Version 1.1

Users Manual

1 Introduction

C2R Prediction Software (C2RPS) is a tool for designing sound systems with C2R loudspeakers. It includes support for the LA 208 line array. A typical use is to design a loudspeaker system for a particular room, with the goal of providing uniform coverage over an audience area. With ***C2RPS*** you can define the room dimensions, add loudspeakers to it and predict coverage over entire surfaces in the room and compute direct frequency response and direct signal arrival at discrete points.

C2RPS is licensed as either the 2D or 3D version. This manual covers the 2D version.

C2RPS uses embedded loudspeaker dispersion data for C2R loudspeakers. The main features of the program are:

- Definition of room main floor and up to three balconies.
- Calculation at third octave frequencies. SPL is computed at a number of points over the third octave band and the SPL's summed to give an overall level for the 1/3 octave band.
- Calculations can optionally be performed over a number of third octave bands to give a broadband SPL.
- Choice of power summation or complex addition to calculate coverage and response. Complex summation is required for accurate line array predictions and is the default mode.
- Display of contours showing SPL on main floor or selected balcony.
- Display of SPL on vertical plane through room.
- Line of sight acoustic shadowing.
- Choice of results display modes, trading off speed of calculation for resolution. *Spot mode* gives virtually instantaneous coverage display.
- Display of signal arrival time and levels for individual loudspeakers (Direct ETC) at a discrete point. Directly shows the affect of adding delays to loudspeakers.
- Display of computed frequency response at discrete points. Display has separate controls for display and calculation resolution with smoothing.
- Line array can be quickly built by defining number of cabinets and relative angles.
- Probe reports computed values at a location simply by clicking on it.
- An Ear Height correction can be entered.

The 3D version allows for modelling of rooms based on a library of shapes. The user simply supplies the dimension. With the Full Geometry option, rooms of an arbitrary shape can be created or imported via DXF. Model building operations include surface copy, extrude, project, revolve and reflect.

2 Installation

Do not attach the dongle until you have installed the dongle driver.

If you received the application as a single file, double click on it to expand it into the installation file kit. You will be prompted for a directory in which to put the files. Chose a temporary, empty directory that can easily be cleaned up afterwards.

Go to the directory containing the installation files and double click on setup.exe.

You will be prompted for an installation directory.

If you are running a relatively old operating system the installation procedure may ask about updating some system files. Allow it to do so. This may require restarting your computer and then restarting the setup procedure.

You can then install the dongle driver, if required, by selecting:

Programs/C2R/Install Dongle Driver

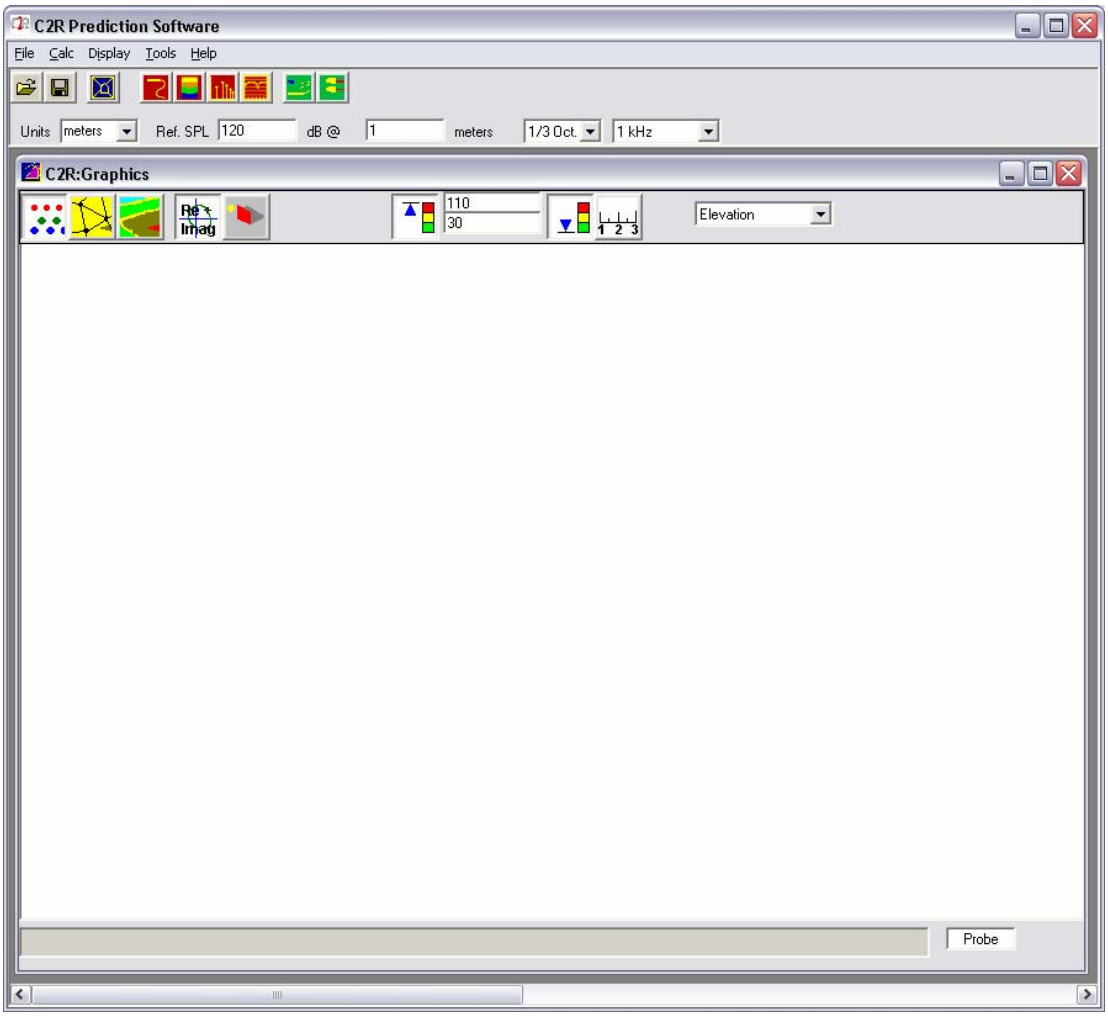
from the start menu.

