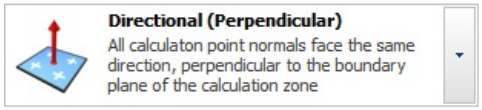
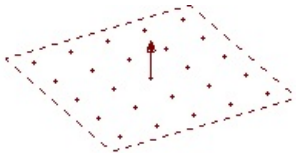
Chapter 8 - Calculations and Results

Visual's primary function is to calculate *illuminance* levels at distinct locations in the lighting *model* for the purpose of lighting system performance verification. This chapter provides a brief overview of the calculations and the techniques for interpreting the results.





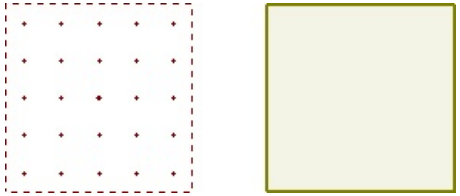
Basic knowledge of lighting equipment and metrics is necessary prior to using Visual to be able to understand the ramifications of choices made in the program and the resultant numbers. Most local sections of the Illuminating Engineering Society provide *Fundamentals of Lighting* classes to suit this purpose.

An advanced discussion of the Visual Calculation Engine is provided in the Appendices of this manual.

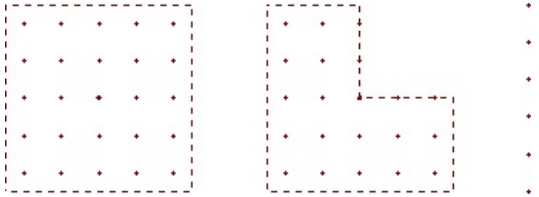
8.1 Calculation Zones

Calculation Zones are an integral part of any lighting model. Statistical information related to **Calculation Zones** is displayed in the **Sidebar**. See Statistics and The Sidebar for more information.

Calculation Zones can be lighting-based (***Illuminance***, ***Luminance***, etc) or power-based (**Lighting Power Density**). By default, Visual shows L**ighting Calculation Zones** in dark red and **Lighting Power Density Zones** are shown with a olive border and are furthermore shaded.



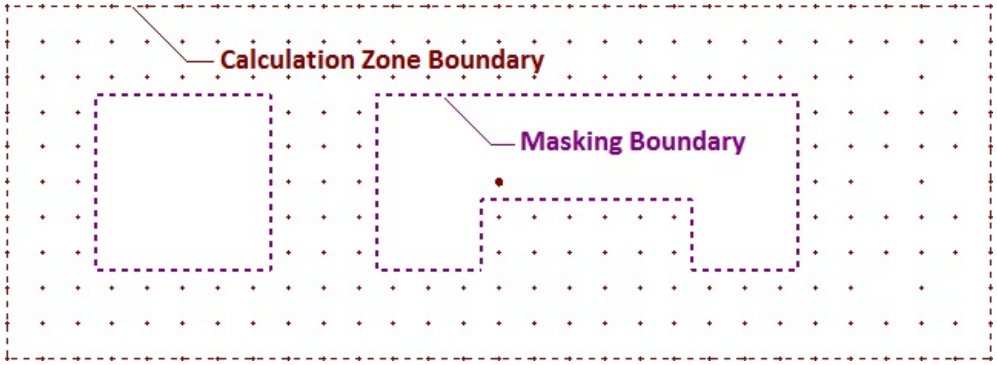
Lighting Calculation Zones can be defined by rectangular areas, areas bounded by a *polygon*, or can be locations along a *linear* path. **Calculation Zones** can also be placed directly on surfaces (**Solid Objects**).



The boundary of the **Calculation Zone** is indicated by a dashed line and points indicated by crosses are placed in an array defined by the user.

Visual assumes the light meter orientation to be perpendicular to the defining (bounding) plane. This can be modified at creation or by editing **Properties** after creation.

Lighting Calculation Zones can be modified to remove points that are unwanted using the ***Masking*** commands. Points can be **Masked** with rectangles, polygons, by surface, or individually.



Mask boundaries are shown with a dashed purple line.

The display of the **Mask** boundary can be turned on or off in the **Settings** dialog.

Statistical Zones can be created to report information about part of a **Lighting Calculation Zone**. **Statistical Zones** are displayed in the **Statistics** *tab* of the **Sidebar** separately from their parent zone.

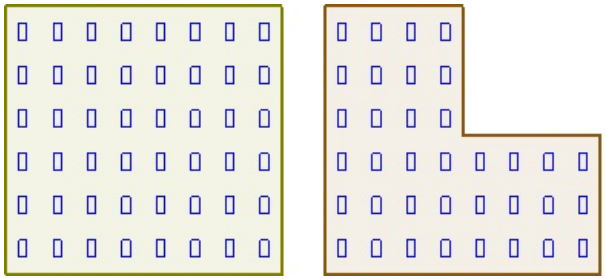
Statistical Zones can be created with rectangles, polygons, or by selecting surfaces. **Statistical Zones** can be grouped in the **Sidebar** for an additional level of reporting and analysis.

Statistical Zone boundaries are shown with a dashed dark green line. Notice how the internal points are omitted by astute boundary selection. Calculation points included in the **Statistical Zone** have a different *symbol*.

For example, only the paved area could be shown for a parking lot. Points in the **Statistical Zone** are indicated with a green asterisk *symbol* by default.

All Points		
Average	3.5	fc
Maximum	9.1	fc
Minimum	0.6	fc
Max/Min	15.2:1	
Average/Min	5.8:1	
Paved Area		
Average	3.4	fc
Maximum	9.1	fc
Minimum	0.6	fc
Max/Min	15.2:1	
Average/Min	5.7:1	

Lighting Power Density (**LPD**) **Zones** can be defined by rectangular areas, areas bounded by a *polygon*. They have associated *luminaires* specifically applied to the calculation. **LPD Zones** can also be placed directly on surfaces (**Solid Objects**).



LPD Polygon		
Luminaires	36	
Total Power	2005.20	W
Area	3008.00	ft²
Power Density	0.67	W/ft²
LPD Rectangle		
Luminaires	48	
Total Power	2673.60	W
Area	3968.00	ft²
Power Density	0.67	W/ft²

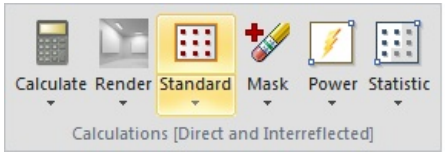
When changes have been made to the lighting model that require a re-calculation, Visual will indicate that **Calculation Zone** values may no longer be valid by bracketing point values.

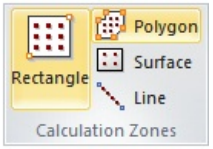
The following section describes the process of entering **Calculation Zones** along with the information required to produce appropriate results.

8.1.1 Rectangular and Polygonal Calculation Zones

Calculation Zones may exist along a *linear* path or within *planar* regions bounded by a rectangle or *polygon*.

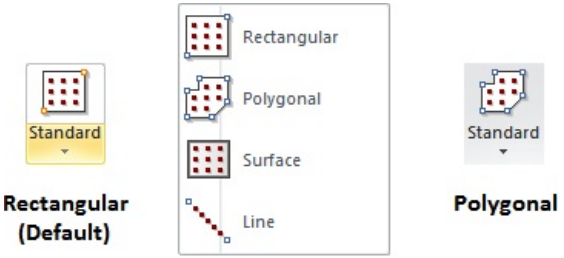
The buttons for the various types of **Calculation Zones** can be found in the **Calculations** *panel* on the **Home** *tab* or the **Calculation Zone** *panel* on the **Calculations** *tab* of the **Ribbonbar**.





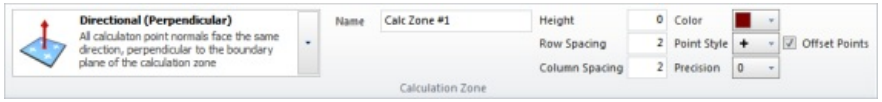
The **Home** *tab* buttons are dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*.

Once a selection has been made other than the default, the upper button portion will change to execute that command with the next press and the graphic is changed accordingly. Selecting one of the other commands from the *drop-down menu* will revert the button to that mode.



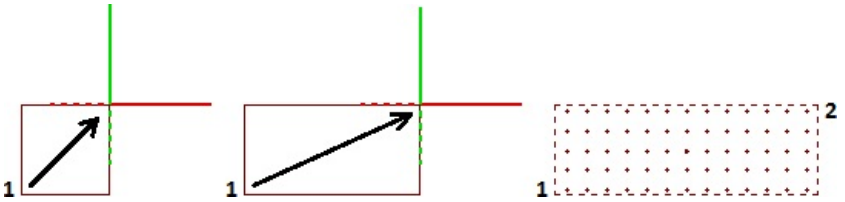
Rectangular and ***Polygonal*** **Calculation Zones** share a similar interface in the **Properties** *tab* of the **Ribbonbar** that is shown upon command execution.

See Calculation Zone Parameters for information on specific parameters.



Note that the basic process of creating **Calculation Zones** is identical to that of creating **Background** or **Solid Rectangles** and **Polygons** except that additional information must be entered on the **Properties** *tab* to space and format the points.

To construct a **Rectangle Calculation Zone**, specify the *coordinates* of the first *vertex* using the mouse, keyboard, or **Object Snap**. In the command, moving the mouse causes Visual to draw the implied **Rectangle** showing what will be created when the command is completed. To end the command, right-click the mouse or press *Enter*. Various parameters can be specified in the **Properties** *tab* as discussed below.



To construct a ***Polygon*** **Calculation Zone**, specify the *coordinates* of the *vertices* using the mouse, keyboard, or **Object Snap**. In the command, moving the mouse causes Visual to draw two types of implied lines: the small-dash line connects the first *vertex* and the last *vertex* specified and the large-dash line connects the cursor to the last *vertex* specified. To end the command, right-click the mouse or press *Enter*. Various parameters can be specified in the **Properties** *tab* as discussed below.

When changes have been made to the lighting *model* that require a re-calculation, Visual will indicate that **Calculation Zone** values may no longer be valid by bracketing point values.

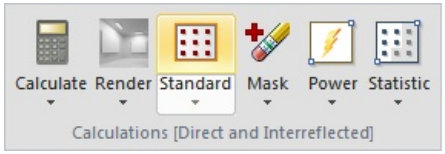
In all cases, the default point normal (virtual light meter) orientation is **Directional (Perpendicular)** that corresponds to a direction perpendicular to the *plane* of the **Calculation Zone** bounding rectangle, *polygon*, or line. Several other options can be chosen to change how Visual orients the virtual light meter. See Calculation Types for other meter orientation options.

