Desktop Radiance Overview[?]

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Introduction

Desktop Radiance is an advanced lighting analysis and visualization tool that can be used to model simple or complex daylight and electric lighting systems. Radiance was initially developed as a research tool for a Unix environment, where it utilized a rather complicated text-based input format.

Radiance is one of the most powerful daylight and electrical lighting analysis tools available since it can handle virtually any space geometry, as well as non-diffuse reflectances. The Desktop Radiance version provides the opportunity for more lighting professionals to easily access this powerful software tool through a graphical user interface. This document will describe the basic operation of Desktop Radiance 1.0 and provide some simple instructions and tips on how to construct and analyze a room model using this software. As you read through this document, you should refer to the flowchart provided in Appendix B of this document, which provides a general outline of the operations, steps, and possible analysis paths involved in applying this software to the design of daylight and electric lighting systems.

To learn more about the software, the reader should consult the Desktop Radiance User Manual, or its help utility, since it is not possible to discuss all of the relevant features and operations in this document.

The Desktop Radiance version is a more user-friendly derivative of this software that runs under the Windows operating system from within AutoCAD 14 using pull-down menus. (It is not yet compatible with AutoCAD 2000.) This user-friendly interface makes most of the complex Radiance commands transparent to the user. Many, but not all, of the key operating features in the standard Radiance version are currently available through this user interface.

For individuals who are familiar with the standard Radiance program, the advanced features that are not currently part of the Desktop Radiance system can be accessed through the MS-DOS batch files by modifying the original text-based input.

Desktop Radiance operates by creating the standard text-based input files used in the UNIX version, then it executes the standard Radiance programs through an MS-DOS batch file. These aspects of the software are transparent to the user since they are managed through the pull-down menus in AutoCAD and the Desktop Radiance simulation manager. Desktop Radiance also contains a number of operational enhancements, such as the RVIEW program, which has an improved user-interface. Since Desktop Radiance is still under development, additional features from the Unix version of Radiance are likely to be implemented in future releases of the Windows version.

Calculations Permitted

With Desktop Radiance, you can compute horizontal illuminance across an arbitrarily oriented grid of points, or you can generate a rendered image of a space that can be queried for the illuminance or luminance of any surface in a rendered image of a room.

Basic operation of the system

Model Construction

Constructing Polygons in AutoCAD

To construct a Radiance model, it is first necessary to create a three-dimensional model of the architectural space you wish to analyze within AutoCAD. Surfaces can be constructed using polygons, 3-D faces, three-dimensional objects, lines with thickness, and extruded or revolved shapes. These include virtually all of the commands available under the AutoCAD DRAW menu. For example, a rectangular room can be created using the BOX command. The box must then be ? exploded? to permit different materials to be assigned to the ceiling, walls and floor. To construct a window on one of these room surfaces, it is necessary to erase and reconstruct the wall and transparent building elements where the window is located.

A window can generally be constructed of a single polygon, unless mullions are desired. The wall that surrounds the window then must be constructed of multiple polygons or trapezoids. It is important when constructing any Desktop Radiance model to be certain that the corners and edges of each polygon are aligned with the corners and edges of adjacent surfaces. The "snap to" feature in AutoCAD should be applied to ensure that a model is constructed in this manner.

A vertical surface such as a wall or partition can be created by first specifying a THICKNESS, then applying the LINE command. A thickness is generally an extension of a line in the z direction to form a polygon. The THICKNESS command (which can be also entered as TH) is entered on the command line. You are then prompted to enter the thickness to assign to each line.

You apply any of the commands available under the DRAW menu that create a three-dimensional object (polygon) to construct your model within AutoCAD. For example, the 3DFACE command is a common command for creating a single polygon in space.

Level of Detail

In creating a room, is important to first assess the level of detail that is appropriate to include in your model. More detail will increase the realism of any image that you create, but may have little impact on lighting system illuminance calculations, and will likely slow down the analysis. For proper photometric analysis of your model, it is important to address all details that impact the amount of light entering a space or the amount of light reflected within a space. For example, if the exterior wall of a building is relatively thick, you should enter the thickness of this wall into your model to accurately describe the view that all points within a space will have of the exterior.

For daylighting situations, it is also important to adequately model the exterior of the building. However, surfaces that do not impact the amount of light in a space, or which are not visible in any views that you plan to create, can generally be eliminated from your model.

Modeling the exterior

It is important to appropriately model the exterior when performing daylighting calculations. This involves modeling the ground; any other exterior light reflecting or obstructing objects, such as neighboring buildings or trees; and shading devices such as overhangs, light shelves, or blinds. At the present time, blinds can only be considered by modifying the radiance text-based files, which is discussed in more detail in a later section. Exterior elements that impact the amount of daylight striking a window must be built into your model, to be considered in a Desktop Radiance analysis.

The ground plane

In a daylight analysis, Desktop Radiance will automatically input a ground reflectance of 20 percent. This ground material is assumed to be non-Lambertian, such that the ground luminance looking back toward the sun will be higher than it is looking away from the sun. This infinite ground plane is also located slightly below the z=0 plane, so that it does not appear as a luminous floor within your modeled space. If the floor of your room goes below z=0, it may be necessary to raise the entire room model above the ground plane. Likewise, if you do not cover the entire floor of your model, this surface will emit light into your space through this opening.

Exterior Shading and Controls

One significant limitation of the approach used to analyze the ground plane in Desktop Radiance is that shadows caused by the building or other exterior elements are not projected onto this surface. If you wish to consider shadows on the ground plane, you must place a rectangle on the ground where the shadows will be located. You must also assign a surface material to this polygon so that it is considered as an obstructing and reflecting object. When doing this, do not to make this ground area larger than necessary, since it can impact the accuracy of an analysis.

Adjacent Buildings

Adjacent buildings can be modeled as simple three-dimensional objects (boxes or a single vertical polygon) with appropriate reflectance characteristics. If it is important to model specular reflections from surfaces on adjacent buildings, such as reflections from reflective glass, these materials can also be considered, however, depending on their size and their distance from the daylight aperture, the impact of these specular reflections may be difficult to accurately model without extremely high execution times (the reason is that Desktop Radiance uses a fixed number of rays at each surface reflection, tracking flux in a backward direction, and small distant elements are likely to be missed by these arrays).

Organizing your Desktop Radiance Model

In constructing your Desktop Radiance model in AutoCAD, it is important to organize the various objects in your model into layers, placing individual surfaces into different layers based on the *surface material* that you wish to assign to these surfaces. This is particularly important when your model is a complex one, since it will make it much easier to assign materials to surfaces. You can assign a material to an entire layer directly in Desktop Radiance by selecting Radiance? Tools? Material Map, then clicking on the Add Layer button. Constructing your model to take advantage of this feature will take some careful organization, but it can be a significant timesaving measure when assigning materials to surfaces.

Material Assignment

After creating the surfaces that make up your room model, it is necessary to attach a Radiance material to each surface. Radiance materials can be either opaque reflective materials (such as metal or plastic, with a diffuse, semi-specular or specular finish) or glazings, which are clear materials, such as glass, that transmit light.

In general, Desktop Radiance considers all surfaces to be double sided. That is, a material assigned to one side of a surface is also assigned to the other side, and both sides can be viewed. This does not, however, mean that objects should be created without thickness, which will detract from the general realism of an image, and could negatively impact the accuracy of the lighting calculations in a Desktop Radiance analysis.

The Desktop Radiance materials library contains a wide variety of surface materials. These have an assortment of reflectance properties and colors. However, a very limited number of patterned materials such as wood grain are not yet available through the library (wood grain and other surface textures can be applied in the Unix version of Radiance, and through the text-based input files in this version for advanced users).

When assigning surface materials, it is possible to search the library for a particular character string, or to rank order the materials based on any one of the material properties (reflectance, roughness, etc.). To apply either of these functions, you must first enter or select your search or sort parameter, then click on the search or sort button. If you simply press on the <Enter> key after entering the name of a material name to find, the program will not perform the search you requested.

Glazing Surfaces

Glazing surfaces are an exception to the double-sided material convention. For surfaces that you plan to assign as glazing, the surface orientation is important. If you construct a window surface using the 3DFACE command, the glazing surface should be constructed using the right hand rule, specifying the points around a three or four-sided polygon in a counterclockwise manner, as viewed from within the room. If a glazing surface has been created using another drawing function, you should check the orientation of the surface normal to insure that it is facing into your room. It is possible to check and alter the surface normal for a polygon using one of the Desktop Radiance menu commands (Radiance? Tools ? Adjust Surface Normals). A small red arrow will point in the direction of the surface normal from the center of the surface. You can then reverse this orientation, if desired.

The Desktop Radiance glazing library currently contains only clear glazing materials, but it is possible to enter a perfectly diffuse material through manipulation of the Radiance text-based input files (as described elsewhere in this document).