C2RPS is developed in Microsoft Visual Basic with Fortran used for a the development of one DLL. Installation uses Microsoft Installer. Any files updates will only happen because the installation procedure determines that the present ones are out of date.

C2RPS makes minimal, benign, use of the registry. It uses it to store some application related parameters, such a window locations. No other registry manipulation is performed beyond that required for installation of a Visual Basic application.

3 Getting Started

4 Main Form



The C2RPS Main Form is displayed when you start the application.

4.1 Menus

File	***New From Library***		Creates a new room from a library definition. You select the room type, enter the key dimensions (guided by a picture) to create a new room.
	Open		Opens the file of a previously defined room.
	Close		Closes the current room.
	Save		Saves the current room back to its file. If this is the first save you will be prompted for a filename. A C2RPS model is saved in two files with .lmf and .lsc.

	Save as		Saves the current room under a new file name.
	Exit		Exits the application.
Calc	***Probe***		Displays the Probe form. The probe allows you to quesy the model to determine the SPL at a selected point.
	Coverage		Plots the SPL over the selected surfaces.
	DirectETC		Displayes the Direct Energy Time Curve. This shows the arrival times and level of the signal from all loudspeakers (and drivers for line arrays) at a selected point.
	Response		Brings up the response form. This allows you to plot the system response at a selected point in te room.
Display	***Switches***	*Loudspeakers*	Toggles the display of loudspeakers in the model.
		Loudspeaker Boresights	Toggles the display of loudspeaker and cluster boresights. Loudspeaker boresights are read, cluster boresights are green.
		Global CS	Toggles the display of the global CS.
		Points & Labels	Toggles the display of points defining the room and their labels.
		Currently Selected Surface only	Only he currently selected surfaces are displayed. This can be used to simplify the display of complex models. Changing the selection does not change the list of displayed surfaces. To change the displayed surfaces, turn this option off, select new surfaces and then re-enable this option.
		Surface Labels	Displays surface labels (numbers) at the centre of the surface.
		Surface Normals	Displays surface normals as red line with small red dot at tip. For correct volume calculations, surface normals **must** point into the room.
		Listeners	Toggles display of Listeners locations.
	Options	*Gray Scale*	Normally results of coverage

			calculations are in colour. This does not always work well for black and white printing. This menu item switches the display to gray scale.
		Free Edges	Displays Free Edges in the model.
		Non-planar surfaces	Highlights all non-planar surfaces in the graphics window.
		Suppress back faces	This option turns off display of surfaces that are at the back of the model. It is a very crude form of hidden surface removal. It is very effective with the spherical room model.
	Mode	*Spot*	Results are displayed at the number of points over a surface. Spot density is control from the Preferences menu.
		Interpolate	Results are calculated at a number of points and the data interpolated to provide results over the whole surface.
		Pixel	Results are calculated at every pixel in the graphics display of the surface. Zoom in for finer detail.
	Save Graphics		Prompts for a file name and then saves the contents of the graphics window in a .bmp bitmap file.
Tools	***Preferences***		Displays preferences form. From here you can control surface calculation density, air temperature and humidity and set listener ear height.
	Save window size		Stores the current size of the four main windows and uses then next time C2RPS starts.
Help	***Contents***		Starts the on-line help
	Register		Opens license registration form.
	About C2RPS		Displays the about box.

4.2 Toolbar

4.2.1 Viewing

Clicking this button displays the graphics window if it currently hidden, it redisplays the current display if already visible.

Autofits the room to the Graphics Window. Zoom and pan will be selected such that all surfaces and loudspeakers in the model fill the graphics region.

4.2.2 Calculations

Probe. Get results at a selected point in the room. The point is selected by left clicking on the Graphics Window. C2RPS selects the point on the closest surface under the cursor, calculates the results for that point and displays them on the Probe form. Speaker angles are only displayed if a single speaker or cluster is selected for display on the Display Options Form. The Probe Form is normally displayed at startup.

Calculate results. Selected results will be calculated and displayed in the manner selected on the Display Options form.

Display the Direct Impulse response. This hows the magnitude and time of signal arrival from all loudspeakers.

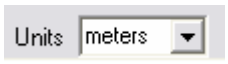
Display frequency response at a selected point in the model.

4.2.3 Room and Line Array

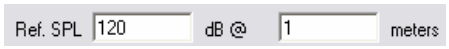
Define room. Brings up the room definition form. See section 5

Define line array. Display line array definition form. A room must be defined before you can define a line array.

4.2.4 Settings



Sets the length units used for this session. Options are feet, inches, metres, centimetres and millimetres. You cannot change units while a model file is open. Close the model, change units and then re-open.