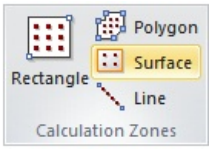
Statistical information related to **Calculation Zones** is displayed in the **Sidebar**. See Statistics and The Sidebar for more information.

8.1.2 Placing Calculation Zones on Existing Solid Objects

The lighting levels on surfaces are frequently of interest because the illumination of a surface is often the primary objective (wall-washing, facade lighting, etc.) of a project and a lighting *model*.

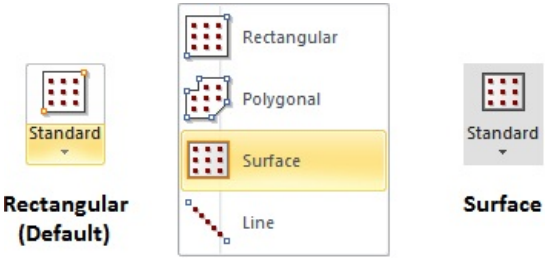
The buttons for the various types of **Calculation Zones** can be found in the **Calculations** *panel* on the Home *tab* or the **Calculation Zone** *panel* on the **Calculations** *tab* of the **Ribbonbar**.





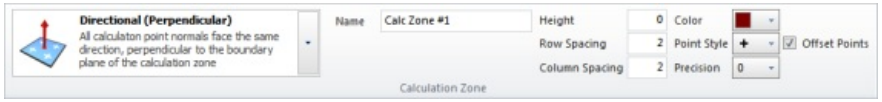
The **Home** *tab* buttons are dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*.

Once a selection has been made other than the default, the upper button portion will change to execute that command with the next press and the graphic is changed accordingly. Selecting one of the other commands from the *drop-down menu* will revert the button to that mode.



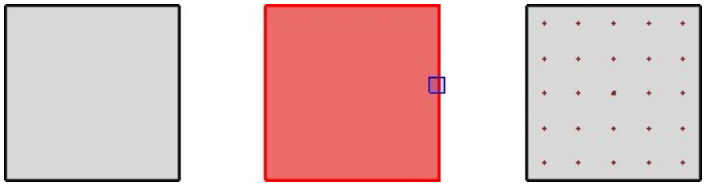
Surface Calculation Zones have the identical interface in the **Properties** *tab* of the **Ribbonbar** that is found when placing **Rectangle** and ***Polygon*** **Calculation Zones**.

See Calculation Zone Parameters for information on specific parameters.



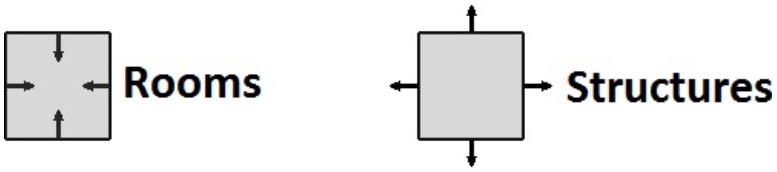
To place a **Calculation Zone** on a **Surface**, select the desired **Surface** to use as the basis by left-clicking, specify parameters as necessary in the **Properties** *tab*, and press *Enter* or right-click to end the command. The selection of a **Surface** provides the bounding *polygonal* (or rectangular) shape just as if that shape had been provided while executing the commands as described in Rectangular and Polygonal Calculation Zones.

Note that the **Height** is applied from the **Surface** itself not the *Cartesian coordinate* system.



The normal of the **Calculation Zone** (and therefore the virtual light meter) will be pointed to the interior when placed on **Room Surfaces** and pointed to the exterior when placed on **Structure Surfaces.**

For the same reasons, **Calculation Zones** placed on **Room Surfaces** will be offset to the interior of the **Room**. **Calculation Zones** placed on **Structure Surfaces** will be offset to the exterior of the **Structure**. This of course assumes a non-zero **Height** is specified.



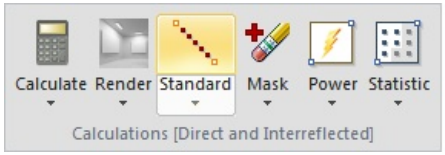
The default point normal (virtual light meter) orientation is **Directional (Perpendicular)** that corresponds to a direction perpendicular to the *plane* of the **Calculation Zone** bounding rectangle, *polygon*, or line. Several other options can be chosen to change how Visual orients the virtual light meter. See Calculation Types for other meter orientation options.

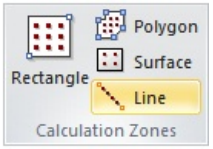
Statistical information related to **Calculation Zones** is displayed in the **Sidebar**. See Statistics and The Sidebar for more information.

8.1.3 Line Calculation Zones

A **Calculation Zone** based on a *linear* path can be placed in a similar fashion to other **Calculation Zones**. This is most commonly used for the analysis of spill light and light trespass.

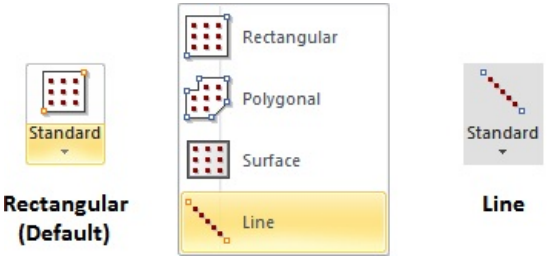
The button for the **Line Calculation Zone** command can be found in the **Calculations** panel on the **Home** *tab* or the **Calculation Zone** panel on the **Calculations** *tab* of the **Ribbonbar**.





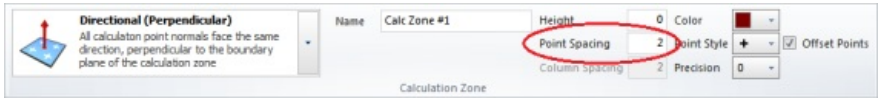
Accessing the **Line** command from the **Home** *tab* requires the use of the dual-function button; the upper portion executes the command, the lower portion initiates a drop-down menu.

On first use, the button will show the default **Rectangular** mode. To select the **Line** option for the button, click the lower portion with the arrow, select **Line** from the *drop-down menu*, and the command will be initiated. The button will remain in **Line** mode until another choice is made from the *drop-down menu*.



Line Calculation Zones share a similar interface in the **Properties** *tab* to **Rectangle** and ***Polygon*** **Calculation Zones** of the **Ribbonbar** that is shown upon command execution. Note that the field name changes to **Point Spacing** and thus **Column Spacing** is not applicable and inactive.

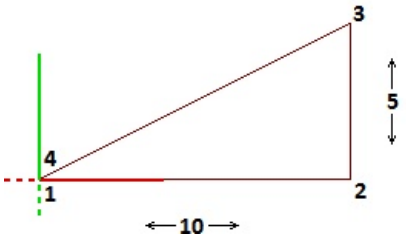
See Calculation Zone Parameters for information on specific parameters.

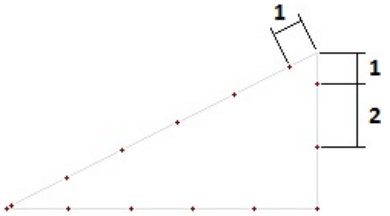


Note that the basic process of entering **Calculation Zones** is identical to that of entering **Background** or **Solid Rectangles** and **Polygons** except that additional information must be entered on the **Properties** tab to space and format the points.

To construct a **Line Calculation Zone**, specify the coordinates of the first *vertex* using the mouse, keyboard, or **Object Snap**. Specify additional *vertices* as necessary. Right-click the mouse or press *Enter* to end the command. Various parameters can be specified in the **Properties** *tab* as discussed below.

Calculation Zone points are spaced starting at the first *coordinate* entered and the user-specified spacing is continued around corners. At right, a spacing of 2 units is applied to a triangular path. Note how the calculation points turn the corner at point 3. The gray lines are for illustration and are not drawn normally.





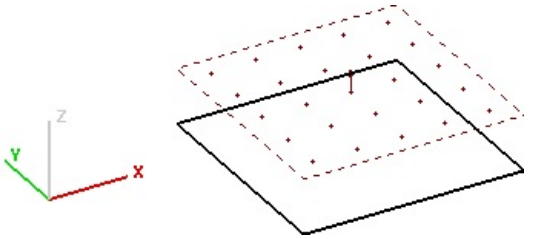
The default point normal (virtual light meter) orientation is **Directional (Perpendicular)** that corresponds to a direction perpendicular to the plane of the **Calculation Zone** bounding rectangle, *polygon*, or line. Several other options can be chosen to change how Visual orients the virtual light meter. See Calculation Types for other meter orientation options.

Statistical information related to **Calculation Zones** is displayed in the **Sidebar**. See Statistics and The Sidebar for more information.

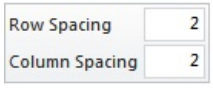
8.1.4 Calculation Zone Parameters

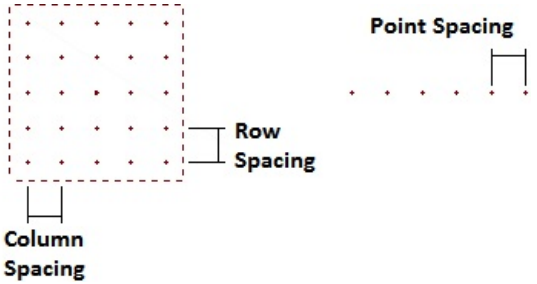
All **Calculation Zone** types share the same parameters to control position, spacing, and format of calculation points.

Calculation Zones are often placed at some level above grade (*workplane* height). While this can certainly be accomplished by choosing the correct *coordinates* when entering the **Calculation Zone** parameters, the **Height** field provides an alternative method. When a **Height** value is entered, the points in a **Calculation Zone** will be displaced perpendicularly from the working *plane* (*plane* of the *crosshairs*) in the direction nearest the point of view. For horizontal **Calculation Zones** this will typically be in the direction of the positive Z-axis as would be commonly desired.



Rectangular and ***Polygonal*** **Calculation Zones** result in an array of points and thus, spacing values must be entered for each dimension of the array. In the case of a **Line**, calculation points are spaced with the specified increment along the path of the **Line**.