Adding Luminaires

After surface materials and glazings are appropriately assigned, luminaires may be added from a reference library. At the present time, Desktop Radiance restricts the luminaires that you may add to those listed in this library. It does not yet permit an arbitrary IES photometric file to be entered into a model through the pull-down menus, but with some additional work and manipulation of the text input files, it is possible to apply any photometric data (through an IES photometry file). Later in this document, we will discuss how to alter the photometric report associated with a library luminaire that you have entered to a model.

The library luminaire files that are attached to your model when you insert a luminaire from the library into your model contain a physical description of the luminaire surfaces (with materials already assigned) along with representative candlepower data for the luminaire. These luminaires are typically the generic luminaires listed in the 1993 IESNA Lighting Handbook. In general, these luminaires contain only a single plane of photometric data, and therefore should not be used for detailed design calculations. Although they emit the proper number of lumens, they are not necessary in the correct direction since all horizontal planes have been averaged.)

Typically, luminaries are arranged in rectangular arrays. To create a rectangular array, first insert a luminaire into your AutoCAD model from a Desktop Radiance luminaire library at one of the corners of the array. Make sure it is properly oriented/rotated, then type the command *array* on the AutoCAD command line. Enter the number of rows and columns, then the spacing or the extents of the array. All luminaires in an array must be oriented at the same angle. For this reason, it is not possible to specify wall wash systems on opposite walls using a single array (because their rotation angles are different). A separate array is necessary for the group of luminaires lighting each wall.

The ability to construct a new three-dimensional model of a luminaire (one that has its own characteristic geometry) and insert it into your model will likely be part of a future release of this software. The process of creating a luminaire from scratch is an advanced Radiance topic, and will not be discussed here. Experienced Radiance users can create/modify the Radiance text files to create and add a luminaire, but this involves significant work as well as detailed knowledge of how different light emitting materials are assigned and treated in Radiance. (These are covered in the Radiance Reference Manual.) The ability to modify the photometry associated with one of the library luminaire models should be sufficient for most applications, since it should provide the proper distribution of light within the modeled space using relatively similar luminaire geometry.

Adding Furnishings

The final library that is supplied with the Desktop Radiance software is a furnishings library. Furniture and a number of other simple objects can be added to your model from this library. Although the objects available in this library are somewhat limited, you can construct any desired object within AutoCAD for inclusion in your Desktop Radiance model, or insert objects available from other AutoCAD libraries into a model. Radiance material assignments must be made to all surfaces present in the imported or self-created objects.

Preparing a Simulation

Once all of the information regarding your model has been entered into AutoCAD, you are ready to perform an analysis or rendering of a space considering daylight and/or an electric lighting system. The types of analysis that are available include single reference points, grids of reference points (for computing horizontal illuminance), as well as general detailed renderings of your model (through which either surface illuminance or luminance can be analyzed, depending on which metric was used to create the rendering in the Simulation Manager screen).

To perform an illuminance calculation, you must first specify a point or grid (Radiance? Analysis? Define Reference Point, or Radiance? Analysis? Define Reference Grid). To specify a grid, you must provide a name for the grid, then enter a pair of opposite corner points, as well as the number of columns and rows of points that will span across this area in each direction.

To produce a rendering of a space, you must provide a name for the camera, then provide a lens size in millimeters. For most viewing conditions, a 20 mm lens size is a good starting point. The lens size will determine the angular width associated with this view (see Table 1). Next you will be prompted to position and orient the camera within the model by specifying an insertion point (x,y,z location), a rotation angle, and the camera height (above the insertion point).

Table 1. Camera lens length and corresponding view angles in Desktop Radiance.

Lens Length (mm)	Horizontal View Angle	Vertical View Angle
50 mm	42.2	27.0
40 mm	52.2	33.4
30 mm	68.1	43.6
20 mm	96.8	61.9
10 mm	120.8	77.3

It is important to note that once a camera, analysis point or grid is positioned in a Radiance model, it cannot be moved. If one of these is positioned incorrectly, you should delete it and relocate a new camera or illuminance meter for an analysis.

Running a Simulation

Illuminance calculations are performed, or a rendering is created, when you run a simulation (Radiance? Simulation? Camera, Radiance? Simulation? Reference Point, or Radiance? Simulation? Reference Grid). You must first select the reference point, grid or camera by clicking on it with your mouse. Next, you will be asked to enter a scenario name, then you must select the surfaces to include in the analysis. Generally, you will respond to this last request (to select the surfaces to be included) with the word *all*, then you must then strike the enter key twice. The software will then display the Workplane Calculation Setup window or the Camera Simulation Setup window, where you can specify assorted input and calculation control parameters related to your analysis (such as the time, site, and sky conditions).

To perform a daylight analysis, it is necessary for your model to have windows or openings to the exterior (unless you are analyzing the exterior of a model). When you run a simulation (either a calculation or a rendering), you must specify the site location in terms of its longitude and latitude (or use one of the available cities), enter the date and time, and specify the type of sky condition that you wish to consider. The available sky conditions are a clear sky, intermediate (partly cloudy) sky, overcast sky, and a uniform sky. A uniform sky is not a real sky condition in nature, but is sometimes used for model analysis. If you don?t want to consider daylight, enter a time that is in the middle of the night (for example, 1AM).

Rendering Modes

Interactive

Desktop Radiance has two different modes through which you can process rendered images. The first is an interactive mode that utilizes a program called *rview*. Rview produces a rendering by starting with a very course image, then it refines the image using progressively smaller and smaller rectangles on your screen. You are able to stop the rendering at any point and modify the view parameters to alter the view of the space, or trace a ray onto a surface to determine the illuminance or luminance of that surface. If you alter the view parameters to achieve a more desirable view of your space, you can save the view as discussed below for use in a future rendering of that space (or for use in a batch rendering).

The rview program has a number of built-in features. There are six boxes with letters in them that permit you to modify various features used to process the rendering, or that permit you to query the view to determine the luminance or illuminance values on a surface. These different buttons permit you to do the following:

E **-** Modify the image exposure. This is like adjusting the aperture on a camera. The adjustment can be done for the average image luminance or by selecting a particular point or region in the image to use for this exposure.

F **-** Refine the image within a selected region (specified by a window).

N **-** Start a new rendering.

P **-** Change the processing parameters. You can access a large number of image processing parameters after selecting this button, which is typically for advanced Radiance users. For most situations, you should make your changes using the selections that are available under the *Advanced* button on the simulation setup screen. It is not possible to save these settings after you are finished refining them in rview, but you can go back to the advanced dialog box in the Simulation Manager and enter these for a duplicate image, in which case they will be saved with this new scenario.

T **-** Trace a ray into your image for the purpose of determining the luminance or illuminance at a point. If you setup the rendering to display luminances (the default), then the last value in the box that appears when you query a point within the image is the luminance in cd/m^2. If you indicated that the rendering should be made using illuminance information, then the final value in this box is the illuminance in lux.

See the Figure 1 below for an example. In both cases, the luminance or illuminance value is the last value in the list that is followed by the letter ? L?. The units are always cd/m^2 or lux, regardless of the units used in the drawing.

V **-** This button will permit you to modify the view parameters, such as the camera location, view angles, etc.. It is then possible to save your view as described in detail below.

If you run the RVIEW program to completion, it will indicate that it is done with the word “Ready”. You can then save the image to a .PIC file, which is a Radiance file format (accessible only through the WINIMAGE program. WINIMAGE can convert this view to a number of different standard formats (.gif, .tif, .pct, .eps and .bmp).

RVIEW provides the best opportunity to refine the extents and direction of a view in the Desktop Radiance system. Once you have refined your view parameters, you can save this view by appending it to the .RIF file that has the name of your current simulation scenario. The software will also ask you to provide a name for this view, and will finally ask you in which view file you would like it to be installed. Here, you should select the view file that you selected for the current simulation. Once this new view is saved to a file, you may request it in the Simulation Setup menu (but you will need to select another view, or the current view, in AutoCAD to get to the Simulation Manager).

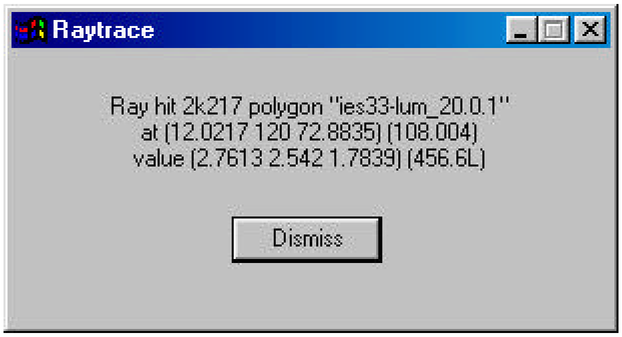

Figure 1 Report from a ray trace performed in RVIEW.

Batch Processing

Although it is quite interesting to watch a view being rendered in the interactive mode, it is a rather inefficient way to render an image. It is much faster to render an image in batch mode, where the rendering is created in the background (saving the work involved in continuously updating the screen image).