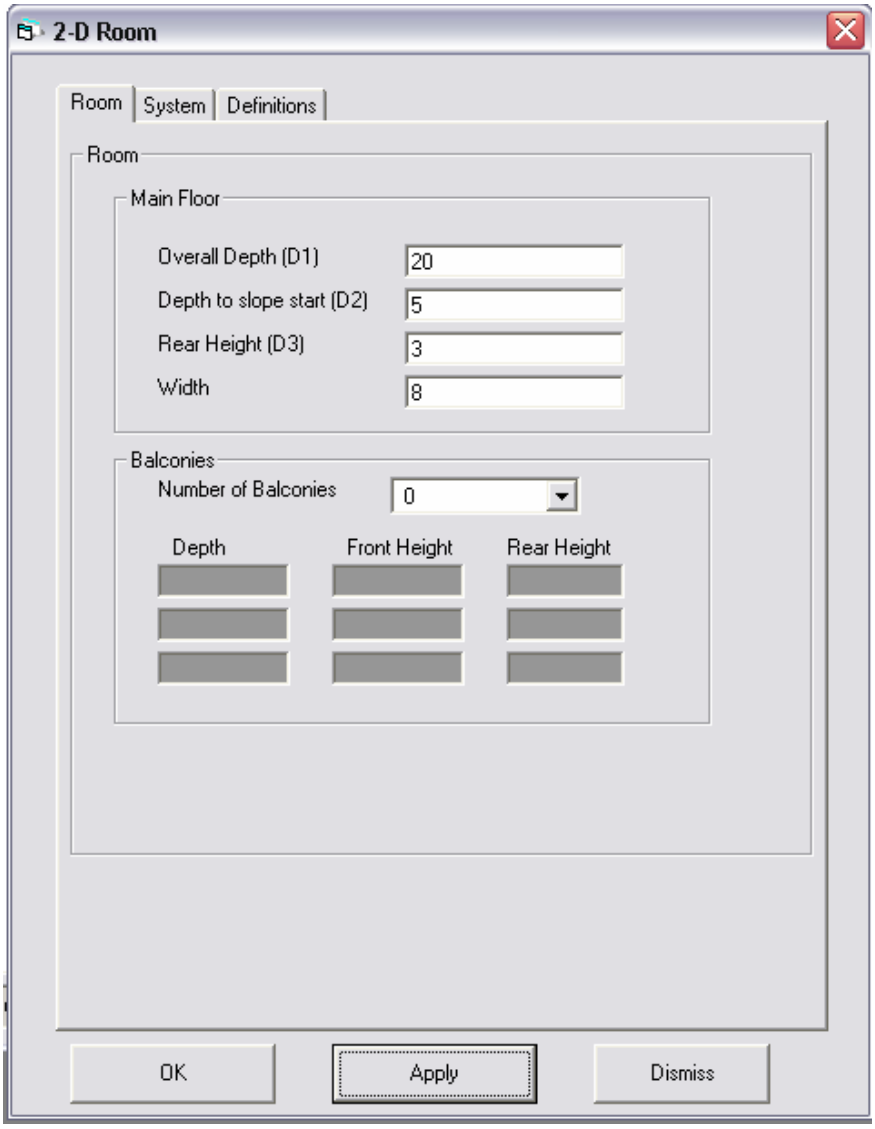


Sets the nominal output for all loudspeakers in the model. Specified as Sound Pressure Level at a defined distance at 1kHz. Defined distance is in current model units. The output level of individual loudspeakers and clusters can be adjusted with the level parameter of each loudspeaker. C2RPS assumes that a loudspeaker has been equalized to be flat across the frequency range.

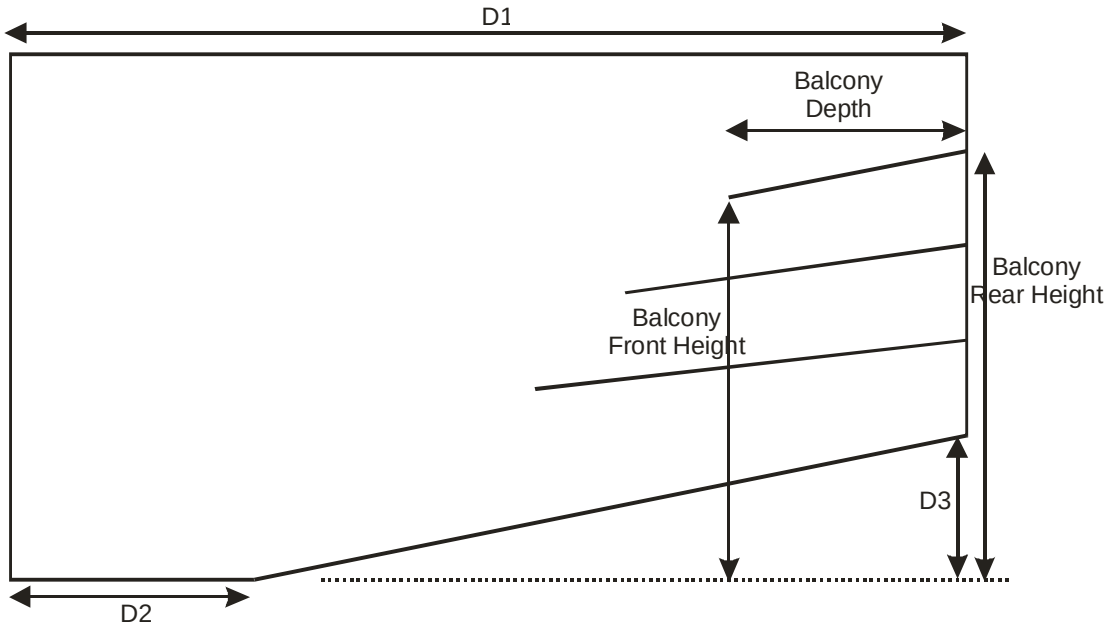
5 Room Definition

A 2D room is defined from the 2-D Room form, Room tab. The sound system location is defined on the System tab on the same form. The form is accessed with the  icon on the main toolbar.

5.1 Room Tab



This form is used to define the main floor and up to 3 balconies for the room. The dimensions are entered in the currently selected units. The dimensions to be entered are shown in the following figure. The displayed height is determined by adding 2m to the highest floor in the room.