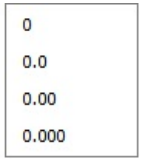




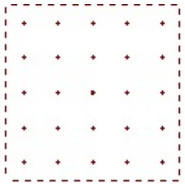
Color can be selected from the **Properties** *tab* in the **Ribbonbar** that will automatically be shown. This selection modifies the points and the associated numerical text. See Using the Color Dialog for information on selecting **Color**.

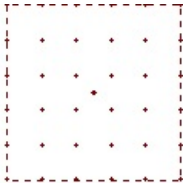
The **Point Style** for a **Calculation Zone** can be chosen at creation. Clicking the button initiates the drop-down graphical menu that illustrates the available **Point Styles** at right.

Precision specifies how many decimal places should be shown for the **Calculation Zone**. Clicking the button initiates the *drop-down menu* to allow for the selection of 0 to 3 digits. It is not possible to display more than 3 digits because it is beyond the accuracy of *photometric* testing in most cases.



The **Offset Points** checkbox tells Visual to either center the grid of calculation points (checked) or to start spacing in the lower left corner (the corner with the smallest x, y, and/or z *coordinates* if creation occurs outside the x-y *plane*), which is likely to leave space between the last points and the edges of the boundary.



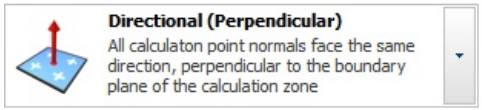


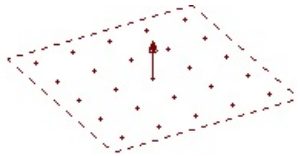
In this section, reference is made to parameter specification on the **Properties** *tab* of the **Ribbonbar** while one of the **Calculation Zone** commands is being executed. See Calculation Zone Properties for more information on modification of parameters after creation.

8.1.5 Calculation Types

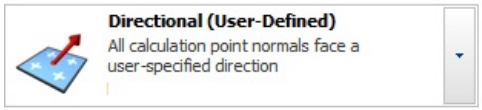
All **Calculation Zone** types share the same options to control virtual light meter ("meter") orientation. Each of the options found in the **Properties** *tab* when creating a **Calculation Zone** provides descriptive text as a reminder of the meter orientation.

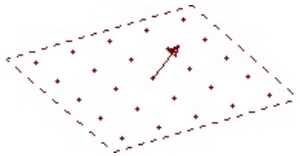
The default for all **Calculation Zone** types is **Directional (Perpendicular)**. This option positions the meter perpendicular to the *plane* that defines the **Calculation Zone**. This is the most common use be it for horizontal or vertical surfaces.



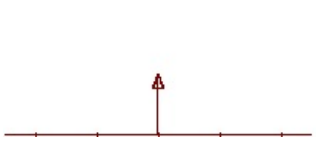


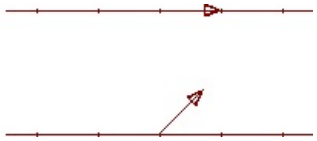
The **Directional (User-Defined)** option allows the point normals to be oriented uniformly in any specified direction. This is commonly used for calculating vertical *illuminance* in a horizontal grid. When this option is chosen, the **Command Line** will prompt for the base and destination points of a *vector* to establish the direction of the point normals. The exact location of the chosen base and head of the *vector* is immaterial as they only serve to describe a direction *vector*. For example, (0,0,0) as the *base point* and (1,0,1) as the destination produces a 45° tilt of the meter in the X-Z *plane*. The base and destination points may be entered with the mouse or keyboard.



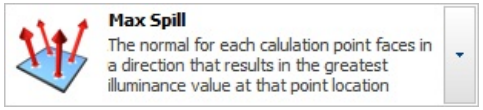


For **Directional Calculation Zones**, Visual draws a unit *vector* showing the orientation of the meter. Because **Calculation Zones** are often large, it may be necessary to **Zoom** to see the *vector*. The tail of the *vector* lies in the *plane* defining the **Calculation Zone**, while the head points in the direction the meter faces. This normal *vector* will not be shown for other **Calculation Zone** types.



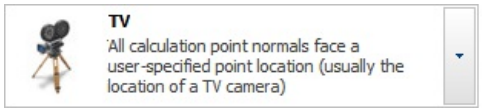


The **Max Spill** option calculates the maximum possible *illuminance* value from all the *luminaires* in the *model* regardless of orientation. This option is typically applied when light trespass is of concern and the "worst case" values on adjacent property are desired. The **Max Spill** option requires no point normal specification.

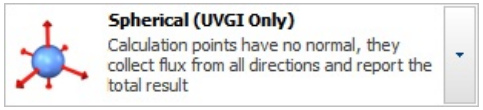


The **TV** option establishes point values based on a single viewing position for sporting events and other applications where special lighting consideration must be given to the operation of television cameras. Each calculation point normal in the **Calculation Zone** is oriented toward the single camera location. When the **TV** option is selected, the **Command Line** will prompt for the *coordinates* of the **TV** camera and a line is drawn from the center of the zone to the camera for reference.

Moving the **Calculation Zone** does not move the camera location.



Spherical orientation of the meter can be assigned for use with **UVGI** calculations. See UVGI Calculations for more information.

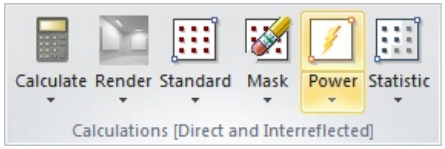


Meter **Tilt** and **Orientation** as well as **TV** camera location can be modified after creation by editing Calculation Zone Properties.

8.2 Power Zones

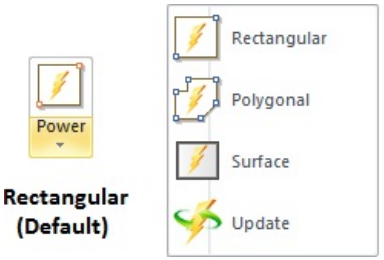
Power Zones are used to analyze and illustrate performance of lighting systems related to lighting power density (LPD). LPD quantifies the amount of power required to provide lighting to a space. LPD is often limited by building codes and is an integral part of sustainability programs such as LEED.

The buttons for the various types of **Calculation Zones** can be found in the **Calculations** *panel* on the **Home** *tab* or the **Power Density** *panel* on the **Calculations** *tab* of the **Ribbonbar**.



The **Home** *tab* buttons are dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*.

Once a selection has been made other than the default, the upper button portion will change to execute that command with the next press and the graphic is changed accordingly. Selecting one of the other commands from the *drop-down menu* will revert the button to that mode.

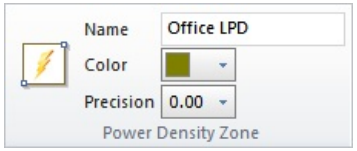


Rectangular and ***Polygonal*** **Power Zones** share a similar interface in the **Properties** *tab* of the **Ribbonbar** that is shown upon command execution.

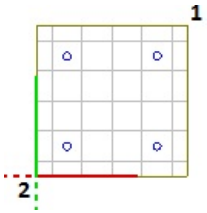
Name allows **Power Zones** to be individually identified for later use and presentation clarity.

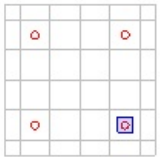
Color can be selected to modify the highlight given to the zone in the **Design Environment**. See Using the Color Dialog for information on selecting **Color**.

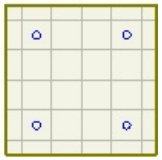
Precision specifies how many decimal places should be shown for the **Calculation Zone**. Clicking the button initiates the *drop-down menu* to allow for the selection of 0 to 3 digits.



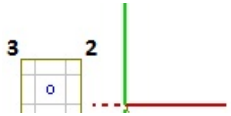
To create a **Rectangular Power Zone**, select the two necessary corners that define the rectangle with the mouse, keyboard entry, or **Object Snap**. Right-click the mouse or press *Enter* to advance the command to the next step. Select the *luminaires* to be associated to the **Power Zone**, see Selecting Objects. Right-click the mouse or press *Enter* to end the command.





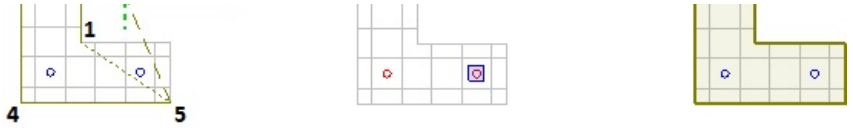


To create a **Rectangular Power Zone**, select the *vertices* necessary to define the *polygon* with the mouse, keyboard entry, or **Object Snap**. Right-click the mouse or press *Enter* to advance the command to the next step. Select the *luminaires* to be associated to the **Power Zone**. Right-click the mouse or press *Enter* to end the

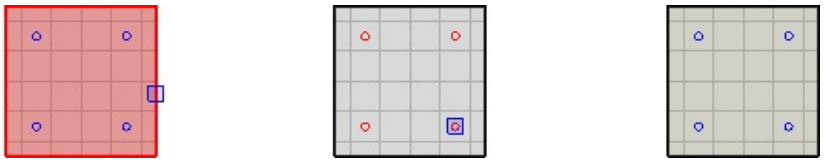


command.

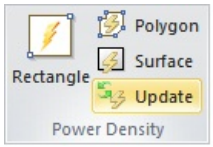
While *drawing* the bounding *polygon*, moving the mouse causes Visual to draw two types of implied lines: the small-dash line connects the first *vertex* and the last *vertex* specified and the large-dash line connects the cursor to the last *vertex* specified.

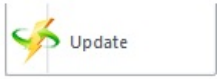


Creating a **Power Zone** based on a **Surface** is perhaps the most useful of the options available since the **Solid Objects** defining the physical space are likely to overlay the boundary related to LPD. To create a **Power Zone** based on a **Surface**, select the **Surface.** Right-click the mouse or press *Enter* to advance the command to the next step. Select the desired *luminaires* to be associated to the **Power Zone**. Right-click the mouse or press *Enter* to end the command.



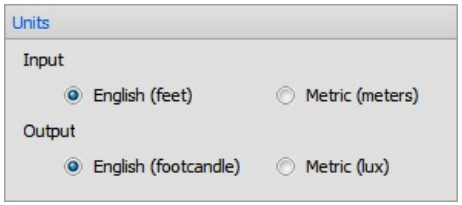
To **Update** a **Power Zone**, select the desired **Power Zone**, right-click the mouse to advance the command, and then add or remove *luminaires* as necessary. See Selecting Objects for information on adding and removing objects from the selection set.