Once you have your view appropriately set, and a desired view saved, you can duplicate your scenario, select *batch mode* for processing, modify any of the advanced processing parameters that you wish to change, and start your rendering. The rendering may take between a few seconds and many hours depending on the processing parameters you have selected. If you wish to receive an update of the progress, you may click on the MS-DOS window. Once the rendering reaches a particular point in the rendering process, it will track its progress in terms of the percentage of the rendering that has been completed.

The batch mode is significantly faster then the interactive mode when the same processing parameters are applied to each. When your batch mode rendering is finished,, you can go click on the Analyze/Display button in the Simulation Manager to call the rendering file viewing program (WINIMAGE) to display your rendering.

Modifying the Desktop Radiance Analysis Parameters

In specifying how Desktop Radiance will perform its analysis, a number of Radiance?s operating parameters can be adjusted. These will determine the speed of the analysis, the quality of the image that is produced, and the accuracy of the results. Desktop Radiance provides a number of simplified analysis control settings that automatically adjust these parameters. These are accessed through the *Advanced* box at the bottom of the Simulation or Calculation Setup window (See Figure 2).

Under the lighting tab, the number of ambient balances can be modified for the room calculation and for the calculation of the photometric distribution to assign to the windows (using the Mkillum Options -ab setting). It is best to set the ambient bounces to a value between 3 and 5 for the room, and a value of 2 or 3 for the mkillum option for a final run. The light variability can also be specified (this is the expected variability of the surface illuminance/luminance produced by your windows and electric lighting conditions).

Under the Rendering tab, you can set the rendering quality to low, medium or high, and also toggle between soft shadows and sharp shadows for area light sources. Selecting soft shadows, which more accurately renders the shadows created by area sources, greatly slows down execution time,

If you are familiar with the advanced Radiance control parameters, you can specify your own parameters by overriding the simulation settings. In most situations, it is best to first analyze a model with the analysis and rendering settings at low to get quick initial feedback on how your model is performing. If higher settings are needed, they can be applied in subsequent runs.

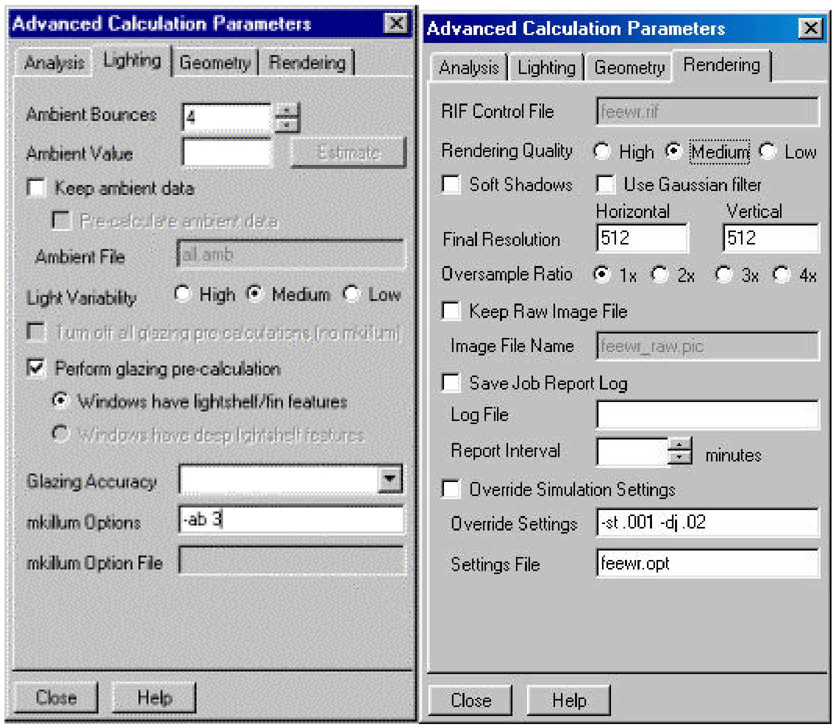

Figure 2. The number of ambient bounces can be set for both the interior and the mkillum calculations. Rendering quality and soft shadows (penumbras) can also be specified.

For reasonably good numerical results, it is advisable to eliminate all ambient light and permit Desktop Radiance to compute multiple reflections. Suggested override settings are -av 0 0 0 (setting the ambient value to 0) and -ab 5 (the ambient bounce setting. For some lighting systems, you may need to increase the number of ambient bounces even further, such as in the case of a light shelf, where multiple reflections are part of the daylight delivery system).

Desktop Radiance Lighting Calculations

Desktop Radiance operates primarily using backward ray tracing. This procedure is used to generate the renderings of a space, and to perform the lighting calculations (at reference points or grids). Rays are traced from the camera position to each surface that is visible in a view to compute the color and intensity to assign to each of the pixels in the rendered image. Some interpolation may be done between individual pixels. A similar analysis is performed for the horizontal illuminance calculations considered at reference points and reference grids. For each ray that is traced to a room surface, a number of additional ray bounces are considered (the number of ambient bounces considered is controlled by the user) until the light ray reaches a source. The reflectance of each surface is considered at each ray bounce, and additional backward rays are spawned. The distribution of these backward rays is statistically determined based on the reflecting material?s surface properties.

The disadvantage of this procedure is that a new calculation is required for each camera position or analysis point. It is possible to save an ambient light file for future analyses, which is used to shorten the computation time for additional images or analyses. The advantage of the backward ray tracing technique is that a fairly complex space can be rendered in a relatively short amount of time. A surface that is not within the field of view is not analyzed unless one of the backward traced rays strikes it. The time that Desktop Radiance takes to process a rendering or calculation depends on the processing settings that are selected. A higher number of ambient balances will result in a slower processing time.

The direct contribution from light sources is considered in a more conventional approach. Here, area sources may be subdivided into as many as 64 individual point sources (an 8 x 8 array). The implications of this are discussed in more detail in a later discussion on glazing materials, since glazing materials can also be considered as light sources.

In performing its calculations, Radiance considers the spectral composition of the light sources and the spectral characteristics of a reflecting or transmitting surface using the equivalent R,G, B composition of the source light and of each material?s reflecting/transmitting properties. In Desktop Radiance, the R, G and B components correspond to a color specification system that is correlated to the typical phosphor colors used in computer monitors. Using this formulation, a green surface will reflect light that is more green than white in accordance with the saturation level of its surface color.

Radiance also attempts to estimate the amount of ambient light in a space to consider all ray bounces beyond the number that are requested. The software automatically estimates the value of this uniform ambient component. It can be turned off by setting the RGB components of the -av command to 0 by adding ? -av 0 0 0" to the Override Settings entry in the advanced dialog box under the Rendering tab (you must remember to check the Override Simulation Settings box to enable these changes). If the number of ambient bounces being considered is small and the -av setting is set to zero, the luminance of any surface in the space is likely to be underestimated.

Daylight Contributions through Windows

There are two different ways to calculate the contribution from a glazing material in a Radiance analysis. These options are as follows:

Windows Considered as a Light Source

A window can be considered as a light emitting area, or light source, using the Desktop Radiance *mkillum* command. This is the default method used by Desktop Radiance. On the glazing properties screen, you will see a check in a box labeled ? Simulation control: as light source?. In this mode, all light from the exterior is first analyzed at the surface of the window, a candlepower distribution is then assigned to the window surface for determining the distribution of daylight within a space. The window is effectively treated like a luminaire.

In a rendering, the view out through a window treated with the mkillum command is still computed. The mkillum calculation is likely to run relatively fast in most cases, but has the disadvantage of assuming a uniform candlepower distribution across the entire window. This will not be the case when there is an exterior overhang or other obstructions in close proximity to the window. When an overhang is present, better results will be achieved with mkillum if the window is subdivided into smaller elements to allow the window to be considered using a series of different candlepower distributions applied over a larger number of smaller areas.

One primary disadvantage of this approach (considering the window as a light source) occurs when an interior surface is located very close to this light emitting surface, the receiving surface may have a non-uniform, discontinuous surface luminance along the edge of the window because the window is subdivided into as many as 64 individual lighting emitting surfaces (maximum 8 x 8) that are treated as individual point sources (see Figures 3-5 below). To reduce the scale of this non-uniformity, it is possible to subdivide a large window into a number of smaller rectangles (particularly along an edge that produces this rendering artifact). This will make the non-uniform pattern less pronounced since a larger number of smaller light emitting elements will be considered along that edge.

When windows are considered as light sources, the direct contribution from the sun?s rays are considered separately, and are not included in the candlepower distribution assigned to the window.