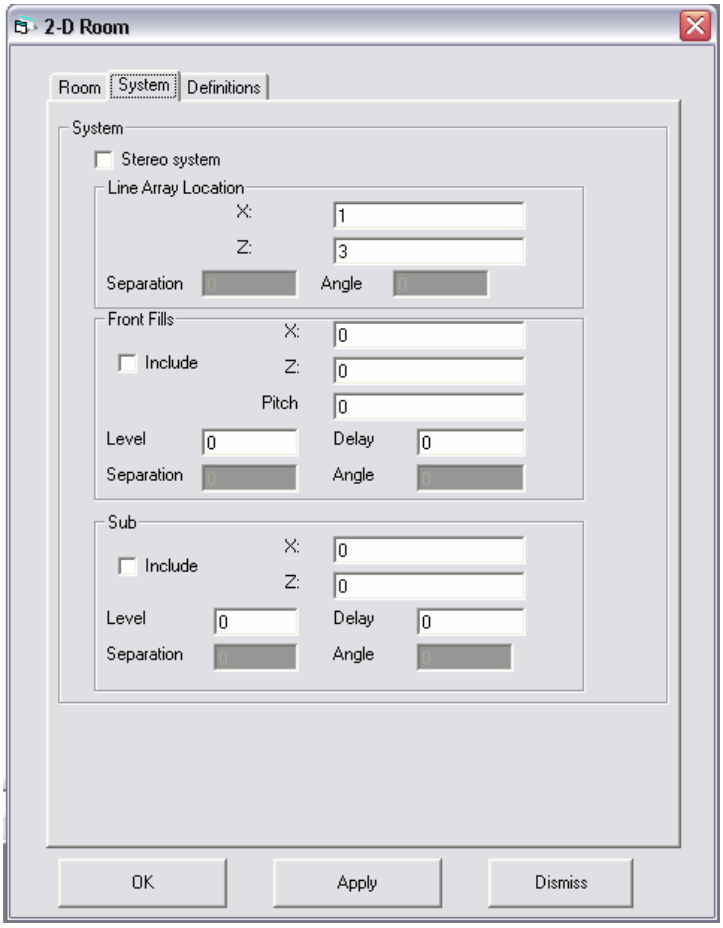


5.2 System Tab

The system tab is shown below. It is used to define the location of the line array, select and locate Front fills and Sub, define relative levels and delay for front fills and sub.

Dimensions are entered in current units. Level is expressed in dB (lower value implies lower level). The delay is expressed in milliseconds and the Pitch angle in degrees, positive is down.

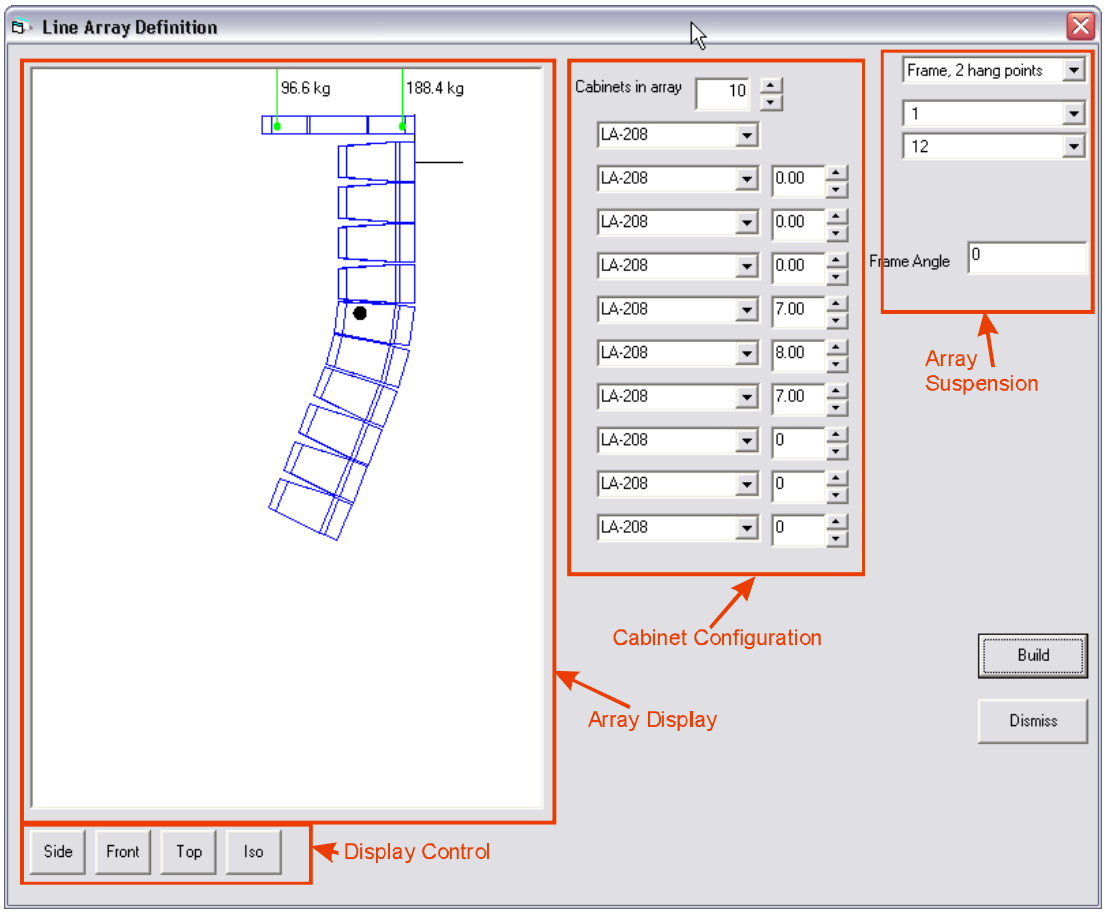
If the Stereo System box is checked, additional fields become active. These additional fields allow you to define the separation of the stereo speakers and their turn in angle. Only the right loudspeaker is included in the model. Good stereo coverage requires that both loudspeaker channels cover the entire audience area. It is therefore preferable to design stereo systems with only one channel active.



5.3 Definitions Tab

The definitions tab shows diagrams that define the terms used on the other tabs.

6 Line Array Definition



This form is used to define the line array in the room. The controls are in 4 groups, as shown in the figure. The function of the controls is described below. After changing any control, the Build button must be clicked to rebuild the array with the new parameters.

6.1.1 Cabinet Configuration Controls

The top control in this section is used to define the number of cabinets in the line array. You can change the number of cabinets using the up and down arrows on the right of the control. The permissible range is 2-16 cabinets.

Each row allows the cabinet model to be selected and the relative angle between the cabinet and its neighbour to be defined. The angle may be in the range of 0-8 degrees in increments of 0.25 degree.

6.1.2 Array Suspension

These controls define how the array is supported. Top control allows selection of the support method. These options and function of the remaining fields are listed in the following table.

Frame, 2 hang points	The cabinets are suspended from a frame. The frame is

	suspended from 2 cables. The angle of the frame from horizontal is set by the user in the Frame Angle field. The attach points of the suspension cables are enetered in the two fields below the support selection control. In this configuration, cabinet 1 is the top cabinet.
Frame, 1 hang point	The cabinets are suspended from a frame. The frame is suspended a single cable. The angle of the frame from horizontal is calculated and displayed in the Frame Angle field. The attach point of the suspension cable is enetered in the field below the support selection control. In this configuration, cabinet 1 is the top cabinet.
Floor Stack	The frame is placed on a horizontal surface and the cabinets attached above the frame. In this configuration cabinet 1 is the bottom cabinet.