Lighting power density is calculated in terms of Watts per unit area; W/ft² or W/m² depending on system settings. See Settings Luminaires for information on changing the units used in Visual.

Calculations are based on the values in the Luminaire Schedule. Values input to the ***Luminaire*** **Schedule** should be ballast Watts based on the most common usage of LPD. The value imported to the ***Luminaire*** **Schedule** from the IES file may be the value measured during testing, *lamp* Watts, or ballast Watts. Care should be taken to include the correct value based on published manufacturer data for the specific *lamp* and ballast components used.

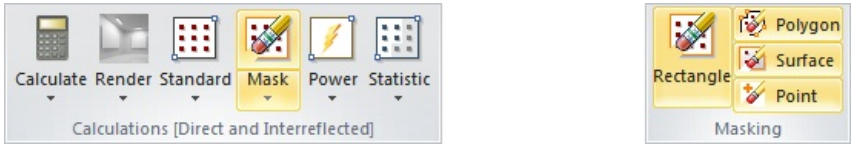


Statistical information related to **Calculation Zones** is displayed in the **Sidebar**. See Statistics and The Sidebar for more information.

8.3.1 Masking Calculation Zones

Certain scenarios require the removal of calculation points from perimeter and internal sections of **Calculation Zones**. In Visual, the removal of calculation points is called ***Masking***.

The buttons for the various types of ***Masking*** can be found in the **Calculations** *panel* on the **Home** *tab* or the ***Masking*** *panel* on the **Calculations** *tab* of the **Ribbonbar**.

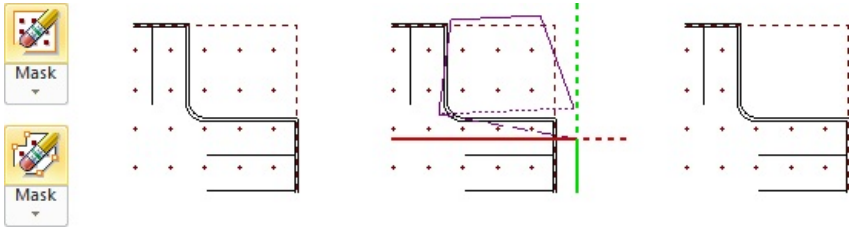


The **Home** *tab* button is dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*.

Once a selection has been made other than the default, the upper button portion will change to execute that command with the next press and the graphic is changed accordingly. Selecting one of the other commands from the *drop-down menu* will revert the button to that mode.

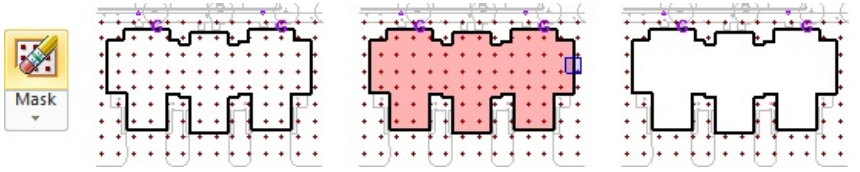
To **Mask** a **Rectangular** or ***Polygonal*** area, select the **Calculation Zone** to be **Masked** by clicking a point, the boundary, or in **Transparent Display Mode**, anywhere inside the boundary. Then select *coordinates* to include the points to be **Masked**, and right-click or press *Enter* to end the command.

At right, a ***Polygonal*** mask is applied to the corner of a parking lot. Note that the *masking* boundary does not always need to be artfully or carefully applied, it simply needs to encompass the points to be removed.



To **Mask** calculation points based on a surface, select the **Calculation Zone** to be **Masked** by clicking a point, the boundary, or in **Transparent Display Mode**, anywhere inside the boundary. The select the **Solid Object** to be used as the basis for the ***Masking***, and right-click or press *Enter* to end the command.

At right, an apartment building (included to block light) is used to remove points in a site lighting project.

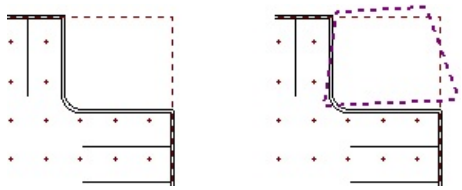


To **Mask** individual points, left-click the point(s) to be removed. Visual instantly removes the point, and allows for removal of additional points. Right-click the mouse or press *Enter* to end the command. Note that Visual will update **Statistics** after ending the command.

In the example at right, a calculation point is inside a column and should be removed.

Visual can be set to show the boundaries of masked areas. See Calculation Zone Properties for more information. Note that this border is a bit thicker than that of **Calculation Zones** themselves.

At right, the boundary from the ***Polygonal*** *masking* example above is shown with a dashed purple border.



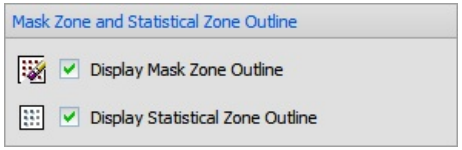
See Unmasking Calculation Zones for information on how to remove ***Masking***.

Remember that ***Masking*** calculation points should be done to produce the most accurate *model*. Removing points should only be done if those points are not truly valid.

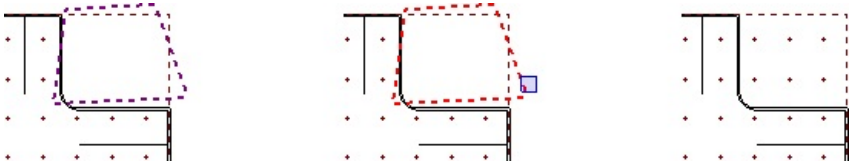
8.3.2 Unmasking Calculation Zones

It may be necessary to remove a **Mask** applied to a **Calculation Zone**.

To remove a **Mask**, the **Settings** must be set to show the **Mask Zone Outline**. See Calculation Zones Settings.

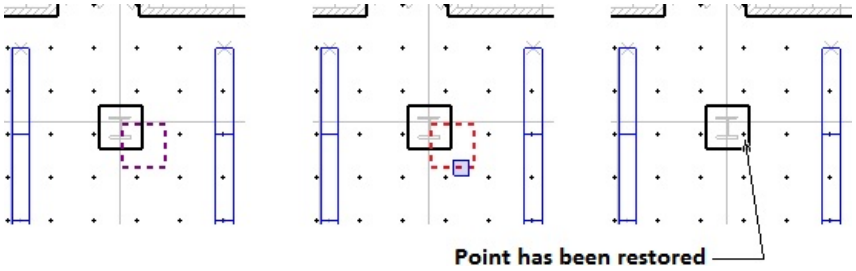


With the **Mask Zone Outline** visible, use the Erase command to remove the dashed outline as shown at right. The calculation points will be restored.



Calculation Zones masked with the **Mask Point** method, don't have **Mask Zone Outlines** to erase. It is necessary to draw a new **Mask Zone** that includes the points to be unmasked. The location of points can usually be assumed from adjacent points.

This process effectively says "Put the points back no matter how they were removed."

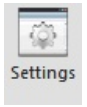


8.4 Statistical Zones

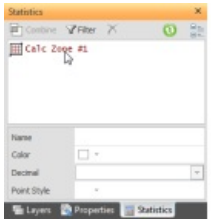
The **Statistics** *tab* of the **Sidebar** provides feedback related to created **Calculation Zones**, **Power Zones**, and **Combined Zones**.

Statistics are shown by default in the **Statistics** *tab* of the **Sidebar**. If closed, the **Statistics** *tab* can be shown by clicking Statistics in the **Windows** menu on the **Ribbonbar**.

The **Statistics** that will be displayed in the **Statistics** *panel* for each **Calculation Zone** can be modified in the Settings Dialog. The defaults are shown at right.



To expand or collapse the **Statistics** for each **Calculation Zone**, double-click on the bold title of the **Calculation Zone** in the **Statistics** *panel*.

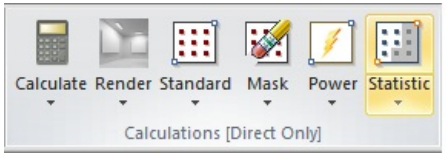


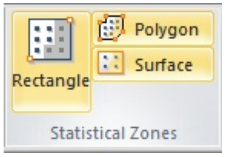
See Statistics for more information about the *tab*, use of the *tab*, and modification of items in the *tab*.

8.4.1 Creating a Statistical Zone

It is often useful to view statistics that are compiled from only a portion of a **Calculation Zone**. In Visual, this is called a **Statistical Zone**.

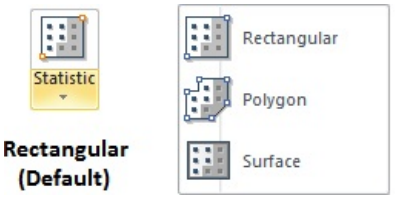
The **Statistical Zone** button can be found on the **Calculations** *tab* and the **Home** *tab* of the **Ribbonbar**.



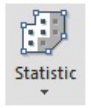


The **Statistical Zone** button is dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*.

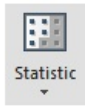
Once a selection has been made other than the default, the upper button portion will change to execute that command with the next press and the graphic is changed accordingly. Selecting one of the other commands from the *drop-down menu* will revert the button to that mode.



Rectangular (Default)



Polygonal

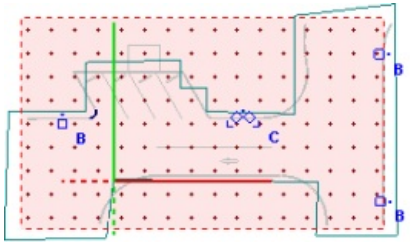


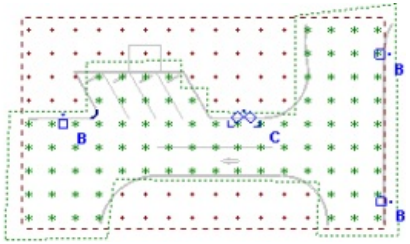
Surface

To create a **Statistical Zone**, select a **Calculation Zone**, then draw a rectangle, *polygon*, or select a surface (depending on the method chosen) where points should be included in the **Statistical Zone**. As it is being drawn, the *polygon* or rectangle is shown in green.

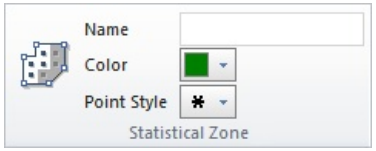
Clicking the second point of the rectangle or right-clicking the mouse in *polygon* mode ends the command and applies the choices made in the **Properties** *tab*.