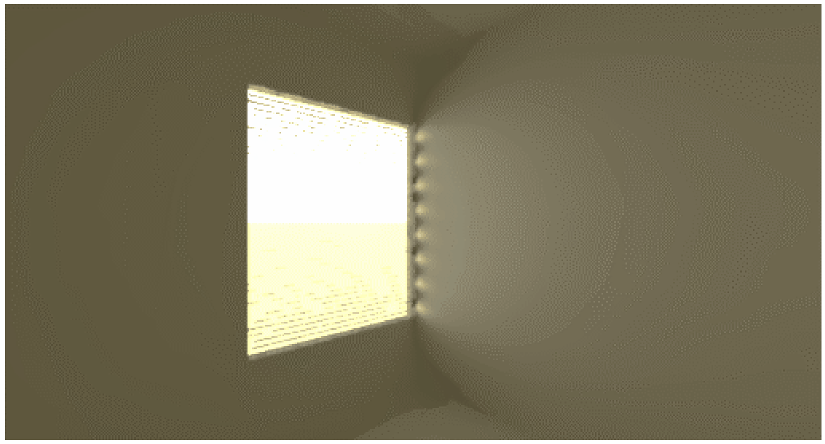

Figure 4. Highlights on side wall with mkillum since window is only subdivided into a maximum of 8 pieces along any dimension.

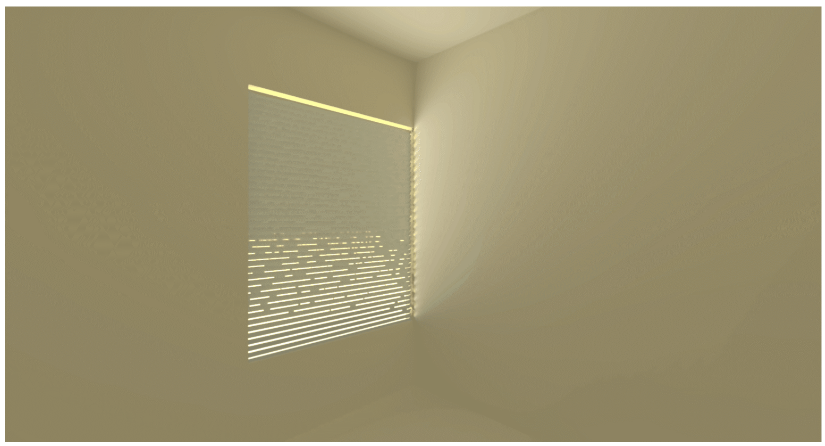

Figure 3. Highlights on side wall are smaller when the window is subdivided vertically into three different window areas (see next Figure). Note: Blinds are at a different angle here than in the previous figure.

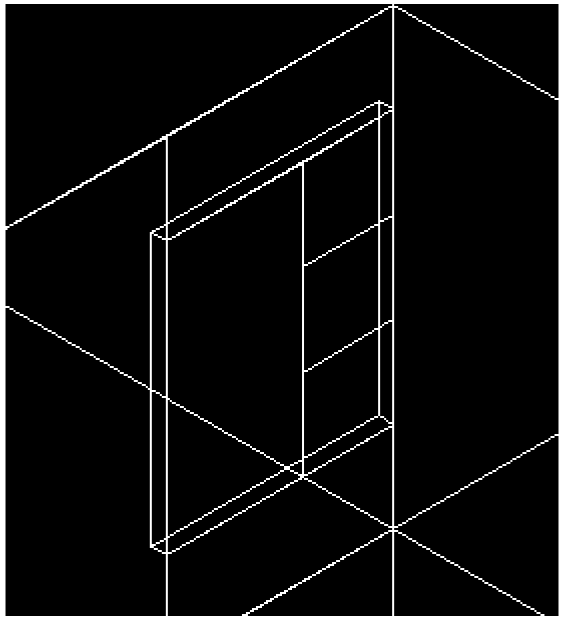

Figure 5. The window in the previous figure has been divided into three different areas along the side wall to reduce the size of the highlights on the side wall. 24 window sources (instead of 8) will be applied along the right side of this window at a high accuracy setting.

Skylights

It is also possible to consider a window or an entire skylight assembly as a light source. To do this, you need to insert a special polygon over the inside of the window or skylight aperture, then select and apply the glazing labeled ? special illum? in the glazing library (see Figure 6 below). This special glazing has a transmittance of 100 percent, and exists solely for use in creating these secondary light sources. In the case of a skylight, this special glazing should be applied to a surface that extends across the bottom of the skylight well to consolidate the calculation of the exterior, the skylight glazing material and the reflections that will occur within the well. In this case, the mkillum command will compute the appropriate luminous intensity distribution emitted from the bottom of the well and apply it across this surface.

Blinds

Using a special illum surface to create a secondary light source is also an appropriate analysis method to apply when considering blinds over a window. The special illum surface is placed on the room side of the blinds to simplify the combination of the glazing and this control device. When applying this approach, it is important that the entire perimeter of the surface to which you assign the special illum glazing is attached to other surfaces (this is necessary to avoid light leaks around the special illum surface. In applying this type of glazing, you should also turn the mkillum (window as light source) calculation off for any window that lies outside this surface.

Windows as Transmitting Surfaces

The mkillum feature can be turned off by un-checking the box described above in the glazing properties section, in which case the window is considered only as a transmissive material, and backward traced rays pass through the window to exterior objects. In this case, the window is considered to have a non-uniform luminous intensity distribution across its surface. This can be a more accurate approach in some situations where there are overhangs, exterior light shelves, or other elements that will impact the distribution of light admitted across the surface of a window, but it is likely to take significantly longer to execute in these situations.

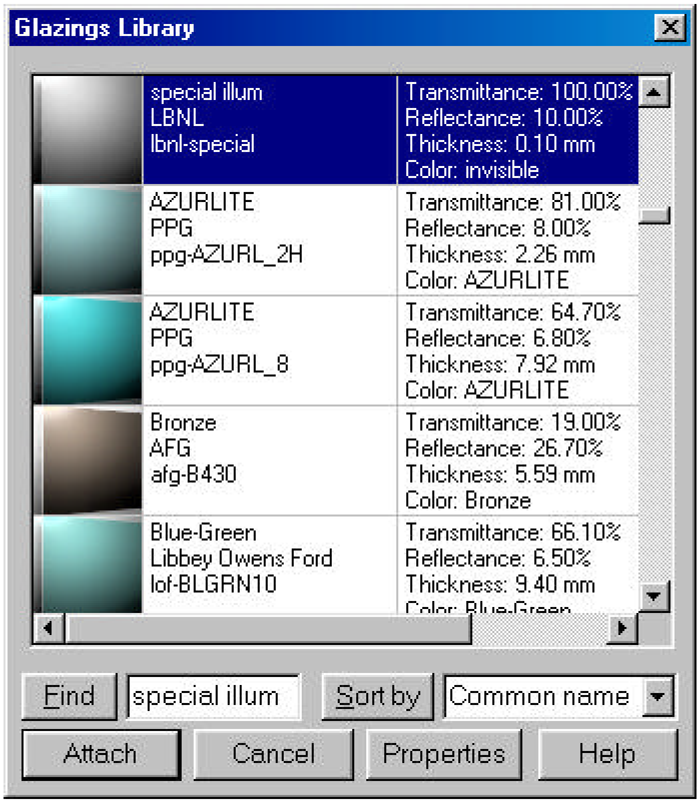

Figure 6. The special illum glazing material used with mkillum.

Turning the light source feature off for a window may create a problem when the window is small and very bright. This is because the reflected rays, which are statistically arranged, may miss this important light source. To get accurate results under these situations, it is important to set -ad quite high (*-ad 3096*); -as should be set to half the value of -ad (if *-ad 3096* is applied, *-as 1548* could be applied, and -aa should be set low (such as *-aa 0.1*).

It is important to note that this approach ,where all rays are transmitted through the glazing material (the non-mkillum approach), is not a very effective approach when applied to blinds. This is due to the large number of reflections (ray bounces) that must be considered to accurately model the performance of the blinds. The fact that blinds have both a through component and a reflected component makes this situation very difficult to properly render. Whereas the mkillum command will generally produce a very smooth distribution of light along the interior room surfaces, turning mkillum off (treating the window as clear transmitting material) may result in a somewhat blotchy or patchy interior when insufficient rays are traced at each reflection. This is due to the fact that reflected light is modeled by projecting a random sampling of additional rays off each surface, which may result in different surface illuminance or luminance along a room surface due to the luminance seen by the sampled rays (some go through the blinds, while others strike the blinds). To perform this analysis with a significantly higher number of reflected rays is often prohibitive since it may result in extremely long execution times.

Ambient Bounces and Daylight

The number of ambient bounces that Desktop Radiance should apply is under user control and will vary depending on the type of lighting system you are analyzing. This number can be changed in the advanced dialog box of the simulation manager (the *advanced* button on the Calculations and Rendering Setup window). When the number of ambient bounces is set to 0 and mkillum is not being used for the glazing surfaces, the ambient lighting calculations are switched off, so a view of the room will consider only direct sunlight patches that are visible from the view point. The sky will be visible through the window, but the contribution of the sky onto each of the room surfaces is not considered. If the program has set the -av value, an additional amount of ambient light is added to each surface in the room.

If the number of ambient bounces is set to 1, light is considered to reach the interior surfaces from the sun's direct rays, from the diffuse sky, and from first bounce reflections of direct sunlight rays from both interior and exterior surfaces. Reflections of sky light off interior or exterior surfaces to other interior surfaces will not be considered. Additional bounces can be added to consider additional flux paths.