For an array hung from cables the cable tensile loads are displayed in the array display. For suspension from 2 cables, if the tensile loads become negative (i.e. the cable goes into compression), the cable is displayed in red.

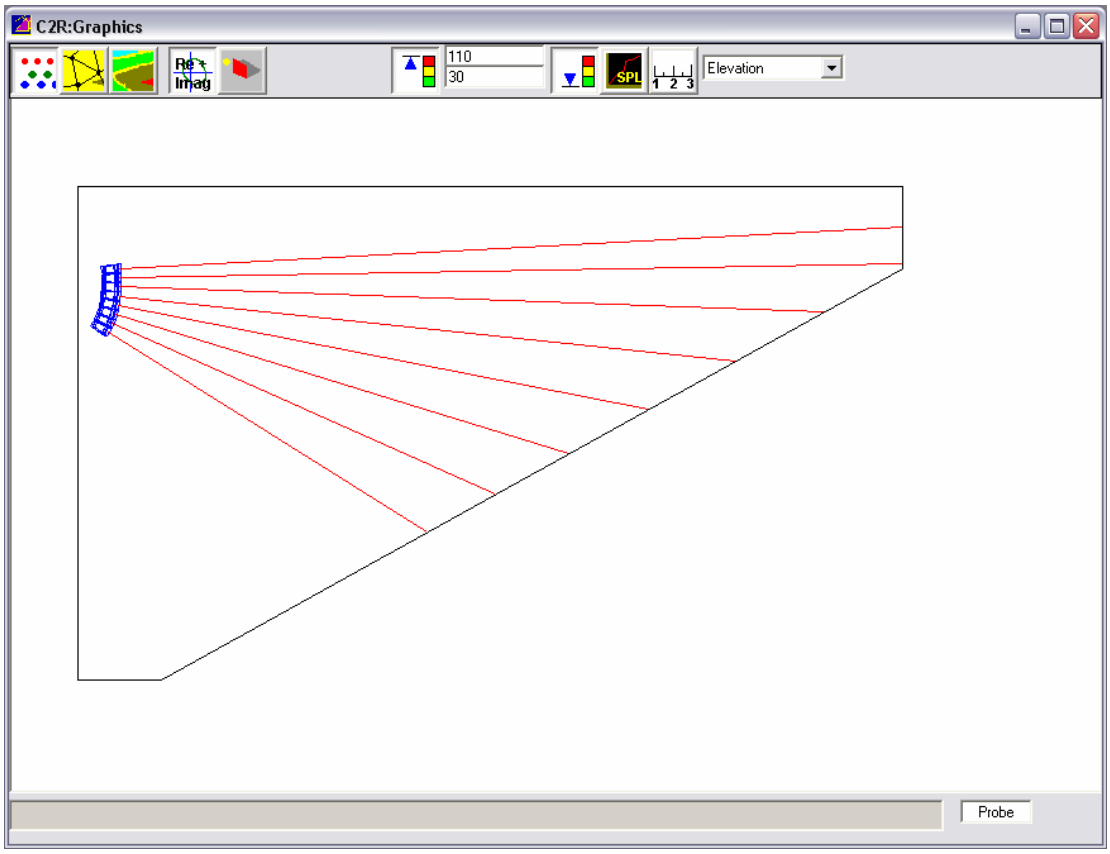
6.1.3 Array Display

Displays the current array configuration and cable loads.

6.1.4 Display Controls

Sets the view of the line array. Options are Side, Front, Top and Isometric.

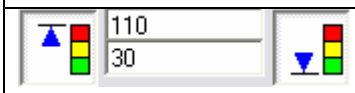
7 Graphics Window



The Graphics Window displays the room geometry and installed loudspeakers. The view is selected from the pull down menu at the top right. This pulldown also selects the surface that calculations will be performed on.

The buttons across the toolbar at the top of the window control the calculation and display of SPL.

Spot  Interp  Pixel 	Selects the SPL display mode. See the discussion below for details and recommendations. **Spot** – calculates and discrete points over the surface and displays a coloured spot to indicate SPL. **Interp** – performs the same calculations as in spot mode but then interpolates between the points to give a complete shaded display. **Pixel** – Computes SPL at every pixel on the surface.
Complex 	Activates complex calculations. Complex calculations include phase affects. For accurate SPL for line arrays, complex calculations are required.

Shadowing 	When active, C2RPS calculates the visibility of a loudspeaker (for line arrays, individual drivers). If the view to a loudspeaker or driver is blocked by a surface that loudspeaker does not contribute to the SPL at the point. Shadowing can significantly increase calculation time.
	The upper text box lists the maximum SPL that will be displayed in colour. The lower text box shows the range of SPL that will be displayed in colour. The Auto Max button,  , activates the automatic setting of the maximum displayed SPL. The Auto Min button,  , activates the automatic setting of the minimum displayed SPL.
Plot SPL 	This displays a plot of SPL versus X-distance for each floor. The loudspeakers nominally point in the +X direction. **Note**: The X-axis value is the percent of surface depth (distance in X). Every floor is plotted from 0 to 100 percent.
Ruler 	Displays Rulers on X and Z axis to indicate distance.
Surface selection 	Selects the surface for calculation. Elevation selects a vertical surface located at Y=0. Main Floor sets the view to a plan view and selects the main floor for displaying calculated results. Balcony 1,2 or 3 selects plan view and the appropriate balcony as the calculation surface.

8 Calculations

C2RPS allows you to perform the following calculations:

- SPL for points in the model, with text read-out or contour display
- Energy time curves for the direct sound (Direct ETC).
- Frequency response curve for the direct sound

Text read out is achieved using the Probe while contour display is initiated with the Display button,  . This button is available on both the Main form and the Display Options form. The Display Option form is discussed at length in section **Error! Reference source not found.**. The further discussion presented here relates specifically to displaying the calculated results.

The Direct ETC is displayed with the  button and frequency response is shown by clicking the  button. Both of these are located on the main form.