After creation, the boundary is shown with a green dashed line. Display of the boundary is controlled in Calculation Zones Settings.





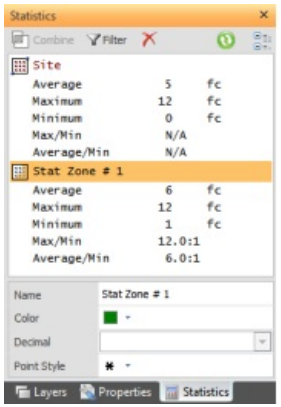
In the command , the **Properties** *tab* allows for naming, and control of the symbols used for the **Statistical Zone** much like that during creation of the base **Calculation Zone**.



The statistics for the zone are displayed alphabetically in the **Statistics** *tab*.

The **Name**, **Color**, **Decimal** precision, and **Point Style** of the zone can be edited as necessary by left-clicking the zone name. The lower *panel* will be populated with zone parameters. See Calculation Zone Parameters for a description of parameters and modification.

Note that **Statistical Zones** have a slightly different *symbol* in the **Sidebar**.



Calculation Zone

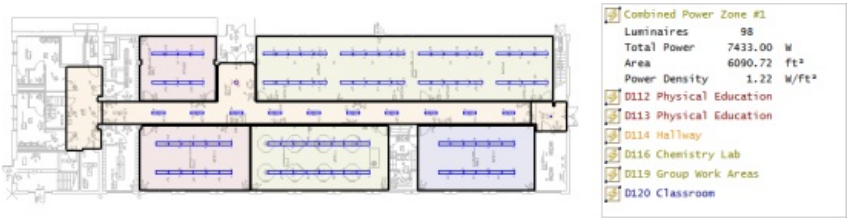
Statistical Zone

Statistical Zones can be Erased, and more importantly they can be Stretched to then change which points are included in the zone.

8.4.2 Combining Zones

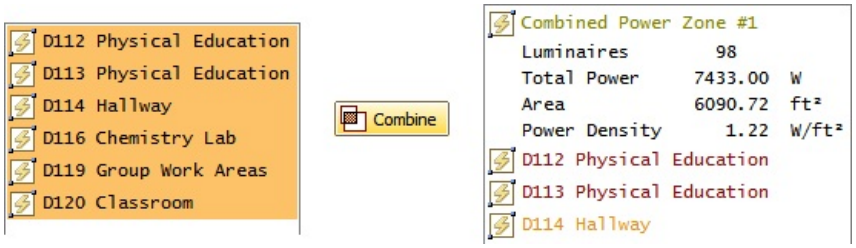
It can be useful to view statistics that are compiled as a combination of two or more **Power Zones** or **Calculation Zones**.

When designing lighting for a building, it is useful to report **Lighting Power Density** for each space type, as well as for the entire building; allowing for illustration of compliance via one or both methods depending on the specification.

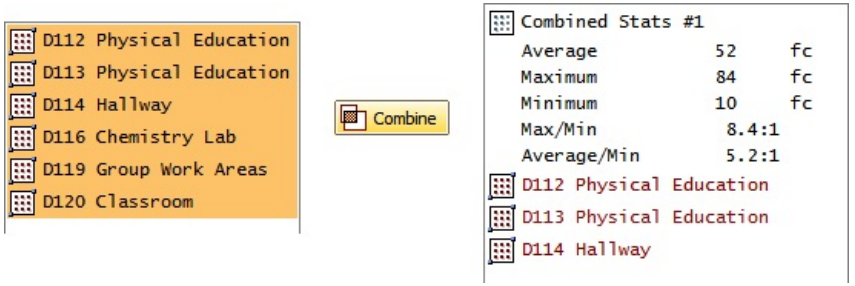


To create a **Combined Power Zone**, first select all the zones to be included in the combined zone within the **Statistics** *tab*; hold down the *Ctrl* key while left-clicking on the desired items.

When all of the desired zones are highlighted, click the **Combine** button at the top of the **Statistics** *tab*. Visual will create the **Combined Power Zone** and display it in the **Statistics** *tab*. The name can be modified as necessary.



The same procedure can be used to create **Combined Calculation Zones**.



8.4.3 Statistics Sidebar Tab

The **Statistics** *tab* is located in the **Sidebar**. The *tab* shows summary data for all **Calculation Zones** and **Power Density Zones** and will change as zones are added and removed.

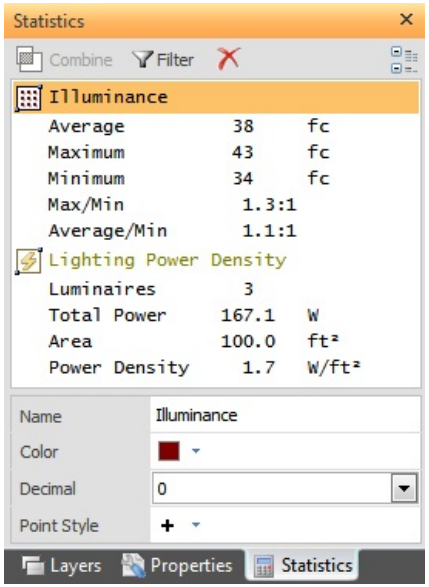
If it is not visible, the **Statistics** (**Sidebar** with **Statistics** *tab* focus) can be shown by clicking the command on the **Windows** sub-menu in the **Options** *panel* of the **Tools** *tab*. *Shift+S* next to the command indicates that this is the *hotkey* to initiate the command.

The **Statistics** *tab* displays both **Calculation Zones** and **Power Density Zones** sorted in alphabetical order by name.

Statistics are displayed for each zone as set in the **Settings** *dialog*. See Settings Dialog for more information.

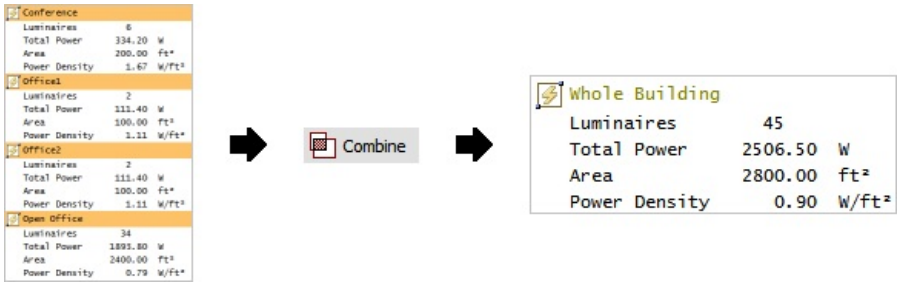
Calculation Zone and **Power Density Zone Properties** can be modified while the **Statistics** *tab* is active in lieu of specifically executing the **Properties** command. To modify **Properties**, click the name of a zone. Visual will populate the **Properties** *panel* at the bottom of the *tab* with the parameters for that zone.

Selected zone names are highlighted in yellow in the **Statistics** *tab* and additionally the associated zone in the **Design Environment** is highlighted in red.

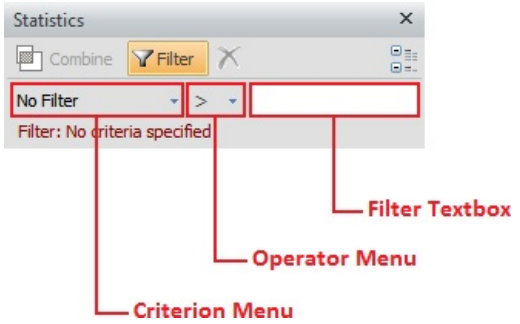


Statistics for multiple **Calculation Zones** and **Power Density Zones** can be selected and **Combined** to provide an overall summary. For instance, multiple **Power Density Zones** could be **Combined** to provide the **Lighting Power Density** for an entire building.

Select the desired zones by left-clicking the names in the **Sidebar**. Select multiple names by holding the *Ctrl* key or *Shift* key. Click the **Combine** button at the top of the **Statistics** *tab*. Visual will make a **Combined** set of **Statistics** and give it a generic name. **Properties** for the combined zone can be manipulated like any other zone; i.e. **Combined** zones can be renamed.



To **Filter Calculation Zones** and **Power Density Zones**, click the **Filter** button to show the **Filter** *panel* in the **Statistics** *tab*. The small down arrow indicates a menu is available, select from the **Criterion Menu**, from the **Operator Menu**, and then enter a value into the **Filter Textbox**. Visual will show only zones meeting that collective criteria.



Note that selecting a criterion applicable to **Calculation Zones** (e.g. "Minimum")automatically means **Power Density Zones** will not be shown and vice versa.

Criteria shown in gray are those not displayed based on system settings in the **Settings** *dialog*. See Settings Dialog for more information.

To reset the filter to show all zones, select **No Filter** from the drop down.

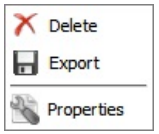
Calculation Zones and **Power Density Zones** can be **Deleted** from the **Statistics** *tab* by selecting the zones to be **Deleted** and clicking the **Delete** button on the *tab*.

Display of zones can be compacted by pressing the **Collapse** button in the upper right corner of the **Statistics** *tab*. Visual will show only zone names. After the button is pressed it changes to the **Expand** button and will be highlighted in yellow. Pressing the **Expand** button reverts to the original state where summary data is shown below the name.

If the **Calculation** status needs to be updated, Visual displays greyed text and blank numerical entries for the sub entries of **Calculation Zones**.

Modifications to *luminaires* (changing to a different type, erasing, changing **Wattage** in the ***Luminaire* Schedule**, etc) will cause Visual to automatically update **Power Density Zone Statistics**.

Right-clicking a **Calculation Zone** name initiates a pop-up menu providing **Delete**, **Export**, and **Properties** commands.



Exporting a **Calculation Zone** is done in CSV format and includes *illuminance* to five decimal places and the height of each calculation point.

Which statistical values are shown is controlled in the **Settings** *dialog*. See Calculations Settings for more information.

8.5.1 Lighting Metrics

A basic knowledge of lighting metrics is necessary to fully integrate Visual into the design process.

8.5.1.1 Illuminance

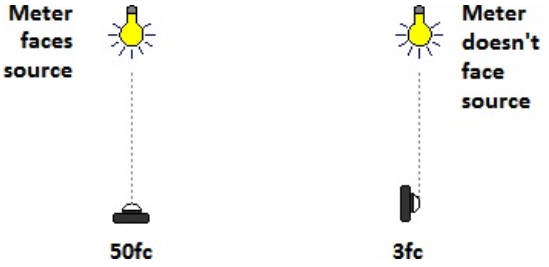
Illuminance is the most common metric used by the lighting industry for system performance verification.