Modeling the Windows

If the thickness of the exterior wall and/or mullions is significant, it is very important to model this thickness since it can impact the view that an interior point has of the exterior. Rarely is a building envelope infinitely thin. Similarly, light well depth is a critical modeling detail for skylighting systems.

Individual mullions in a window that will be visible in a rendering should be included if you desire a more realistic view of a space. If, however, you only wish to perform a photometric analysis (illuminance calculations) in a space, you may apply a single large window with a slightly lower (adjusted) transmittance that accounts for the transmission loss caused by the mullions.

Recessed luminaries

In modeling recessed luminaires, such as parabolic troffers, it is necessary to create holes in the ceiling into which the luminaires are placed. This will permit you to see up into the luminaire. It will obviously take more time to create such a ceiling for a large room, since the ceiling surface must be constructed from a number of individual surfaces. Using the array command to create these surfaces should make this construction process faster and easier.

In the case of the round downlights that are included in the Desktop Radiance Library, the apertures have been constructed with luminance bottoms. This was done because it is extremely time consuming and difficult to create a ceiling with round holes in it and to have the ceiling exactly meet the perimeter of the luminaire aperture when it has a round shape. For these luminaires, the luminous bottoms are positioned just below the ceiling surface when the luminaires are properly located at the ceiling plane. A single solid ceiling surface can therefore be applied with these luminaries.

Pendant luminaries

Pendant luminaires should be located at the appropriate suspension distance from the ceiling. The suspension device (tube/pipe/wire) can extend above the actual ceiling, and will be rendered accurately. For added realism, you may want to add a support cover where the post or support cable goes through the ceiling.

Appendix A: Special Operations - Modifying the Text-Based Input Files

To access a few special features that are not yet available in desktop Radiance, it is necessary to modify the Radiance ASCII text input files and run the simulation from Windows Explorer or an MS-DOS prompt. At the present time, it is necessary to do this for the following:

1. To change the luminaire photometry from that which is included in the standard library luminaires to photometry from a user-supplied IES formatted file.

2. To add blinds to a window.

3. To input a diffuse glazing material.

Modifying Luminaire Photometry

It is possible to retain the geometry and general appearance, but replace the photometry for a luminaire that has been loaded into a Desktop Radiance model from the program's luminaire library. To do this, you must first create a data file that contains the photometry in a format that Radiance can use, then make a few small changes to a text-based input file to instruct Desktop Radiance to use the new photometry in your model. First, you'll need a working Desktop Radiance model that has a library luminaire installed, and the IES formatted photometric file for the luminaire that you wish to install into the model. The structure of the photometric file and the changes that you must make depend on whether the light emitting area of the luminaire is a single polygon, as is the case with a recessed or a completely direct or completely indirect luminaire, or a three-dimensional light emitting surface (one with length, width and height). If the luminaire emits light both up and down, it will generally be considered using a luminous three-dimensional rectangular solid. We will consider each of these situations separately.

Modifying Photometry for a Recessed Luminaire (or any luminaire with a single luminous polygon)

The instructions for changing the photometry for a typical recessed (or single polygon) luminaire is as follows:

Step 1: Edit the luminaire file that was extracted from the Desktop Radiance database. For example, let's assume that we selected IES luminaire #47 from the Desktop Radiance library, which is a batwing fluorescent troffer (See Figure 7 below). Let's also assume that your AutoCAD file is named room1.dwg. After it is loaded into this model and an initial simulation is run, the luminaire photometric data and surface geometry will be located in a subfolder of your working directory. The main folder should have a name that is the root name of your AutoCAD file (in this case *room1*), and the luminaire is located in a subfolder of this directory with the pathname: lum/lbnl/ies47. The Desktop Radiance input file that describes this luminaire will be named IES47lum.fmt and its photometry is stored in a Radiance data file with the name IES47.DAT.

Locate the .FMT file and edit it using Wordpad or another ASCII or text editor, and look for a line that begins with "illum polygon". In the lines that immediately follow this one, you should see the x, y and z coordinates of the corner points of the polygon that is the light emitting polygon to which the photometry is applied in Desktop

Radiance. Note the physical size of this polygon in the x and y dimensions (assuming the luminaire is not tilted). For the IES47 luminaire, these dimensions are 48 and 24 inches, respectively.

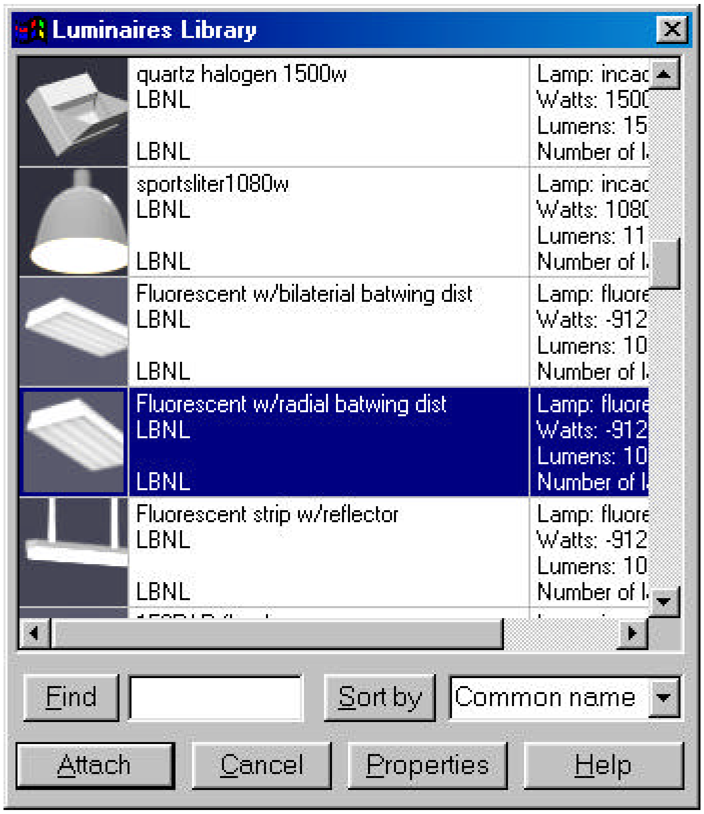

Figure 7. The IES #47 luminaire in the Desktop Radiance Luminaire Library.

Step 2: Edit the IES data file so that the dimensions of the luminaire are identical to those of the light-emitting polygon in the .fmt file. In the IES file, the dimensions must be reversed. The x-dimension in the .FMT file is the y-dimension in the .IES file and vice versa. For more information on the IES file format, please see the appendix at the end of this document. Most IES files use dimensions of feet, so for the 24 by 48 in. rectangle, these dimensions should be entered as 2 and 4 feet if they are not already equal to these values (typically they will be slightly smaller due to the luminaire's frame). After making these changes to the IES file you plan to use, save this copy of the IES file to a new filename so you do not overwrite the manufacturer's master photometric file. For the purpose of this discussion, we will assume this new filename is newlum.ies. It is important that the long and short dimensions match those in the .IES file. That is, the short dimension should typically be in the x-dimension in both.

Step 3: Copy the new IES photometry file into a temporary folder and make note of the path in which this file is located. Go to a DOS prompt by selecting Start? Programs? MS-DOS Prompt, then set the current directory to the directory containing the newlum.ies file using the CD command (CD \PATH, where PATH is the full path to the directory containing the .fmt file). Then, run the ies2rad program using the following parameters:

```
ies2rad -di -t white newlum.ies
```

The *-di* option will output the luminaire with its dimensions in inches (which is what Desktop Radiance uses if you are working in Imperial units) and the *-t white* command will make all three RGB components the same for the light emitted from this luminaire. Newlum.ies is the name of the file that contains the photometric data that you wish to use. This will create two new files within this directory named newlum.dat and newlum.rad. Copy the .DAT file into the folder that contains the IES47.DAT and IES47LUM.FMT files.

Note: If you view the .RAD file and inspect the .DAT file, you may see that ies2rad has rotated your luminaire by 90 degrees. This rotation is the format applied by Desktop Radiance for library luminaires so that IES photometry files will be in agreement with Desktop Radiance library luminaire geometry. The name of the .DAT file that was generated by the IES2RAD command can simply be inserted into the .FMT file and the new luminaire will be applied in the next simulation.

Step 4: Now, open both the new .red file created by ies2rad, and the .FMT file for the library luminaire in a text editor. Compare the line of text following the line containing the word brightdata. In some cases, you may need to insert or remove the string src_phi4 to make the .FMT file match what is in the .red file. At the same time, you need to increment the number at the beginning of that line up or down by one if you are adding or deleting a string (this value informs Radiance of the number of entries on that line. Finally, insert the name of the new .DAT file in place of the library .DAT file on that line.