SPL calculation include air loss by default. The air loss values are read from file C2RPS.ini, located in the main C2RPS directory. The standard values used are from ISO 9613-1:1993 for 50% humidity, 20 degrees C. View this file for more details. C2RPS.ini also contains a switch to deactivate air absorption calculations.

8.1 The  button

This button causes ***C2RPS*** to compute and display results over model surfaces. The options related to this function are on the Display Options form described in section **Error! Reference source not found.**. See that section for a definition of what the options are. This section expands on those descriptions.

The button is duplicated on the Display Options form. The two are exactly equivalent, it is simply a matter of which is most convenient to use.

8.1.1 The Display Modes

Each point on a surface has its own value of the calculated result, whether this is SPL or one of the geometry related quantities. For practical purposes it is necessary to calculate the result at a finite number of points and limit the display to a finite number of points. The different display modes use different resolutions for calculation and display. The modes are discussed below and examples given.

8.1.1.1 Spot Mode

Spot mode maps a grid of points onto the surface and then calculates and displays results only at those points. To make the points more visible the result is displayed as a finite size spot of a single colour.

The grid density is controlled from the Plot tab of the preferences form (Tools/preferences menu). The values to be entered are:

Grid Area	The number of grid points is obtained by dividing the area of the surface by this value. It is essentially the surface area represented by a grid point. The final number of points may not be precisely this value. Additional points may be added to cope with surface shape and boundary.
Minimum per surface	This is the minimum number of points on a surface. It prevents small surfaces from being represented by a single point.
Maximum per surface	The maximum number of points per surface. Sets an upper limit for the number of points so that (together with the Minimum per Surface) a model with very large and small surfaces can be accommodated. Values in the range 1000-4000 give a good compromise in speed while allowing adequate resolution to show complex interactions in Interp mode.
Spot size	The diameter, in screen pixels, for each spot.

The big advantage of spot mode is speed, it is close to instantaneous for most models on most computers. It provides a very quick first look at a design. Spot mode supports Persistent Results. This option is activated from the Display/Options menu. When active the displayed values are automatically updated when the model or display parameters are changed.

8.1.1.2 Interpolate Mode

The calculations are performed at the same points as are used for spot mode. These results are then interpolated to fill in results over the entire surface. The interpolation is done at pixel resolution, therefore the larger the surface on the screen, and the higher the screen resolution, the longer the calculations will take.

Since interpolation is involved, the results will be more accurate for more closely spaced grid points. The grid uses the same controls discussed in Spot Mode.

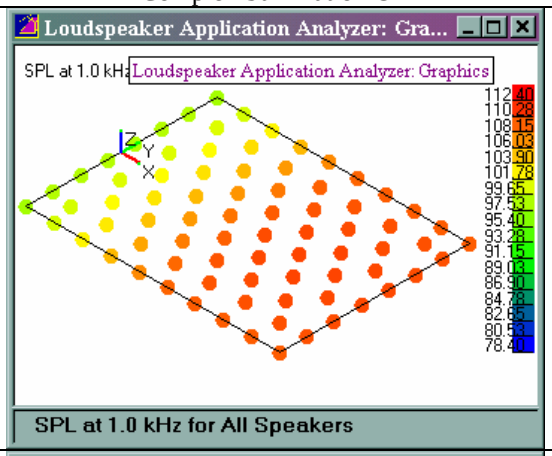
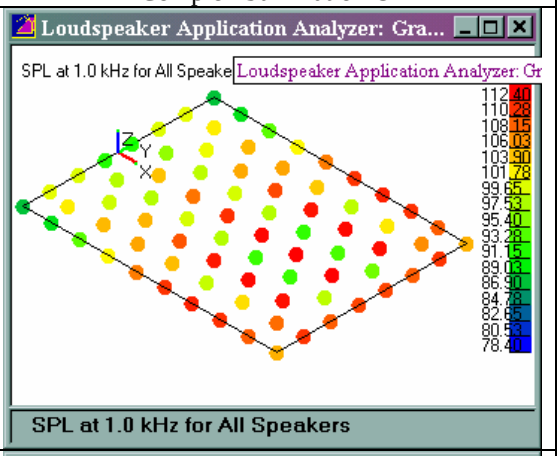
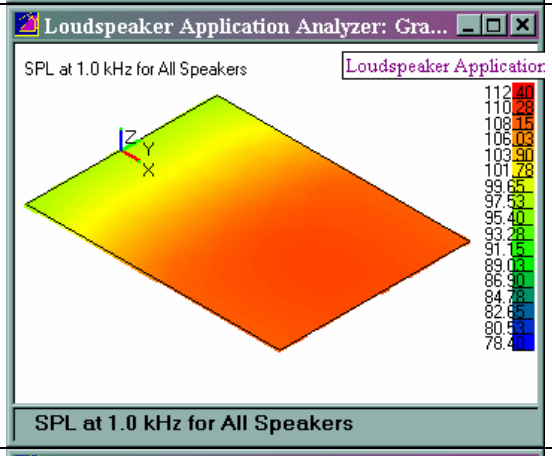
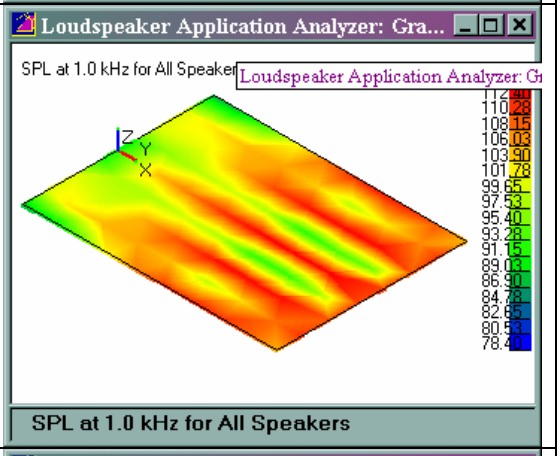
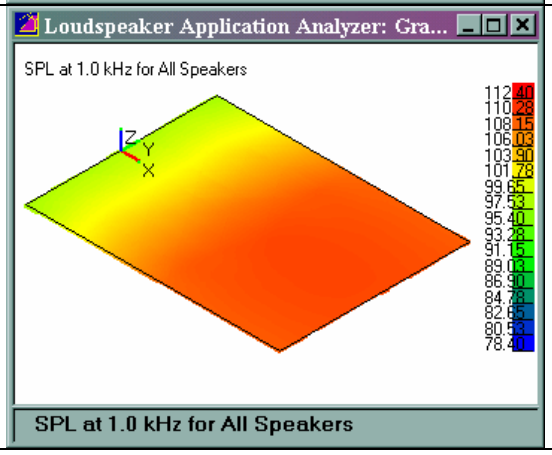
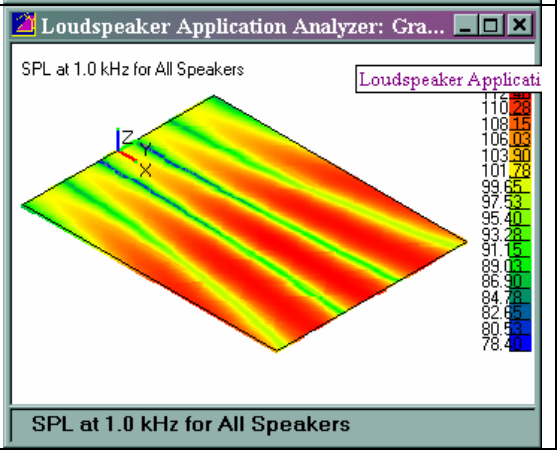
It is not appropriate to use this display mode with complex summation turned on. Complex summation shows changes in level due to interference between multiple sources, at higher requencies these variations have finer detail than can be represented by calculating only at grid points. Of course, if the design has only a single loudspeaker the results will be good, as there is no interference.