Loosely defined, *illuminance* (E) is the amount of light falling onto an area. Thus, *illuminance* is a density. The *footcandle* is the English unit for *illuminance* and represents the number of lumens (light) incident on an area per square foot of that area. *Lux* is the metric equivalent of the *footcandle* and represents the number of lumens incident on an area per square meter of that area. The units used to display *illuminance* values in Visual may be changed in the Settings Dialog.

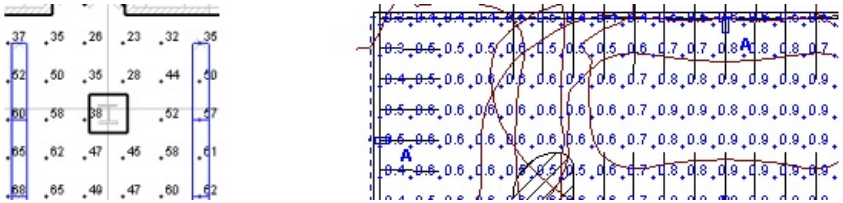
$$E = \frac{I(\theta, \psi) \cdot \cos(\xi)}{D^2}$$

Illuminance is a directional quantity, meaning that one must speak not only of the *illuminance* at a location in the *model*, but of the *illuminance* in a particular direction at a location in the *model*.

One can think of each calculation point as a miniature *illuminance* meter. The value that each *illuminance* meter reports depends on the orientation of the meter. For example, a meter at a particular location will have a greater *illuminance* reading when facing a source than if it faces away from the source.



The most common lighting calculations measure horizontal *illuminance* on a floor or at desk level for interior applications, or on the ground for exterior applications. This is analogous to placing a light meter on one of these surfaces, facing the meter straight up, and taking a reading.

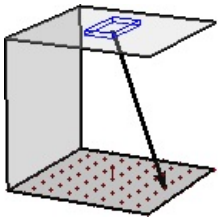


Other common calculations such as vertical *illuminance*, TV *illuminance* and maximum spill *illuminance* require alternate orientations of the light meters. Visual provides the means to specify calculation points to calculate all of these *illuminance* types. Indeed, any orientation of the calculation point normals (light meters) may be achieved. For more information on the placing and orientation of **Calculation Zones** see section Placing Calculation Zones.

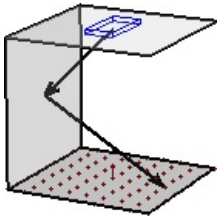
8.5.1.2 The Components of Illuminance

The *illuminance* value at any calculation point in a lighting model has two components. The user can control which types are calculated.

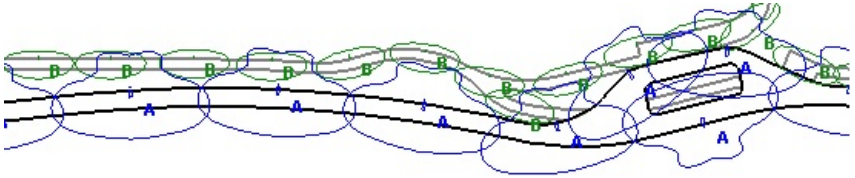
The first component is called the *direct component* and consists of *illuminance* produced at the calculation point by light that reaches the point directly from a ***Luminaire*** without being reflected off any of the **Solid Objects** in the model. The *direct component* of *illuminance* is a relatively straightforward and rapid calculation.



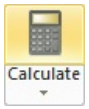
The second component is the *interreflected* component and consists of *illuminance* produced at the point by light that, once emitted from a ***Luminaire***, reflects off of one or more Solid Surfaces in the model before reaching the calculation point. Calculation of the *interreflected* component is more complex and time consuming.



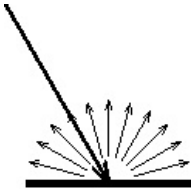
By default, Visual does not calculate the inter-reflected component of *illuminance* for exterior *models*. In exterior lighting *models* the *interreflected* component of *illuminance* is most often considered insignificant and therefore the additional calculation time that would be necessary to calculate this component is unjustified. By default, both components are calculated for interior lighting *models*.



However, the user may calculate this component by changing the **Calculation Mode** as discussed in Initiating a Calculation.



Calculations in Visual are performed with the assumption of perfectly *diffuse reflectance*.



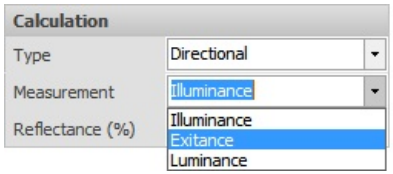
8.5.1.3 Exitance

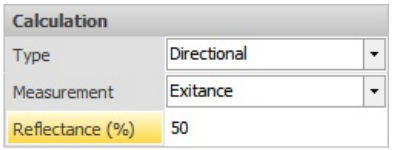
Exitance is the converse of *illuminance*. Rather than the density of light incident upon a surface, *exitance* is the density of light leaving a surface.

In practical terms, *exitance* (M) may be calculated by multiplying the *illuminance* on a surface by the *reflectance* of that surface. The units of *exitance* are lumens/square foot and lumens/square meter.

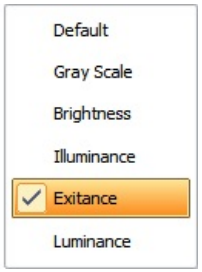
$$M = \rho \cdot E$$

Visual can report *exitance* by using Properties to change the **Measurement Type** and assign a ***Reflectance*** to a **Calculation Zone** after it is created. Select the **Calculation Zone**, click the **Measurement** list in the **Calculation** *panel* in the **Properties** *tab* and select "*Exitance*", then specify a ***Reflectance***. Right-click or press *Enter* to apply the changes. Visual will immediately apply the ***Reflectance*** without recalculation.





Exitance can be displayed in the **Rendered Display Mode** By selecting from the **Display Menu** on the **Calculations** *tab*. (This is not the same as the **Display** button on the **Home** *tab*.)



8.5.1.4 Luminance

Luminance is another metric of light leaving a surface. Unlike *exitance*, *luminance* is a directional quantity. That is, the *luminance* of a surface is dependant upon the angle at which the surface is viewed.

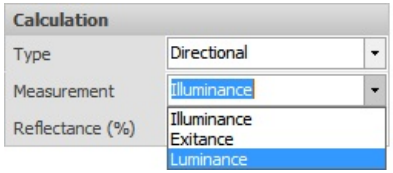
A perfectly *diffuse* surface is special in that it exhibits constant *luminance* over all angles. All surfaces in Visual are modeled as perfectly *diffuse*, so this in practice results in the *luminance* of a surface being directly proportional to the *exitance* of the surface and the *illuminance* on the surface. The units of *luminance* are lumens/square foot/steradian or lumens/square meter/steradian.

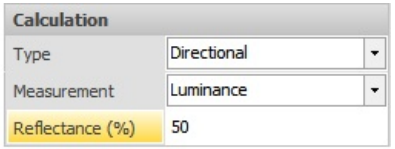
$$L = \frac{\rho \cdot E}{\pi}$$

Brightness is the perceptual analog of *luminance*. The mathematics and perception research are complex and beyond the scope of this manual. The simplest relationship is expressed by the Stevens Power Law shown at right. Effectively, a 2x increase in brightness requires 8x more *luminance*.

$$B = \alpha \cdot L^{0.33}$$

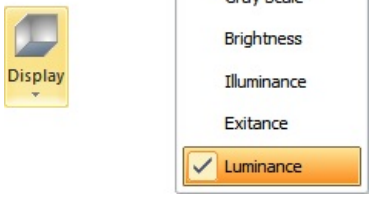
Visual can report *luminance* by using Properties to change the **Measurement Type** and assign a ***Reflectance*** to a **Calculation Zone** after it is created. Select the **Calculation Zone**, click the **Measurement** list in the **Calculation** *panel* in the **Properties** *tab* and select "*Luminance*", then specify a ***Reflectance***. Right-click or press *Enter* to apply the changes. Visual will immediately apply the ***Reflectance*** without recalculation.





Luminance can be displayed in the **Rendered Display Mode** By selecting from the **Display Menu** on the **Calculations** *tab*. (This is not the same as the **Display** button on the **Home** *tab*.)

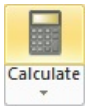
Brightness can similarly be displayed by making that choice form the sub-menu.



8.5.2.1 Initiating a Calculation

Once the necessary components of a lighting *model* have been created, Calculating only requires pressing a single button.

The **Calculate** button can be found on the **Home** *tab* and the **Calculations** *tab* of the **Ribbonbar**. The **Calculate** button becomes active after at least one *Luminaire* and **Calculation Zone** are placed. See Placing and Orienting Luminaires and Placing Calculation Zones.



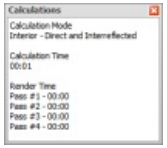
The **Calculate** button is dual function; the upper portion executes the command, the lower portion initiates a *drop-down menu*. Once a selection has been made, that choice will remain until Visual is closed, or a new choice is made.

Choose the most appropriate **Calculation Type** from the upper 3 choices by left-clicking. **Interior Lighting** and **Exterior Lighting** set a large number of parameters used in surface analysis, initial flux evaluation, radiative transfer analysis, and processing renderings specific to either case. Under normal circumstances, no difference in calculations will be seen. **Sign Lighting** expands analysis to provide proper modeling of shadows caused by sign lettering. This mode is much slower than the others and should be chosen judiciously.

Choose **Direct and *Interreflected*** or **Direct Only** as desired. The choices are obvious. **Direct Only** still considers **Solid Objects** as light blockers.

The **Status Bar** indicates which mode has been chosen.

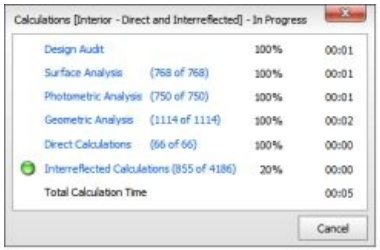
Left-clicking the **Status Bar** section initiates a *dialog* providing details about the last calculation.

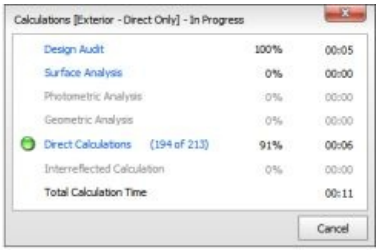


Once activated, calculation progress is shown in the **Calculations *Dialog***.