(From newlum.rad, compare the text in bold with that in the library .FMT file)

```
void brightdata newlum_dist
5 flatcorr newlum.dat source.cal src_phi4 src_theta
0
1 1

newlum_dist light newlum_light
0
0
3 1.34549 1.34549 1.34549

newlum_light polygon newlum.d
0
0
12
      24    12    0.00984252
      24    12    0.00984252
      24    12    0.00984252
      24    12    0.00984252
```

This section of the .FMT file for the library luminaire may look something like this.

```
void brightdata ies45_dist
6 flatcorr lum/lbnl/ies45/ies45.dat source.cal src_theta
      -rz ${TWIST}
0
1 ${DIM}
# if using a polygon
      1/(48*2.54/100)*(24*2.54/100)=1.345488802
# if using boxcorr 4 1 1.2192 0.6096 0.0005
```

```
ies45_dist illum ies45_light
0
0
3 11.8403 11.8403 11.8403
# 3 (8.8 8.8 8.8)*1.345488802= multiplier for this
      flatcorr

ies45_dist alias illum ies45_light
```

Now, make the changes noted below, copying the text from the new .red file into the .FMT file, and incrementing (or decrement) the number at the beginning of the flatcorr line as needed (depending on whether you are adding or deleting an entry from this line related to src_phi4.

```
void brightdata ies45_dist
7 flatcorr lum/lbnl/ies45/newlum.dat source.cal src_phi4
      src_theta -rz ${TWIST}
0
1 ${DIM}
# if using a polygon
      1/(48*2.54/100)*(24*2.54/100)=1.345488802
# if using boxcorr 4 1 1.2192 0.6096 0.0005

ies45_dist illum ies45_light
0
0
3  1.34549 1.34549 1.34549

# 3 (8.8 8.8 8.8)*1.345488802= multiplier for this
      flatcorr

ies45_dist alias illum ies45_light
```

You can then save your .FMT file using the original name, but it must be saved as an ASCII text file. You should also save it a second time to a different name in the event that Desktop Radiance overwrites your revised file with the luminaire #47 data again (it shouldn't do this, but you may want to check this after doing a large amount of additional work on your model).

You are now ready to run your Desktop Radiance simulation again using a different scenario name. Typically, this can be done from within AutoCAD or within the Simulation Manager without overwriting the new luminaire .fmt file. The new photometry will be used in any subsequent analyses.

Modifying Photometry for a Direct/Indirect Luminaire (a luminaire that applies a luminous three-dimensional rectangular solid)

The instructions for transforming the photometric data for a typical pendant-mounted luminaire are slightly different than those for a recessed luminaire. These are described in detail below.

Step 1: Edit the luminaire file that was extracted from the Desktop Radiance database. For demonstration purposes, we will use IES luminaire #33 from the Desktop Radiance library, which is a pendant luminaire (see Figure 8 below). As in the previous instruction set, we will assume that your AutoCAD file is named room1.dwg. After the luminaire is loaded into your model and an initial simulation is run, the luminaire data files will be located in a subfolder of your working folder (a folder with a name that is the root name of your AutoCAD file -- in this case *room1*) with the path lum/lbnl/ies33. The Desktop Radiance input file that describes this luminaire will be named IES33lum.fmt.

Locate this file and edit it using Wordpad or another ASCII or text editor, and look for a line that begins with "illum polygon". In this section of text and the five similar groupings of lines that follow this one, you should see the x, y and z coordinates of the corner points that describe the six sides of a rectangular solid which is the light emitting rectangular solid that Desktop Radiance assumes is the light emitting area of the luminaire. This rectangular solid is invisible in a view and will typically surround the physical elements that describe a library luminaire that has both upward and downward directed light. Note the physical size of this region in the x, y and z dimensions (assuming it is not tilted). For the IES33 luminaire, these dimensions are 48 x 6 x 3.96 inches, respectively. As was the case with the troffer, the x and y dimensions are reversed in the IES file. The IES2RAD command will convert these into the Radiance format by placing the long dimension along the x-axis. Typically, the long dimension (along the lamps) is oriented along the y-axis, which coincides with the 0-degree plane of photometry. For the photometric report that we would like to install for this luminaire, we will need to re–oriented the photometry so that the horizontal planes of photometric data (0 through 90 degrees) are reversed. A utility has been written to accomplish this task on a radiance .DAT file.

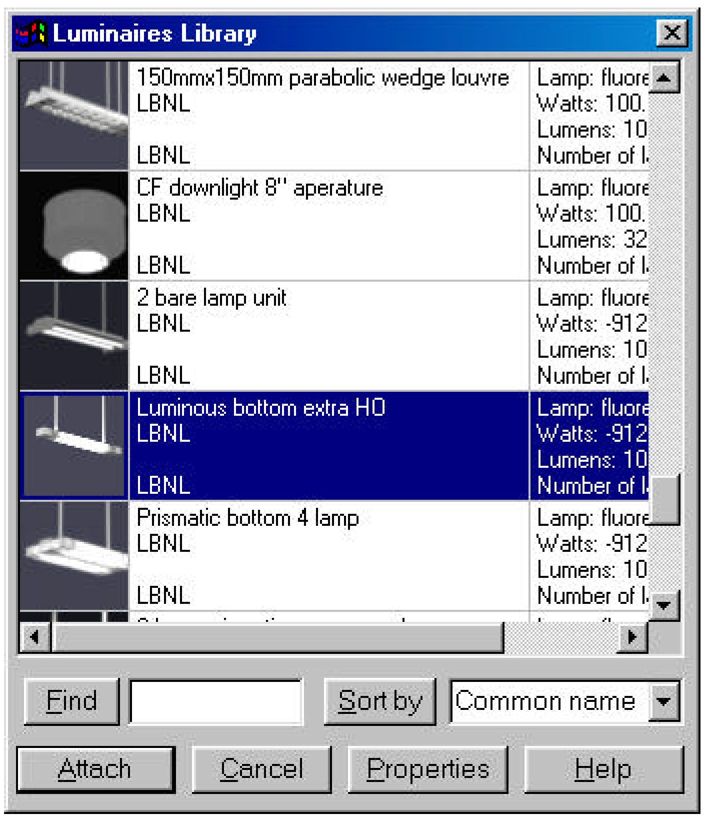

Figure 8. The IES #33 luminaire in the Desktop Radiance luminaire library.

Step 2: Edit the IES data file so that the dimensions of the luminaire are identical to those of the light-emitting rectangular solid defined in the .FMT file discussed in Step 1. For more information on the IES file format, please see the appendix of this document. Most IES files use dimensions of feet, so for the 48 x 6 x 3.96 rectangle, these dimensions should be entered as 4, .5 and .3 feet. After making these changes, save this copy of the IES file to a new filename so you do not overwrite the master file. For the purpose of this discussion, we will assume this new filename is newlum.ies

Step 3: Copy the new IES photometry file into a temporary directory and make a note of the path in which this file is located. Go to a DOS prompt, by selecting Start? Programs? MS-DOS Prompt, then set the current folder to the folder containing the newlum.ies file using the CD command (CD directory path). Then, run the ies2rad program using the following parameters:

```
ies2rad -di -t white newlum.ies
```

The *-di* option will output the luminaire with its dimensions in inches and the *-t white* command will make all three RGB components the same for the light emitted from this luminaire. Newlum.ies is the name of the file that contains the new photometric data that you wish to use. This will create two new files within this directory named newlum.dat and newlum.rad. Copy the newlum.dat file to the folder that contains the .FMT and .DAT files from the database.

The name of the .DAT file that was created can simply be inserted into the .FMT file and the luminaire will be properly considered in the next analysis.

Step 4: Now, open both the new .red file created by ies2rad (it will have the same root name as your IES file), and the .FMT file for the library luminaire in a text editor. Compare the line of text following the line containing the word brightdata. In some cases, you may need to insert or remove the string src_phi4 to make the .FMT file match what is in the .red file. At the same time, you need to increment the number at the beginning of this line up or down by one for each item that you add or delete from this line (this value informs Radiance of the number of entries on that line. Insert the name of the new .DAT file in place of the library .DAT file on that line. Finally, copy the three values from the "light" or "illum" line in the new .RAD file to the equivalent line in the .FMT file.

(From newlum.rad, compare the text in bold with that in the library .FMT file)

```
void brightdata 1121a_dist
5 boxcorr newlumr.dat source.cal src_phi4 src_theta
0
4 1 1.2192 0.1524 0.100584

1121a_dist light 1121a_light
0
0
3 1 1 1
```

The similar section of the .FMT file for the library luminaire may look something like this.

```
void brightdata ies33_dist
10 lboxcorr lum/lbnl/ies33/ies33.dat source.cal src_theta -rz
${TWIST} -t 0 0 -38.5
0
4 ${DIM} 1.2192 .1524 .100584
# original boxcorr 4 1 1.2192 0.1524 0.100584

ies33_dist illum ies33_light
0
0
3 2.2 2.2 2.2
ies33_dist alias illum ies33_light
```

Now, you need to make the necessary changes to the two angle designations (src_phi4 and src_theta) in the .FMT file to make it agree with the .RAD file. Change the number at the beginning of the line if you add or delete an entry. Also, change the .DAT file that this .FMT file will use. Finally, if the numbers in the third line after the illum line are different, modify these to agree with those from the .RAD file.

