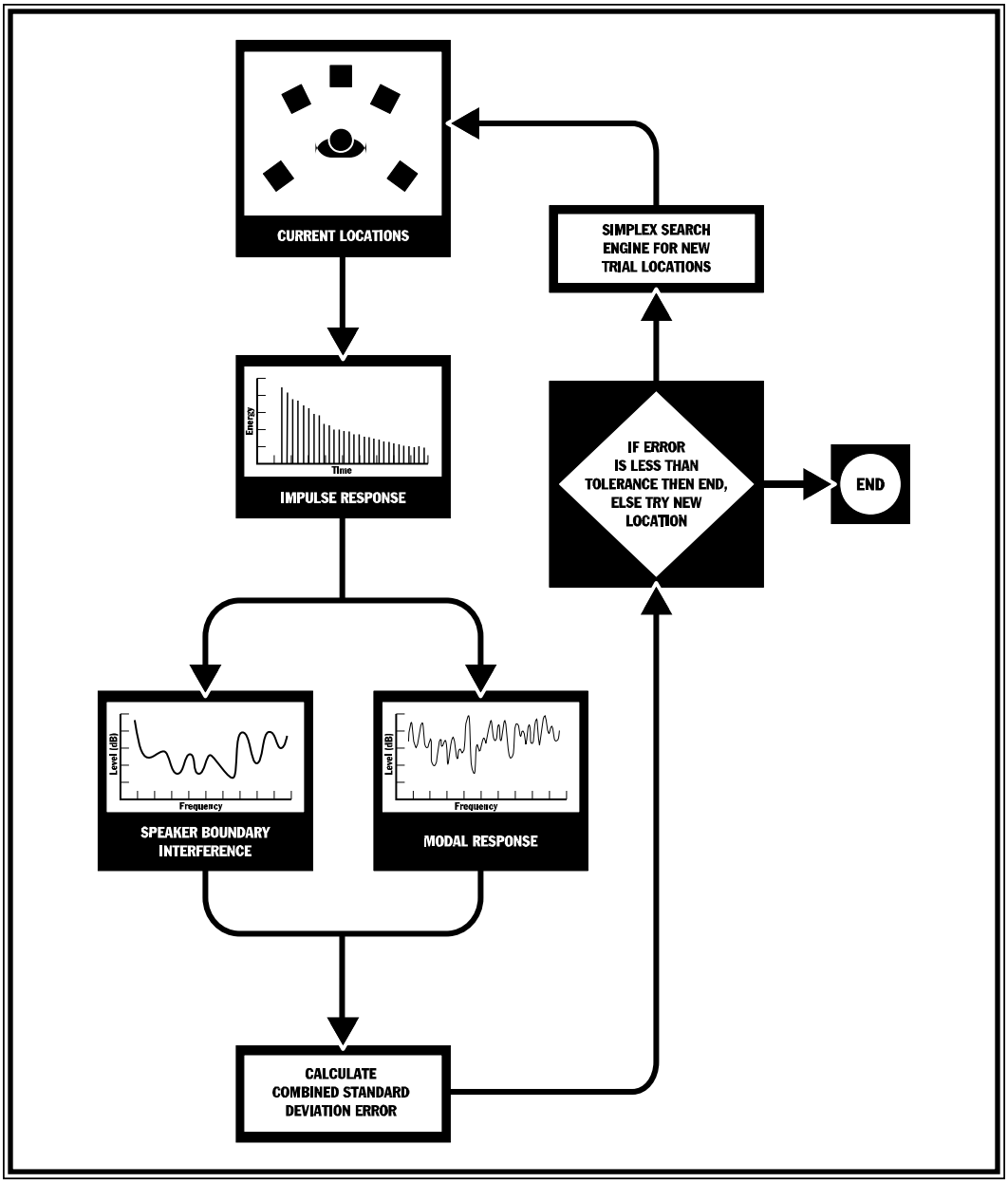
Room Optimizer™

A program to optimize the placement of listener, loudspeakers and acoustical surface treatment in critical listening rooms and home theaters



Listen to the Music, Not the Room!™

RPG DIFFUSOR SYSTEMS, INC., 651-C COMMERCE DRIVE, UPPER MARLBORO, MD 20774

OPENING THIS PACKAGE CONSTITUTES ACCEPTANCE OF THIS AGREEMENT
PLEASE READ THIS AGREEMENT BEFORE OPENING THIS PACKAGE
IF THIS AGREEMENT IS NOT ACCEPTABLE, PLEASE CONTACT RPG AT 301-249-0044 (in USA) OR RETURN THIS PACKAGE, UNOPENED, TO THE PLACE WHERE YOU OBTAINED IT, FOR A FULL REFUND