The *dialog* indicates which mode has been chosen and shows progress in the various steps of analysis. Pressing the **Cancel** button halts progress, closes the *dialog* and returns to the **Design Environment** as normal.

When calculating **Direct Only**, several sections (shown in gray at far right) are skipped.





When changes have been made to the lighting *model* that require a re-calculation, Visual will indicate that **Calculation Zone** values may no longer be valid by bracketing point values.

8.5.2.2 Automatic Calculation Feature

When making minor adjustments and/or revisions to a lighting *model* it is often useful to see the updated values after each modification.

Visual has an **Automatic Calculate** feature that, when on, recalculates the *model* after any change that could effect the *illuminance* (or other metric) values.

To toggle the **Automatic Calculate** feature on or off select **Auto Calculate** from the **Calculations** tab of the **Ribbonbar**.

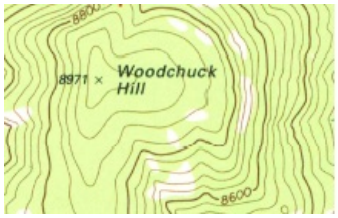
It is recommended that this feature be used at the end of *model* creation when fine-tuning is being done, not at the start of the project. There is no detriment to using the feature early-on, but it is very much inefficient since a majority of actions would require a recalculation.

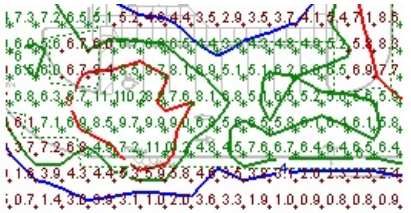
8.5.2.3 Setting and Displaying Contours

Contours are contour lines that are drawn on top of **Calculation Zones** showing constant values. These are most often associated to *illuminance*, but are based on the metric used to define the **Calculation Zone**. See Lighting Metrics for discussion of different metrics.

Just as contours on topographical maps show constant elevation, **Contours** in Visual most often show constant *illuminance*.

The magnitude of the *illuminance* (or other metric) is then analogous to elevation on the topographic map.





To show **Contours**, click the **Contours** button on the **Calculations** *tab* of the **Ribbonbar** to initiate the sub-menu.

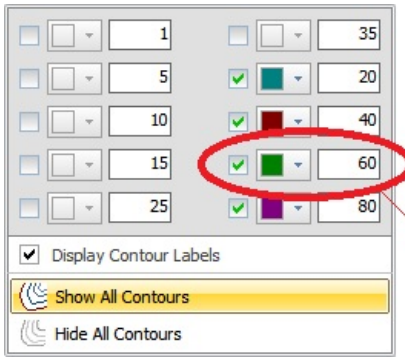
On the sub-menu, place a check in the desired number of contour line checkboxes to activate them.

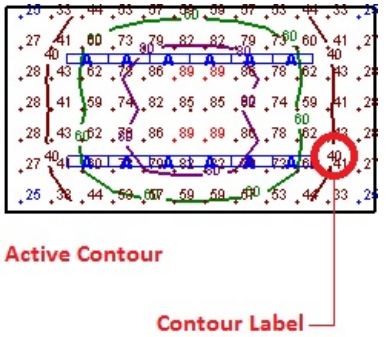
The **Color** for each **Contour** Line can be specified by clicking the Color button.

Once activated, specify the iso-*illuminance* value in each textbox.

Select **Show All Contours** to turn the feature on.

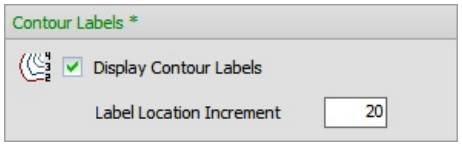
Conversely, select **Hide All Contours** to turn the feature off.





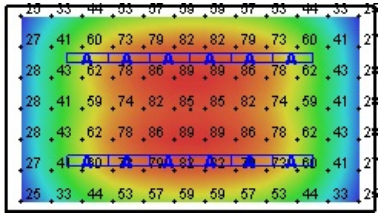
The display of **Contour Labels** can be toggled in the **Contours** sub-menu as shown above. This can also be toggled in the Settings *dialog*.

Contour *Label* increment is set on the **Contours** *tab* of the Settings *dialog* and uses the base *drawing* units. For example, "20" implies each *label* will be placed nominally 20 feet or meters apart.

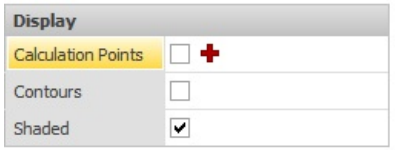


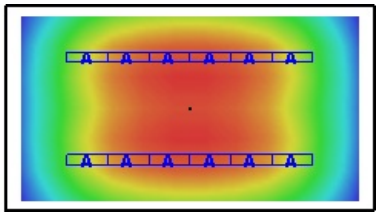
Contours can be displayed in a **Shaded** fashion (with pseudocolor) by editing Properties for a **Calculation Zone** and placing a check in the **Shaded** box in the **Properties** *tab*.

The method used to **Shade** is that chosen in the Calculation Zones Settings.



Note that the display of **Calculation Points** can be toggled in Properties as well. This is likely useful when displaying a **Calculation Zone** with **Shading** as discussed above but depends on user preference.





Contours are displayed to the boundary points not the bounding edge of a **Calculation Zone**. This is due to the fact that construction of the contour lines requires values for interpolation; values are not known past the last points on the edges, regardless of the bounding *polygon*.

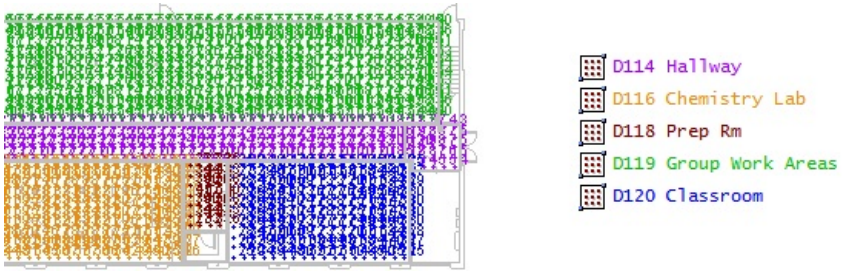
8.5.2.4 Color-Coding Illuminance Values

Visual provides several options for color-coding *illuminance* values.

Calculation Zones can be colored at creation by making choices in the **Properties** *tab*. See Calculation Zone Parameters.

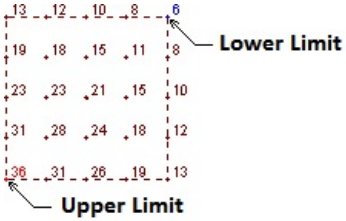
After creation, **Calculation Zone** color can be modified in the Properties *tab* of the **Sidebar**. See Calculation Zone Properties

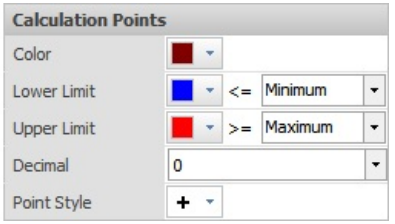
This can allow for easier identification in more complex projects.



Point values can be highlighted based on an **Upper Limit** and/or a **Lower Limit**. To modify highlights, edit the **Calculation Zone** Properties, and make **Color** and/or **Value** selections as desired.

The default is to highlight the **Maximum** and **Minimum** values. New defaults can be set in the Calculation Zones Settings

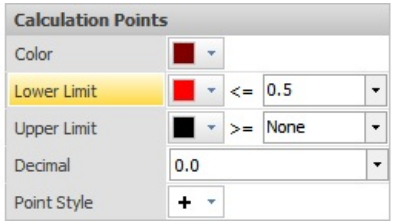




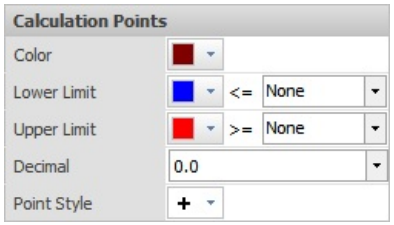
Using the **Lower Limit** to highlight all points below a **Minimum** value required in a specification provides quick feedback, particularly in site lighting projects.

Values can be set by editing Properties and selecting a common value from the list or typing a custom value. At right, the specification calls for 0.5fc minimum at any point, and values below that are shown in red.

The same process could be used to find **Upper Limit** values above a criteria or related to unacceptable *max/min* ratios.



The **Lower Limit** and **Upper Limit** can be set to not highlight at all. Edit the **Calculation Zone** Properties, and select "None" in both the **Lower Limit** and **Upper Limit** listboxes.

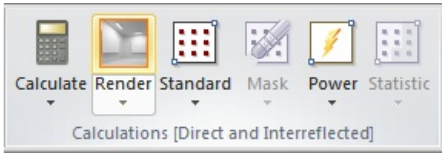


See Setting and Displaying Contours for information about **Contours** and color coding with shading methods.

8.6 Rendering

Rendering in Visual is a single-click task that is in most cases a quick task. The view can be manipulated without need for a new **Rendering** due to the fact that all surfaces are perfectly *diffuse*. **Renderings** can be equally generated for interior and exterior projects. Note that exterior **Renderings** require a **Solid Object** to be placed to mimic the ground, and it may be advantageous to change the background color of the **Design Environment** in the **Environment Settings**.

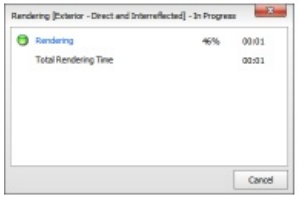
The **Rendering** button can be found on the **Calculations** *tab* and the **Home** *tab* of the **Ribbonbar**. To execute the command, left-click the top portion of the button.



After initiating the command, a Calculation will be performed if a valid solution is not present. Visual will then display the **Rendering In Progress** window to report the completeness of the calculations necessary to generate the **Rendering**.

This is the first of up to four "passes" made to refine the **Rendering**.