8.1.1.3 Pixel Mode

In Pixel Mode a grid of triangles is mapped onto the surface. Each triangle is then scanned and the result explicitly calculated at a location corresponding to every pixel that falls inside the triangle. This is the most computationally intense mode but is the only mode capable of showing interference between multiple sources. If complex summation is not activated, the results for this mode will be very similar to Interpolate Mode. Since complex summation is only applicable to SPL calculations, Pixel Mode will also be similar to interpolate mode for all non-SPL calculations.

Pixel mode calculates at every pixel inside a surface. The grid is used to divide the surface into easy to manage shapes (triangles) for scanning. The calculation time and accuracy do not depend on the grid settings.

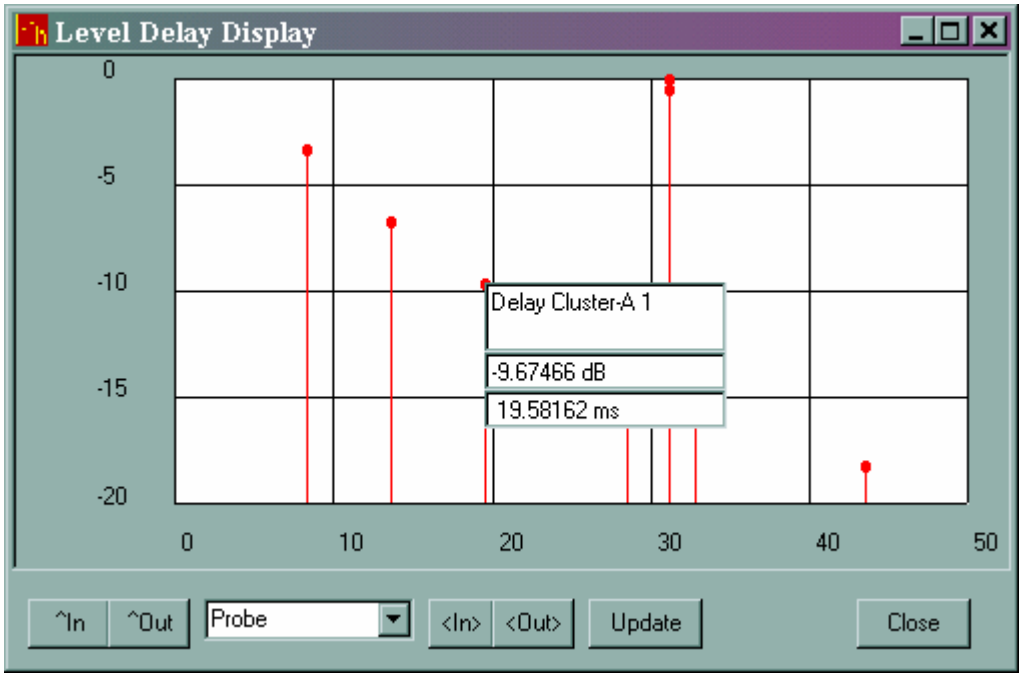
The following figures show results for two loudspeakers positioned above a rectangular floor. Results are presented for each display mode, with and without complex summation.

	Complex Summation Off	Complex Summation On
Spot Mode		
Interpolate Mode		
Pixel Mode		

The coverage calculations shown in these displays are performed at a single discrete frequency. This tends to over-emphasise the nulls and peaks shown in pixel mode compared to the perception of a human listening to typical broad band material. The default is to calculate the SPL by averaging over a 1/3 octave band. Selecting 'Calculate at band centre only' on the Preferences form, Listener tab, causes calculations to be performed at band centre frequency only.

8.2 Direct ETC Calculations

The Direct ETC shows the arrival time and level of the signals from all the selected loudspeakers and from individual drivers on a line array. Its main use is in setting delays in order to align the loudspeakers. In 2D mode, the Direct ETC can only be calculated at the probe location. Ensure that the probe form is active and a location selected before requesting a Direct ETC display.



The vertical axis is level in dB, relative to the strongest arrival. The horizontal axis is time in ms.

The text box in the centre of the display is activated by clicking on the tip of one of the arrivals. It shows the loudspeaker where the signal originated, the arrival time and the level relative to the largest signal received. In this case it is clear that some loudspeakers need delays to be set.

The calculations are performed at the frequency selected on the Display Options form. The arrival times are not affected by the frequency setting, on the levels are

This display is not the same as the Energy Time Curve (or log squared impulse response) that you would measure in the room. That will include signals reflected from floor, walls and other surfaces. These reflections are not included in this display.