The .FMT file will then read as follows:

```
void brightdata ies33_dist
11 lboxcorr lum/lbnl/ies33/newlumr.dat
   source.cal src_ph14 src_theta -rz ${TWIST} -t
0 0 -38.5
0
4 ${DIM} 1.2192 .1524 .100584
# original boxcorr 4 1 1.2192 0.1524 0.100584

ies33_dist illum ies33_light
0
0
3 1 1 1

ies33_dist alias illum ies33_light
```

This new .FMT file will direct Desktop Radiance to use the new photometry file, which has been properly configured to match the luminaire model being used here.

You can now save your .FMT file using the original name (be sure you save it in a text format), but it is also recommended that you also save it to a different name in the event that Desktop Radiance overwrites your revised file with the luminaire #33 data again.

You are now ready to run your Desktop Radiance simulation again using a different scenario name. The .FMT file should be retained for subsequent simulations.

Inserting Blinds into a Model

Radiance can consider the impact of blinds applied to windows when computing the light distribution in a space, and will insert them into the rendering of a space when they are entered to a model. At the present time, however, this can only be done manually (outside the Desktop Radiance environment), by adding the blinds to the text-based Radiance input files. This section will explain how this can be accomplished for horizontal blinds. Vertical blinds can also be created by rotating horizontal blinds about the x-axis prior to locating them in your model.

In analyzing the impact of blinds, there are two different approaches you can instruct Radiance to take in its analysis. The first is to consider the window and blinds by applying a special glazing material inside these surfaces and have all light passing through this material considered as a light source (using a special illum surface). The daylight contribution to a space is then determined using a photometric distribution that approximates the luminous intensity of light emitted from the inside of the blinds (using mkillum).

The second option is to consider the blinds in a full raytrace analysis, which will normally take longer than the mkillum (light source) analysis, and may result in a less than uniform (patchy) appearance on the interior room surfaces. For this reason, the mkillum analysis is generally recommended. First, we will discuss the mkillum option, then address what changes need to be made to your model to have the blinds and window considered in a full raytrace analysis.

that covers a window or skylight aperture to consider it as a light source.

Illum (light source) approach to analyzing blinds

Step 1: Construct your room model as you normally would, and insert the glazing material in its appropriate location. If blinds will cover the entire window, it is not important to place mullions within the window, since the blinds will hide them. However, their impact on the overall transmittance of the glazing should be considered. You simply take an area-weighted average of the glazing transmittance (t_g) and the mullion transmittance ($t_m = 0$) as follows.

$$t_{g,ave} = [A_g (t_g) + A_m (t_g)] / (A_g + A_m) = A_g (t_g) / (A_g + A_m)$$

This glazing material should not be considered as a light source (illum surface), so this property should be turned off in the properties dialog box when you assign this glazing to a window surface (polygon) in your model.

The window assembly should also be constructed using the actual thickness of the windowsill and wall, etc.. Some thickness is necessary because you need to place a special glazing material on the room side of the blinds to be considered as a secondary light source (light emitting surface) in your model. You must provide sufficient space between the actual window and this imaginary glazing material into which you can place the blinds. The glazing properties applied to the actual window surface should not be considered as a light source. It is necessary to turn this option off by deleting the check in this box in the glazing properties window. The imaginary window surface must be built so that it touches another surface along each of its edges so that all daylight must pass through it to reach the interior.

When a window is considered as a light source, the entire extent of the window will have the same light emitting properties. If the window has an exterior overhang, the light emitting properties are likely to change across the window with the vertical distance from this overhang. In this case, you should break the window up vertically into a number of different areas, or consider the analysis using a full raytrace (i.e., do not treat the window as a light source). For this special glazing surface, you must select the special illum glazing material from the glazing database, which has a transmittance of 100 percent (See Figure 9 below).

Step 2: When you are finished with your room model, except for adding the blinds, setup the analysis you wish to run and start a simulation for this rendering or illuminance grid analysis (in either interactive or batch mode). When the simulation starts to run, you should terminate it in either RVIEW or in the MS-DOS batch file. Now, you will have all of the files needed to re-run this analysis on your hard disk (they are exported by Desktop Radiance and run from a batch file). You next must apply the Radiance *genblinds* commands to create a description of the blinds and insert these blinds into your model. To run the genblinds command, go to an MS-DOS prompt (using Start > Programs >MS-DOS Prompt/Command Prompt). Next go to the folder that has all of the .RAD files whose name begins with the scenario name you selected (the subfolder in which these files are located should begin with the root name of your .DWG file).

Then, at the MS-DOS prompt, run the genblinds command, specifying the required input as listed in the example provided below. If you are working in Imperial units, the Radiance model dimensions are generally specified in inches. You will need to assign a material to be applied to the blinds, and this material must also be included in your Radiance model (i.e., in the files). You can obtain the name of a library material from the material library selection screen. It is located on the third line, to the left of the transmittance value. It will generally consist of both numbers and letters, such as 3e311. This material must also be included in your Desktop Radiance model. One of the easiest ways to insert this material in your model is to create a small surface outside your room or someplace where it will not be visible, and assign the material that you plan to apply to the blinds to this surface. When you run your simulation, this material will be exported and automatically included in the text files.

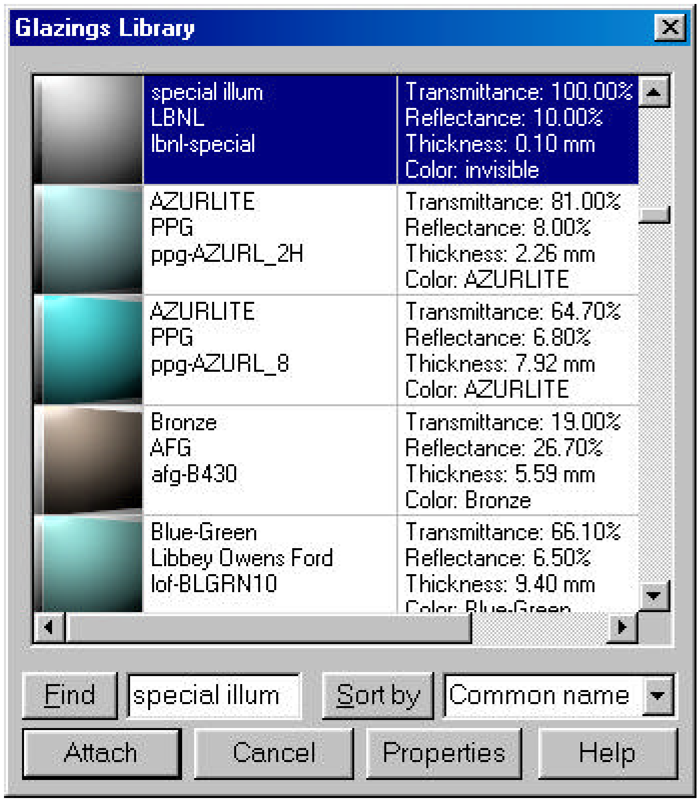

Figure 9 - The special illum glazing that is assigned to a surface that covers a window or skylight aperture to consider it as a light source.

Before you create your blinds, you will need to determine how many actual slats will be used in the set of blinds you plan to create. Assuming a 15 percent overlap on each blind, the number of blinds is simply the height of the blinds divided by the width of the blinds (i.e., the width of the individual slats) multiplied by 1.15. Let?s assume that we have a window opening that is 36 inches wide and five feet (60 inches) high onto which we want to install horizontal blinds. We will use the 3e311 material, assign an arbitrary name, in this case ? blind1" to the blinds, and assume that 60*1.15/1 or 69 individual horizontal blinds are needed.

You also need to rotate the entire set of blinds and translate this rotated set of blinds to their position just inside the actual glazing surface (or between the actual glazing surface and the special illum surface if you are considering the window configuration as a light source using mkillum). Prior to rotation and translation, the blinds will be arranged with the long dimension of the blinds running along with the global Y-dimension.

When the entire set of blinds is not rotated, they are ready for application on a West-facing window. To rotate the blinds about the Z-axis so they are oriented properly for a South-facing window, a 90-degree rotation angle is needed. Similarly a 180-degree rotation angle is needed for an East-facing glazing situation and a 270-degree angle (or -90 degree angle) is needed for a North-facing window. In rotating the blinds, they are rotated about the corner positioned over the origin (0,0,0), which is the lower left hand corner as seen in plan view. The blinds must then be translated to a location between the two glazing surfaces (the actual glazing material and the special illum surface) by properly entering the distance (in x, y and z) that this origin point must be moved. Remember, when the blinds are rotated, the origin point is no longer at the lower left hand corner of the blinds. See Figure 10 for a graphical example.

