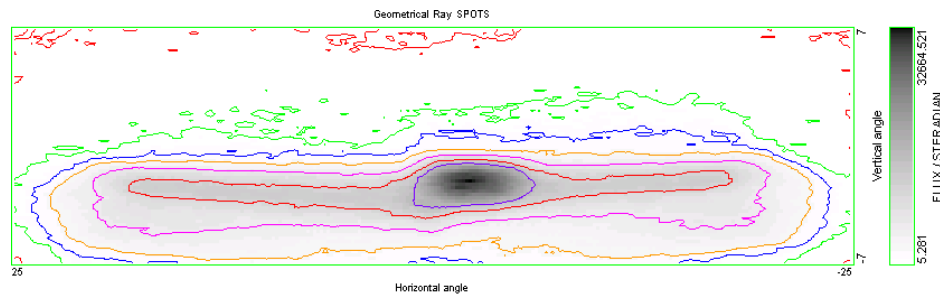


Figure A.2: Output calculated by ASAP. Resolution is 70 pixels vertical and 243 pixels horizontal.

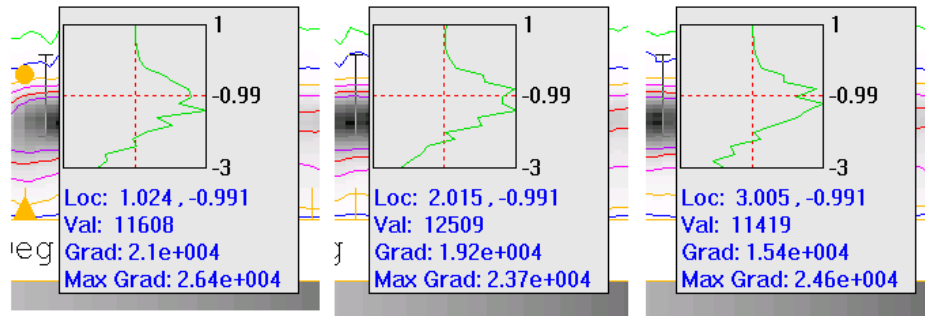


Figure A.3: Vertical derivative for output slices along 1, 2 and 3 degrees right, as measured in ReflectorCAD using the gradient query feature.

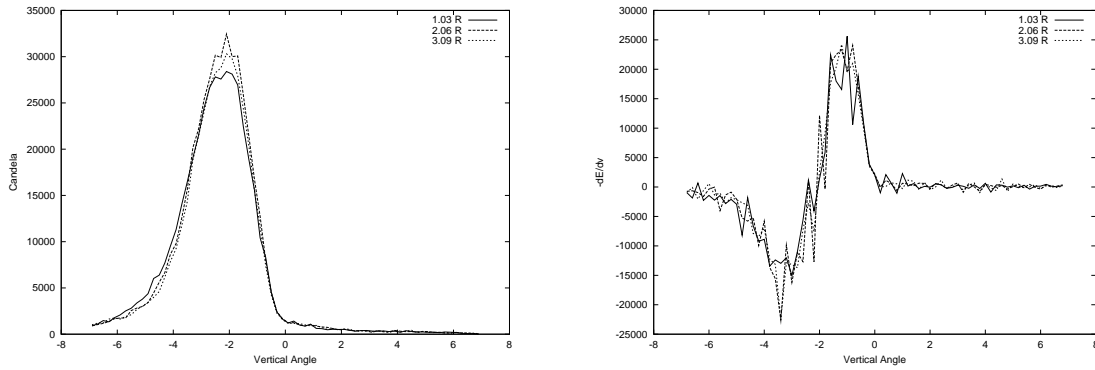


Figure A.4: Vertical slices along 1, 2 and 3 degrees right, showing the output (left) and vertical partial derivative of the output (right), as calculated by ASAP.

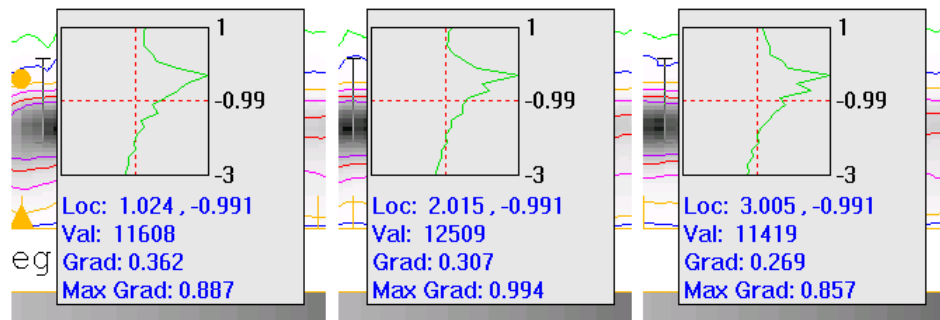


Figure A.5: Vertical gradients for slices of output along 1, 2 and 3 degrees right, as calculated by ReflectorCAD.