END USER SOFTWARE LICENSE AGREEMENT

Terms and Conditions

1. DEFINITIONS.
As used in this Agreement, the following terms shall have the meanings set forth below:
1.1 "RPG" means RPG Diffusor Systems, Inc.
1.2 "Customer" means the original end-user of the software.
1.3 "Designated Computer" means a single computer designated by the Customer. One licensed copy of the Software is required for each computer system that the Software is used on.
1.4 "Software" means the RPG Room Optimizer™ Software Product, regardless of the form in which Customer may subsequently use it or them, and regardless of the modifications that may be made to it or them. As used herein, Software includes all documentation and other written materials relating to the Software provided.

2. LICENSE.
2.1 Subject to the terms and conditions of this Agreement, RPG hereby grants Customer a non-exclusive, non-transferable right to use the Software on the Designated Computer and to make one copy of the Software as a backup.
2.2 The license granted under this Agreement authorizes the Customer to use the Software in executable form solely on the Designated Computer. Only one user may have access to the Software at any time. A separately licensed copy of the Software is required for any additional computer.
2.3 Customer shall not have the right to sublicense the Software. Customer shall not have the right to print, copy, reproduce, distribute, modify or in any other manner duplicate the Software, in whole or in part. Customer shall not decompile, disassemble or otherwise reverse engineer the Software or any part thereof. Customer shall not have the right to obtain or use any source code for the Software.
2.4 Customer understands that unauthorized reproduction or transfer of the Software may be a crime, and would subject Customer to damages and attorneys fees.

3. SUPPORT.
3.1 Any support services provided by RPG, including but not limited to, installation and training services, shall be provided on a time and materials basis at RPG's then current prices, subject to the availability of RPG's resources to provide such services.

4. NO WARRANTY.
4.1 RPG EXPRESSLY DISCLAIMS ANY WARRANTY FOR THE SOFTWARE. THE SOFTWARE AND ANY RELATED DOCUMENTATION ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. The entire risk arising out of use or performance of the Software remains with Customer. No employee, agent, dealer or distributor is authorized to make any warranties or modify the foregoing disclaimer of warranties. If implied warranties may not be disclaimed under applicable law, then any implied warranties are limited in duration to thirty (30) days after the date of Customer's initial use of the Software. Some states do not allow limitations on how long an implied warranty may last, so the above limitation may not apply to Customer. Further, neither RPG not its licensors warrant, guarantee, or make any representations regarding the use, or the results of the use, of the Software in terms of correctness, accuracy, reliability, currentness, or otherwise. Customer assumes the entire risk as to the results and performance of the Software. RPG's obligation with respect to support shall be solely as provided in Article 3.
4.2 With respect to infringement or misappropriation, Customer's sole and exclusive remedy shall be as provided in Section 7.3 hereof.
4.3 IN NO EVENT SHALL RPG OR THE DISTRIBUTORS, SUPPLIERS, LICENSORS, RESELLERS OR MANUFACTURERS OF RPG PRODUCTS, INCLUDING THE SUPPLIERS OR DISTRIBUTORS OF PRODUCTS WITH WHICH THE SOFTWARE MAY BE BUNDLED, BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT, CONSEQUENTIAL, OR PUNITIVE DAMAGES WHATSOEVER (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION OR ANY OTHER PECUNIARY LOSS) ARISING OUT OF THE USE OR INABILITY TO USE THE SOFTWARE OR OTHERWISE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

5. PROPRIETARY RIGHTS.
5.1 Customer acknowledges that ownership of the Software, including all intellectual property rights therein and all modifications thereof, is and shall remain in RPG or its licensors. Customer acquires only the rights to use the Software expressly granted herein and does not hereby acquire any other rights of ownership in the Software. RPG or its suppliers own all title and copyrights in and to the Software, the accompanying printed materials, and any copies of the Software. You may not copy the printed materials accompanying the Software. RPG reserves all rights not specifically granted by the Agreement.
5.2 Customer agrees to reproduce and include any copyright or other proprietary notices included in the Software on all copies, in whole or in part, in any form, including partial copies of the Software.