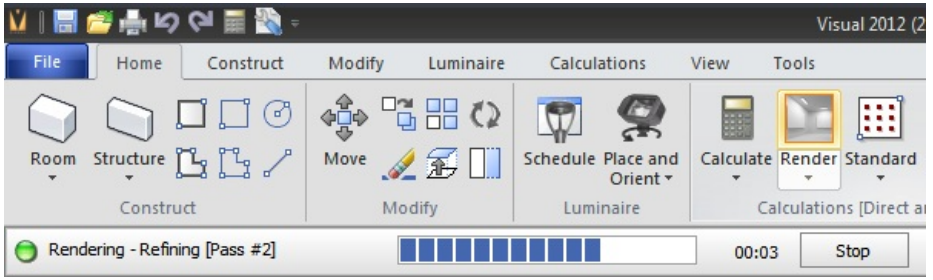
After the first pass is complete, Visual displays the current **Rendering** in Rendered Display Mode. The View can be changed without impacting the rest of the process where Visual will enhance the **Rendering** to provide greater detail.



After the first pass, the **Rendering Status Bar** is displayed at the top of the **Design Window**. If the results are immediately unacceptable, the process can be cancelled by clicking the **Stop** button.

Visual will proceed through up to four passes to analyze the surfaces. In this process, Visual determines where high gradients exist and where more analysis is needed. After each pass is completed, Visual displays the newly refined **Rendering**.

When the process is complete, Visual will close the **Rendering Status Bar**.

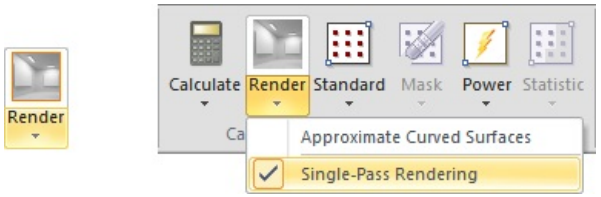


Luminaires are displayed in a **Rendering** as defined in the **Model** *tab* of the **Luminaire Editor**. If a **Luminaire Model** is not defined, the ***Luminaire Symbol*** will be used.

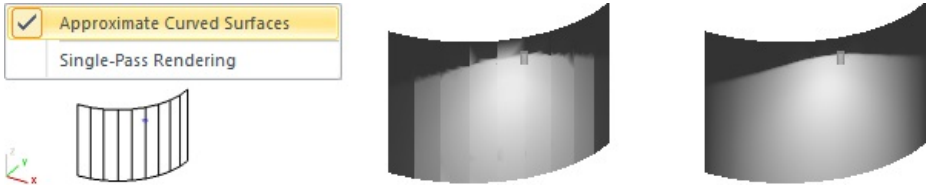
The **Render** button is dual function. The lower portion of the button initiates a sub-menu that allows for selection of options in the **Rendering** process.

Left-click an item to toggle the option on or off.

Single-Pass Rendering is just that; only one pass as described above will be completed to provide an ever quicker analysis to provide proof of concept prior to a full **Rendering**.

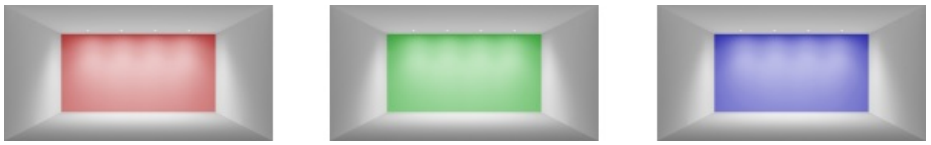


Approximate Curved Surfaces tells Visual to use additional analysis beyond the actual **Solid Objects** in the *model* to generate more visually correct data that drastically reduces "faceting" as illustrated at middle-right. The system default is to have this option active, as shown at far right.



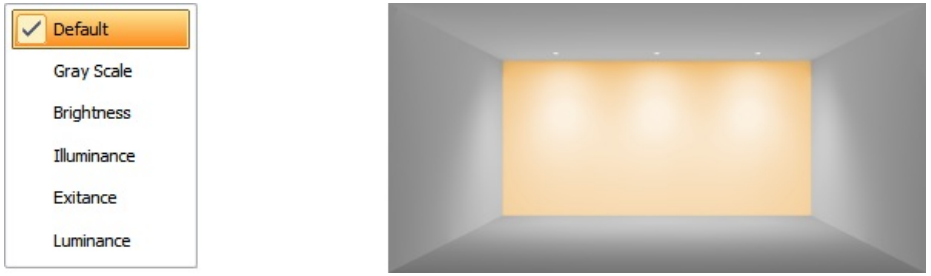
Renderings can be colorized by choosing appropriate **Colors** at **Solid Object** creation or by modifying **Solid Object Properties** after creation.

The modification of **Solid Object Color** does not require a new **Rendering** to be performed, assuming the new **Color** has the same ***Reflectance*** as the one used for the last calculation. To provide fast yet useful **Renderings**, Visual does not track the colored components of light and therefore does not provide a prediction of interaction between colored surfaces.

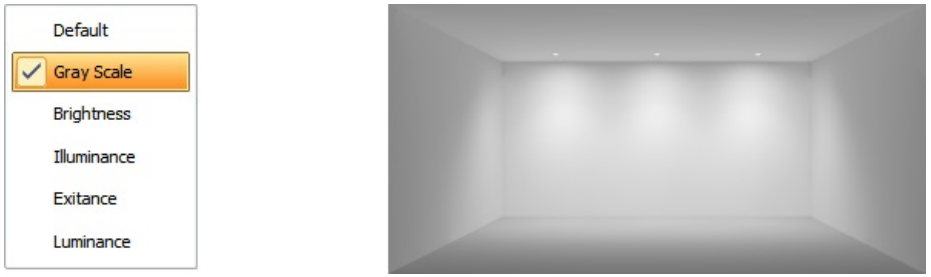


On the **Calculations** *tab* of the **Ribbonbar**, the **Display** button in the **Render** *panel* allows for varying metrics to be used in **Rendered Display Mode**. Clicking the button initiates a sub-menu with multiple choices. The default mode is to use **Solid Object Colors** as they are defined in the **Design Environment**.

Pseudocolor is controlled on the Calculation Zones Settings in the **Pseudo-Color Shading** *panel*.

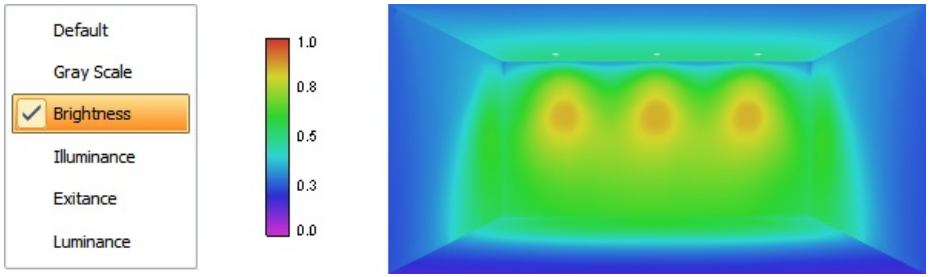


The **Gray Scale** mode converts all **Colors** to the gray equivalent.



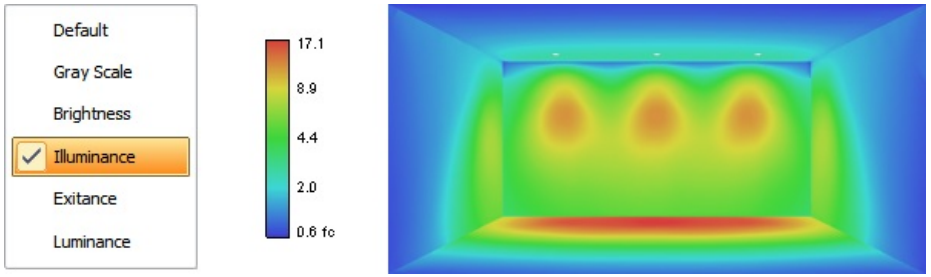
The **Brightness** mode displays the pseudocolor from 0.0 to 1.0.

A colored scale is provided in the lower left corner of the **Design Window**. Since brightness is a concept based on human perception, no units are involved.



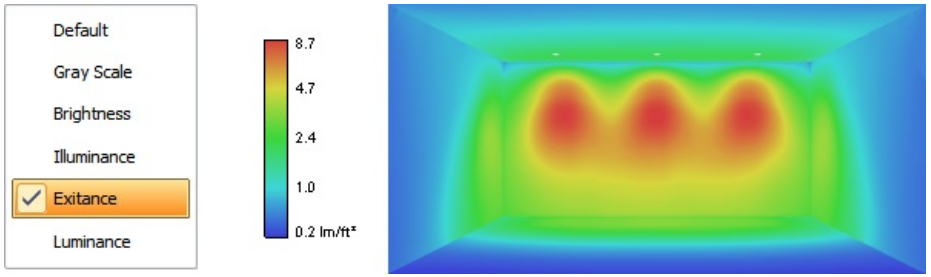
The ***Illuminance*** mode shows the **Rendering** with pseudocolor shading that maps *illuminance* onto all surfaces with actual calculated *illuminance* used for scaling.

A colored scale is provided in the lower left corner of the **Design Window**. ***Illuminance*** is shown with units of footcandles (fc)



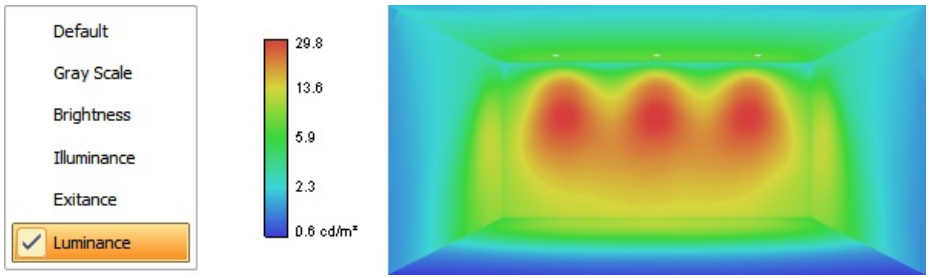
The ***Exitance*** mode shows the **Rendering** with pseudocolor shading that maps the *exitance* off all surfaces. Note that Exitance factors *illuminance* by the ***Reflectance*** of the base **Solid Object**.

A colored scale is provided in the lower left corner of the **Design Window**. ***Exitance*** is shown with units of lumens per square foot or lumens per square meter based on system unit settings.



The ***Luminance*** mode shows the **Rendering** with pseudocolor shading that maps the *luminance* of all surfaces. See Luminance for discussion of how that varies from brightness and *exitance*.

A colored scale is provided in the lower left corner of the **Design Window**. ***Luminance*** is shown with units of *candela* per square meter regardless of system units.



See Rendering in the appendices for advanced information on the **Rendering** process.