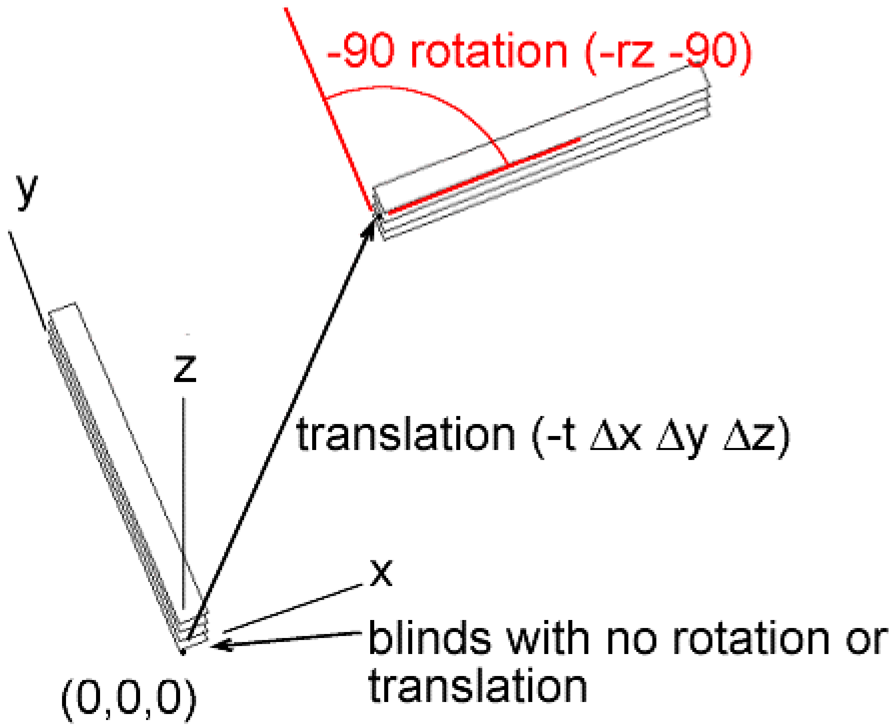

Figure 10 - Blinds that are not rotated or translated are aligned with the y-axis with a corner located at the origin (0,0,0). They must be rotated and translated place them at their appropriate room position.

The example below will position the blinds on a North-facing window with an approximate maximum y-position of 10 feet. The upper left corner of the rotated blinds, as seen in plan view is at x=12 ft., y = 12 ft., and this point is 3 ft. off the floor.

genblinds 3e311 blind1 1 36 60 69 0 -r 0 |xform -rz -90 -t 144 144 36 >blinds1.rad

(Note: The above should be typed on a single line.)

The order of data following the genblinds command is the following:

3e311 = material name to assign to the blinds.

blind1 = arbitrary name (your name for the blinds to be used within Radiance)

1 = width of blinds in inches (this dimension will be along the x dimension when the blinds are created (if not rotated)

36 = length of the blinds along the window in inches (y)

60 = height of the blinds in inches (z)

69 = number of slats to use

0 = blind angle (in degrees) , a positive value will slope the blinds up in from the lower to the higher x-dimension.

-r 0 = apply a radius of 0 to the individual blinds (no curvature). If a -r is used, the curvature is downward (the usual orientation). If a +r is used, the curvature is upward.

|xform = xform the position of the blinds as specified by the rotation and translation parameters that follow.

-rz -90 = rotate the entire set of blinds around the z axis (x=0, y=0) by a -90 degrees, which is 90 degrees in a clockwise direction.

-t 144 144 36 = after the blinds are rotated, translate the entire set by 144 inches in the x and y directions and 36 inches in the z dimension.   These dimensions are in inches because these are the units used by Desktop Radiance in the exported model description files when working in Imperial units. This would likely place them on a north-facing window of a small (12 ft. x 12 ft.) room.

>blinds.rad = place all of the geometry created by this set of commands into a Radiance input file named blinds.rad.

Step 4: One the .RAD file is created for the blinds, these files must be added to your Radiance analysis. This is done by adding this file to the files listed in the "scene=" line in the .RIF file for your scenario (It will have a root name that is your scenario name). If you have more than one set of blinds, you will likely have more than one .RAD file to add, unless you combine the contents of these into a single file. Remember to save the .RIF file in a text format.

Step 5: Once the blind .RAD file is added to the .RIF file, you can restart the analysis by double clicking on the .BAT file that was created for your scenario. The analysis should then begin for your room model with the blinds included in the model.

Note: If you go back to AutoCAD and rerun an analysis or go back to the Simulation Manager and duplicate this analysis, your blinds will be not be included in the new .RIF file. They must be inserted into the file and the simulation must be restart by hand.

Full Raytrace Analysis

To run a full raytrace analysis, the process is similar to one performed for the special illum surface method listed above, except that the special illum surface is removed from the model. In order to provide more detailed calculations, the various parameters should be set to medium or high, and the number of ambient bounces set to a reasonably high number. Still, it is possible that the number of rays considered will not be sufficient to produce a smooth illuminance distribution across the room surfaces.

Inserting a Diffuse Glazing Material into a Model

To insert a diffuse glazing material into a model, it is necessary to define this material and to the replace the glazing assignments for the windows on which you want to apply this diffuse material. First, you'll need to find the .rad file that contains the window polygons. This file should have the root name that begins with your drawing name, followed by _g_ then the glazing material name. You need to edit this file, install a series of lines that defines your diffuse transmissive material, then assign this name to each of the glazing polygons.

The basic description of a translucent material that must be entered to your glazing file is as follows. This text must appear before it is assigned to any polygons.

```
void trans name
0
0
7 1 1 1 spec rough trans tspec
```

where:

1 1 1 = the RGB ratios of transmitted light (white)

spec = specular reflectance of this material (0-1).

rough = surface roughness (0 for smooth, range: 0-1)

trans = total transmittance of the material (0-1)

tspec = fraction of transmitted light that is not diffusely redirected (passes straight through the material) (0-1)

Let's now consider an example. Here, the diffuse glazing is described in the first four lines, then the old glazing name (for example, grn_low_e_glass) is replaced by the new glazing name, diffus60, everywhere it occurs in the file, as has been done in the second group of lines which assign the glazing material to one polygon in the model. Remember to make this change to each window polygon.

```
void trans diffus60
0
0
7 1 1 1 .04  0 .60 0

diffus60 polygon dimzone_2B.0.1
0
0
12 384   384   36
384      0     36
384      0     102
384      384   102
```

After you make these changes, save the file using a text format, then re-run the simulation by double clicking on the .bat file for this scenario (this can be done from within Windows). A new rendering will be created and any old .PIC file will be overwritten. If you go back to AutoCAD and initiate a new simulation or if you duplicate a scenario, this file will be overwritten and the original glazing material will be applied. For this reason, you should also the file to another name so that it can be copied over the glazing file each time you start a new scenario. The simulation then must be run by hand by double clicking on the .BAT file for that scenario.

Reference Information on Radiance

Significant information is available on the operation of the standard version of Radiance, which will permit you to access and gain a better understanding of some of the more advanced features not available in the Desktop Radiance version, and to better understand the format of the .RAD, .RIF and other file types. These reference materials include a complete book on the software, as well as extensive instructions, tutorials and the reference manual. Much of this information can be downloaded from the Internet (http://radsite.lbl.gov).

Appendix A - IES Photometric File Format

The following contains a description of the organization of an IESNA standard formatted file for the exchange of luminaire candlepower data. This information may be needed to convert IES files into a format that is compatible with Desktop Radiance. In particular, it is generally necessary to modify the luminaire X, Y and Z dimensions so that they agree with the physical size of the luminous area that is used for the library luminaire within Desktop Radiance to which this photometry will be assigned.

Description of file:

```
IESNA91
[XXXX] XXXXX
     (descriptive information)
[XXXX] XXXXX
TILT=NONE   (or INCLUDE, followed by a few lines of
tilt angles and associated light loss factors)
# of lamps, # of lumens/lamp, Candlepower Multiplier,
   # of vertical angles, # of horizontal angles,
   Report type, Report units, X-dimension,
Y-dimension, Z-dimension
Ballast Factor, Ballast lamp factor, input watts
Vertical angles
   Horizontal angles
   Candlepower data (vertical sweeps through each
      horizontal angle)
```

Example of File:

IESNA91
[TEST]1
[MANUFAC]GENERIC
[LUMCAT]SIMILAR TO IESNA HANDBOOK LUMINAIRE #29
[LUMINAIRE] 2 x 4 3-LAMP PARABOLIC
TILT=NONE
3 2900 1 11 5 1 1 2.0 4.0 0
1 1 98
0 5 15 25 35 45 55 65 75 85 90
0 22.5 45 67.5 90
2666 2666 2573 2376 2039 1534 955 514 274 106 0
2666 2661 2586 2418 2128 1599 943 442 261 111 0
2666 2667 2620 2506 2277 1699 963 413 250 112 0
2666 2676 2652 2589 2388 1800 1034 472 266 112 0
2666 2679 2671 2628 2416 1821 1094 519 275 120 0

Appendix B - Desktop Radiance Operations Flowchart

The graphic below is a flowchart that describes the basic operations and tasks involved in applying Desktop Radiance. It also indicates the name of specific programs such as the simulation manager, rview and winimage, which perform important operations in the software.