8.2.1 Controls

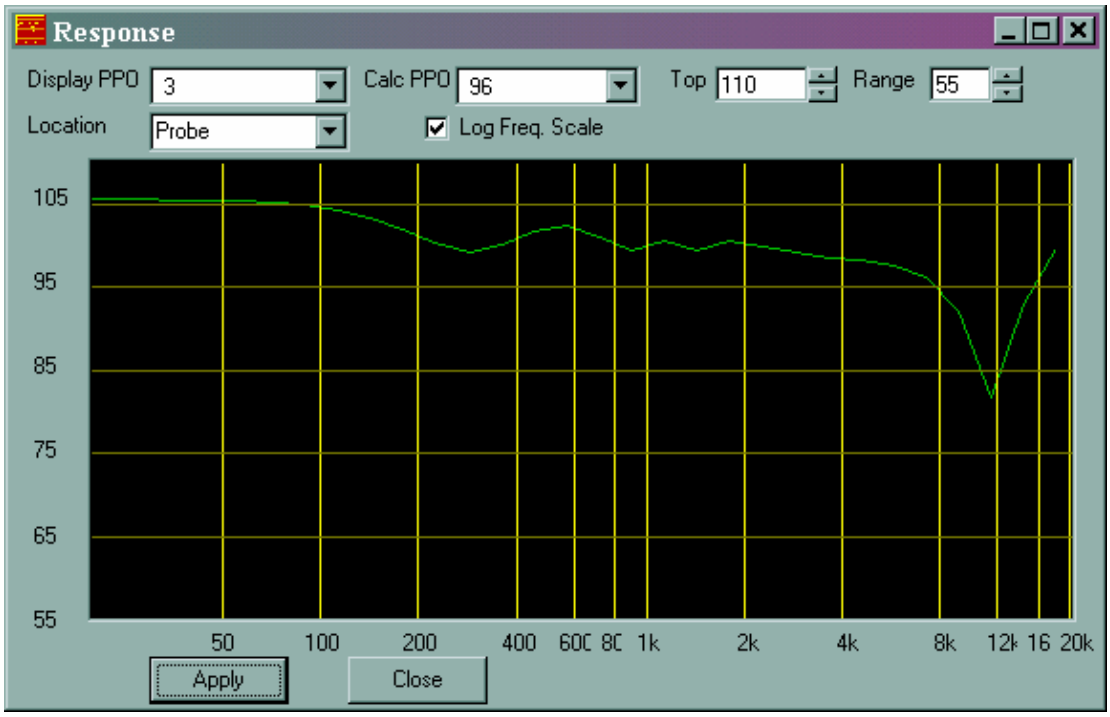
^In	Zooms in on the vertical scale. The top of the scale is always zero. The range is halved every time you click on this button.
^Out	Zooms out on the vertical scale. The top of the scale is always zero. The range is doubled every time you click on this button.
Location	This pull down selects the location where the

	calculations are performed. The only option available in 2D mode is: **Probe** – The last position probed. You may need to open the probe form to use this option. The Ear Height correction is applied to the selected location.
<In>	Zooms in on the horizontal scale. The left of the scale is always zero. The range is halved every time you click on this button.
<Out>	Zooms in out the horizontal scale. The left of the scale is always zero. The range is doubled every time you click on this button.
Update	Updates the display after selection of new location or other change in the model.
Close	Closes the form.

8.3 Frequency Response

C2RPS can calculate the frequency response due to the direct signals from the loudspeakers. This calculation always uses complex summation. You can control the number of frequencies per octave that are used in the calculation and the number of frequencies per octave that are used for display. This response is what you should see if you measured the frequency response with a pseudo-anechoic measurement technique such as Time Delay Spectrometry. Measurements made with a Real Time Analyzer (RTA) will also include reflected signals.

Complex summation is always used when calculating the response. In 2D mode, the response can only be calculated at the probe location. Ensure that the probe form is active and a location selected before requesting a Direct ETC display.



8.3.1 Controls

Display PPO	Display Points Per Octave. The number of points per octave displayed.
Calc PPO	Calculation Points per Octave. The number of points per octave calculated. This should ususally be set to a higher number that Display PPO. ***C2RPS*** will then perform the calculation and smooth the results to the requested Display PPO. If the Display PPO is set to a higher value, its value will be used for determining the Calc PPO.
Top	The highest level to be displayed.
Range	The range of levels to be displayed. The bottom value of the Y-Axis display will be (Top – Range).
Location	The location at which the response will be calculated. IN 2D mode the only choice is Probe, the last probed point. The Ear Height correction is applied to the selected location.
Log Frequency Scale	When checked the frequency scale will be displayed in log format.
Apply	Update the response curve to implement any changes made on this form or in the model.
Close	Close this form.

9 Preferences

Preferences are accessed from the Tools/Preferences menu. The preferences form contains 5 tabs. The contents of the forms as described below.

9.1 Listener Tab

When selecting locations for calculations it is most convenient to pick locations on an audience floor. However, listeners ears are not at floor level. The fields in this tab define a vector and distance that translates from selected floor point to the listeners ears.

The X,Y and Z fields that define the vector should rarely need to be changed.

The 'Display Results At Ear Height' controls where the SPL is plotted on the room. When checked the SPL will be displayed at the ear location, when unchecked the display is on the surface. In either case the SPL is calculated at the ear location.

The Ear Height is only used for surfaces that include the audience. It is not applied to vertical surfaces, for example.

9.2 Plot Tab

This tab controls the density of the SPL calculation points on a surface. The nominal number of points is computed as (Area of Surface)/ Grid Area. If the number of points exceeds the 'Maximum per Surface' value, it is reduced to that value. The Minimum per Surface value is used in a similar way.

The Spot Size sets the size of the SPL spot in Spot mode. The units are pixels.

9.3 Help Setup Tab

Not used in 2D mode

9.4 System

Not used in 2D mode.

9.5 Ambient

Sets Temperature, Pressure and Rel. Humidity of the room for which calculations are performed. These have no affect if the 'Include Air Loss in Calculations' check box is cleared. the air absorption is calculated as described in ISO 9613.

High frequencies are significantly attenuated by air. In a room of any significant size there will be high frequency roll off in the frequency response plot resulting from air absorption.