the intensity at vertical angle v (measured in degrees). Using this definition, screendumps of the gradient measurement in ReflectorCAD are shown in figure A.5. Peak values range from 0.857 to 0.994. The corresponding plots for the output calculated by ASAP are shown in figure A.6. Peak values, ranging from 0.857 to 0.887, agree well with those from ReflectorCAD. Figure A.7 shows the gradient query settings used in ReflectorCAD for the screen captures shown in figure A.5.

Table A.1 summarizes the results of this comparison. Overall, there is good agreement. It is important to remember that the quick output engine in ReflectorCAD makes use of several approximations, the validity of which can vary between reflectors. While for typical uses it will achieve accurate results, it is still important to verify the performance of finished designs using a more complete analysis package like ASAP. See section 3.4.1 (page 36) for more information on the limitations of ReflectorCAD's quick output engine.

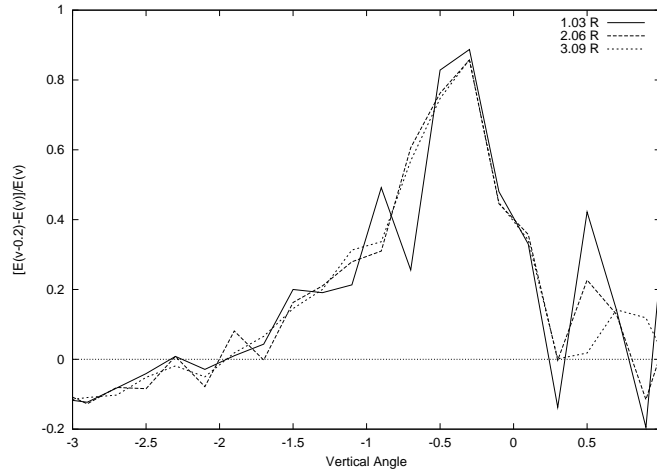


Figure A.6: Vertical gradient for slices of output along 1, 2 and 3 degrees right, as calculated by ASAP.

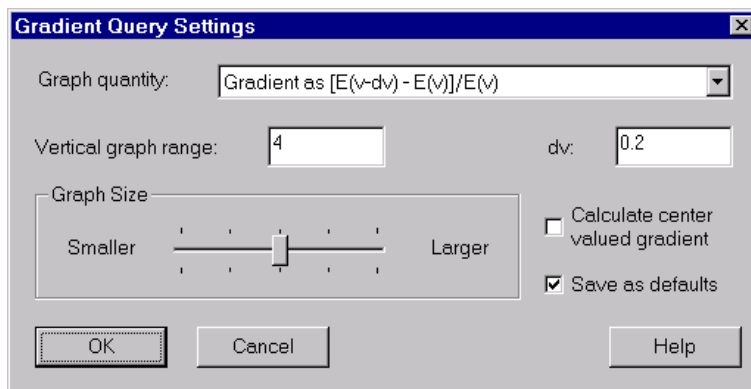


Figure A.7: Gradient query settings used in ReflectorCAD for measurements shown in figure A.5.

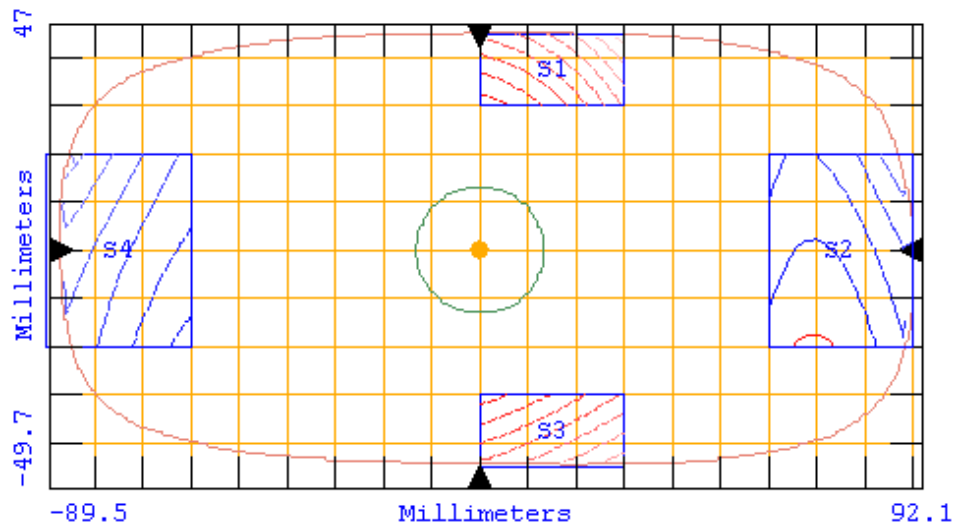
Quantity	ReflectorCAD	ASAP
Total Lumens	575.9	594
direct illum. subtracted		577.5
Peak Candela	31,637	32,664
Calculation Time	~ 30 seconds	~ 2 hours
Peak Vertical Derivatives		
1° Right	26,400	25,600
2° Right	23,700	23,300
3° Right	24,600	24,200
Peak Vertical Gradients		
1° Right	0.887	0.887
2° Right	0.994	0.857
3° Right	0.857	0.859