5.3 RPG represents and Customer acknowledges that the Software is proprietary to RPG or its licensors and includes copyrighted works, trade secrets and may include software for which patents have been applied for or issued. Customer may disclose the Software to its employees, representatives and contractors only on a need-to-know basis and shall obtain written confidentiality agreements from third parties. Customer will hold the Software in confidence and safeguard it from disclosure to third parties, unauthorized reproduction and use and access by third parties. Customer agrees not to provide or disclose the Software in any form, including, but not limited to, program listing, object code, or source code.
5.4 Customer shall not provide or permit public access to the Software in whole or in part, including, but not limited to, by computer networks, periodicals, newspapers or any other accessible or distributed media.
5.5 Customer agrees to take all reasonable steps to insure that the terms and conditions of this Agreement are made known to anyone who uses the Software. Customer agrees to insure that all materials that could lead to the use of the Software in a manner that violates this Agreement will be erased or destroyed, when they are no longer needed.

6. DURATION.
6.1 This Agreement is effective from the date the Customer receives the software and shall remain in force until terminated.
6.2 Customer may terminate this Agreement at any time by destroying the Software together with all copies, modifications and merged portions in any form and giving notice thereof to RPG.
6.3 Either party may terminate this Agreement if the other party materially breaches a provision of the Agreement and fails to correct the breach within 30 days following written notice of the breach. Upon such termination, Customer shall destroy the Software together with any and all copies, modifications and merged portions in any form and certify the same to RPG.
6.4 Customer's obligations of confidentiality hereunder and to make payments as provided herein and RPG's obligations of confidentiality hereunder shall survive any termination hereof.

7. INDEMNIFICATION.
7.1 As an express condition to the use of the Software, Customer agrees to indemnify and hold RPG and its licensors harmless from all claims by third parties rising out of Customer's use of or modifications to the Software.
7.2 Neither RPG not its licensors shall have any liability for any claim of infringement based on (a) use of superseded or altered release of the Software if such infringement would have been avoided by the use of a current unaltered release previously made available to Customer by RPG or (b) the combination of operations or use of any Software furnished under this Agreement with software or other components not supplied by RPG if such infringement would have been avoided by the use of such Software without such other components.
7.3 In the event that the Software is held to violate the proprietary rights of third parties, or RPG reasonably believes such a holding is possible, RPG shall have the option, at its expense to (a) modify the Software to be noninfringing, (b) to obtain for Customer a license to continue using the Software or (c) refund any license fee paid to RPG for the Software.
7.4 Section 7.3 states RPG's entire liability for infringement or other violations of proprietary rights.

8. GENERAL.
8.1 If any of the provisions or portions thereof, of this Agreement is invalid under any applicable statute or rule of law, they are to that extent to be deemed omitted and the balance of this Agreement shall remain in full force and effect.
8.2 This is the complete and exclusive Agreement between RPG and Customer and supersedes all proposals, oral or written, and all other communications between the parties relating to the subject matter of the Agreement. This Agreement may not be modified orally.
8.3 This Agreement shall be governed by and interpreted in accordance with the substantive laws of the State of Maryland.
8.4 The waiver by either party of any default or breach of this Agreement shall not constitute a waiver of any other or subsequent default or breach.
8.5 The Software, including copies an any medium, are to be used for the sole and exclusive benefit of Customer and for no other entity. Customer may make no assignment or delegation of any right or duty under this Agreement without the express prior written consent of RPG. Any prohibited assignment or delegation shall be null and void for all purposes.
8.6 All notices hereunder shall be in writing and shall be deemed given on the fifth business day after being sent by certified or registered mail or on the date of delivery if sent by other means.

9 DUAL-MEDIA SOFTWARE.
9.1 You may receive the Software in more than one medium. Regardless of the type or size of medium you may receive, you may use only one medium that is appropriate for the Designated Computer. You may not use or install the other medium on another computer. You may not loan, rent, lease, or otherwise transfer the other medium to another user.

10 EXPORT CONTROLS.
10.1 You may not export or re-export the Software or any underlying information or technology, except in full compliance with all United States and other applicable laws and regulations. In particular, but without limitation, you may not export the Software or underlying information or technology to or for a resident or national of Cuba, Haiti, Iraq, Libya, Yugoslavia, North Korea, Iran, Syria, or any other country to which the Unites States embargoed goods; or to anyone in the United States Treasury Department's list of Specially Designated Nationals or the United States Commerce Department's Table of Deny Order. By using the Software, you are agreeing to the foregoing and you are representing and warranting that you are not located in, nor under the control of, or a national or resident of any such country or on any such list.