Table A.1: Summary of results calculated by ReflectorCAD and ASAP.

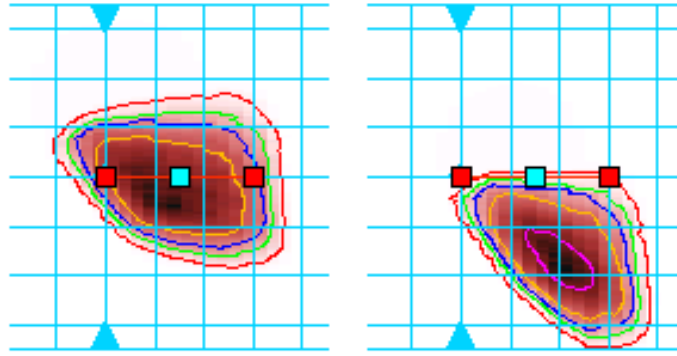
Appendix B

Notes for TightCutoffSegments Example

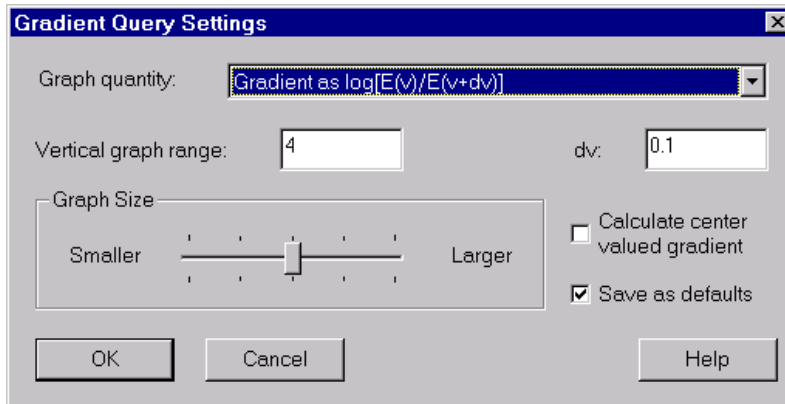
These are notes to accompany the file ‘TightCutoffSegments.rdf’, which is included with ReflectorCAD in the ‘Visual Aim Headlamp’ example directory. After loading the file in ReflectorCAD, the reflector view should look similar to the figure below.



Make sure output has been calculated for the reflector by clicking the  button. Select segment **S1** by clicking inside it with the mouse. Its output will be shown in the output view. While **S1** is selected, right click in the Reflector view and select **Segment Properties**. Notice that the **Source Point** for this segment is the inner edge of the filament. This provides for a tighter cutoff on the upper boundary of its aim region. To see this effect, change the **Source Point** to be ‘EFP of Src #1’ (essentially the filament’s center). The figure below shows the output of **S1** when developed using the filament center (left) and the filament’s inner edge (right) as the source point. In both cases the segment is aimed to a horizontal line.

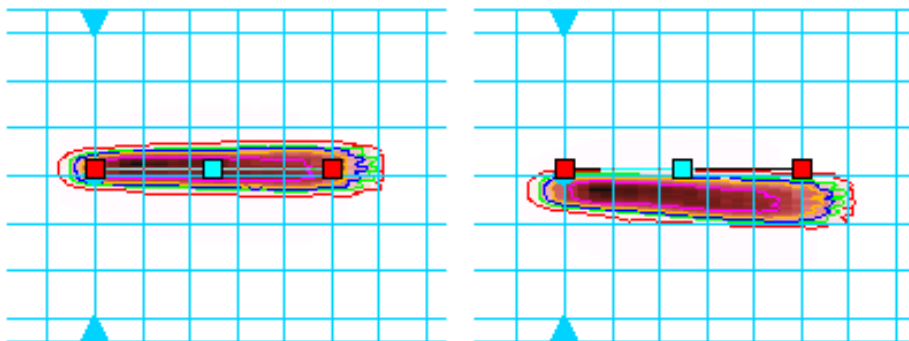


When the filament's inner edge is used, vertical gradients in the 0.2 to 0.4 range are calculated in ReflectorCAD, using the gradient query settings shown in the figure below (this dialog is accessed by right clicking in the Output view and selecting **Gradient Query Settings** from the popup menu).



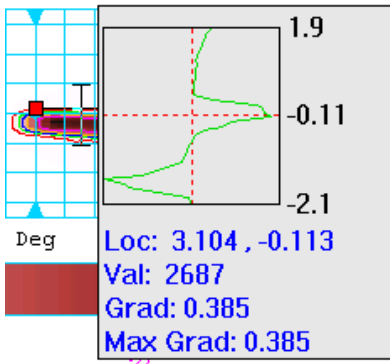
To calculate gradients in the Output view, hold down the **Control** key and left mouse button simultaneously.

Segment **S2** was developed using the bottom center of the filament as the source point. The figure below shows the output of **S2** when developed using the filament center (left) and the filament's bottom center (right) as the source point.



When the bottom center is used as the source point, the output pattern stays below the segment's horizontal aim line. Calculated gradients vary between 0.3 and 0.5 along the top

of this output pattern. The figure below shows the gradient query results from one location in the pattern.



Segment **S3** employs the same idea as **S1**, except that the outer filament end is used as the source point because the segment is below the filament. Segment **S4** uses the bottom center of the filament, just as **S2** does.

Appendix C

Release Notes

C.1 ReflectorCAD 1.5

C.1.1 Backward Compatibility

You can open files in ReflectorCAD 1.5 that were generated by previous versions of the product. However, previous versions of ReflectorCAD cannot open files that are generated by version 1.5.

C.1.2 What's New in 1.5

Import of IGES Base Surfaces A new utility, IgesToBaseSurf, translates IGES files to sampled base surfaces without the need for ASAP.

Positional Output The quick approximate output engine in ReflectorCAD can now calculate positional output (illuminance), in addition to directional output (luminous intensity).

Gradient Measurement A graph tip allows vertical gradients to be determined using the mouse.

New Sources Approximately 85 sources are now available in ReflectorCAD. Sources are now faceted more finely for improved output calculation accuracy.

User-Defined Source Points Additional user-defined source points can be positioned, at filament ends for example, to improve segment performance.

Assigned Source Points A segment can be assigned a specific source point. For example, a segment associated with the low beam of a headlamp can be assigned to always use the low beam source point when developed.

Alternate Segment Developer An alternate segment integration pattern provides more control over segment performance.

Improved Built-in Base Surfaces The conic section base surface can now be shifted (which allows the focus to be at the origin). The ‘racetrack’ shape was added as a bounder.

Easier Aim Adjustments All corners and edges of the aim region can now be immediately dragged to a different position. The aim balance is easily distinguished from other aim region points.

Updated 3D Viewer Support A new 3D Viewer is included with ReflectorCAD. Similar to the 3D Viewer in ASAP, it includes such features as an object name tree and mouse-based object selection.

Source Positions Exported to IGES All source positions can be exported, optionally, to an IGES file along with the reflector geometry.

Configuration Preferences Many settings, including units, can be saved as defaults for new reflectors.

New Quick Tour As part of the revised documentation, a new quick tour is included to show off some of the new features.

C.1.3 Minor Enhancements

- Edge shadow heights and data values are now reported in tool tips for enhanced readability.
- The default system units are now millimeters.
- Units have been added to the output and reflector views.
- Keyboard accelerators and toolbar buttons have been provided for some common operations, including switching between sources, creating rectangular segments, and calculating output.
- A list of the most recently used files is now maintained on the file menu.
- The end-of-line character used for exported IGES files can now be set.

C.1.4 Bug Fixes

- Zero-range map files (for sampled base surfaces) caused ReflectorCAD to hang.
- Sources could be positioned improperly in ASAP if user preferences specified different units than were used in ReflectorCAD.
- Temporary 3D Viewer files were being written to the current working directory.
- The aim balance point could be unmovable if the segment had a zero spread aim in one direction.
- Contours were being drawn as dashed lines in the output view.