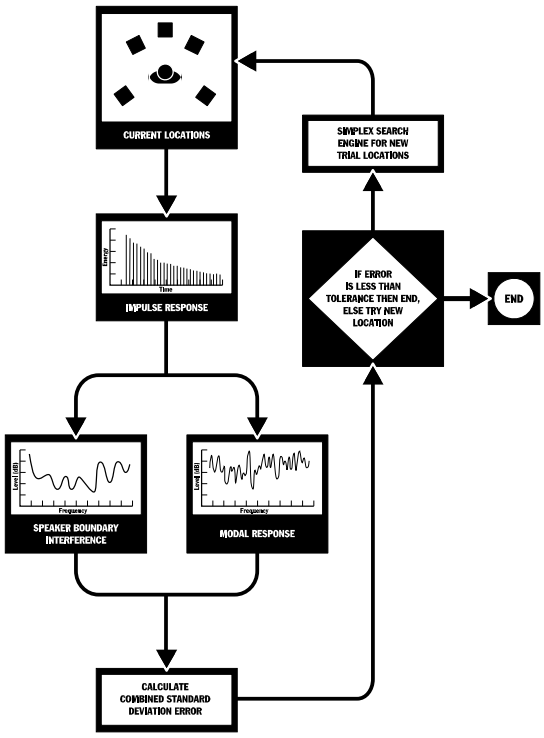
Table of Contents

1 What is Room Optimizer™?

Please read the white paper in the Appendix for a more thorough discussion of the scientific principles used in Room Optimizer™

A new approach to automated optimized listener/loudspeaker placement
Room Optimizer™ is a Windows 95™ program to help determine the optimum locations for listener and loudspeakers in a rectangular room. The theory behind the program is detailed in the accompanying White Paper in the Appendix.

There have been various approaches that suggest room dimensions and the positioning of listeners, loudspeakers, and acoustical treatment within a room. Most of these are relatively simple calculations, which were developed when powerful desktop computers did not exist. With the computational desktop power now available, more sophisticated positioning and evaluation algorithms can be used. The need for a new optimized approach grows as we move from stereo to 5.1 multi-channel music and home theater digital surround formats. In these new musical delivery formats, the room design and loudspeaker/listener placement become much more complex. For example, in a typical 5.1 home theater you may have to determine the best location for the listener, 5 full range loudspeakers, multiple sub-woofers, plus absorptive and diffusive room treatment. Room Optimizer™ is a novel coupling of modern room acoustics prediction techniques with iterative multi-dimensional optimization methods. The program carries out an automated search for the best positions for listener and low-frequency loudspeakers (woofers) in a rectangular room.



The flow chart indicates the iterative process. First, a random set of listener and loudspeaker locations is evaluated by calculating the energy impulse response via an image model. The image model is an efficient method to find all specular reflections from a source to a receiver. It converts

the problem of a source reflecting from boundaries to an equivalent problem involving multiple mirror image sources and no boundaries. Then two FFTs are performed on the impulse response to reflect the transient and long term aspect of the way we perceive music. A windowed 65 ms short-term FFT of the low-order reflections determines the speaker boundary interference response. A long-term FFT of the entire windowed impulse response extending to many orders (15 is the default) gives the 'modal' response. It is assumed that the best room response is obtained when the speaker-boundary interference and modal response spectra are smoothest and flattest. The evenness of the spectra are evaluated by taking a weighted sum of the standard deviation of each response over the low frequency range, typically between 20-300 Hz. If the error is below the tolerance set for the optimization then the program ends. If the error is above the tolerance, the optimization enters a simplex search routine which suggests the next best trial locations. These locations are then evaluated in a similar manner until the error is below tolerance. In this way the program finds locations in the room that are the best for reproduction of sound at low frequencies. In those instances in which there is no opportunity to change the listener or loudspeaker positions, you can use the RoomOptimizer™ to evaluate the room and suggest the locations of acoustical surface treatment.

Acoustic Distortion

The interactions among listener, loudspeakers and room boundaries may produce what we call Acoustic Distortion. Loudspeakers used for sound reproduction in recording studios, listening rooms and home theaters are designed in many ways. These consist of forward-firing dynamic monopoles, dipoles (spatially displaced drivers out of polarity with each other), bipoles (spatially displaced drivers in polarity with each other) and "multi-poles". Electrostatic and ribbon dipole speakers can also be used. This wide range of speakers provide directivities ranging from directional to omnidirectional. When the coverage pattern is wide enough for the emitted sound to reflect off the room boundaries, interference effects occur between the direct sound and the reflected sound and the listener then experiences the combined result of this interference. At low frequencies, where all loudspeaker types are omnidirectional, this interference manifests itself as a speaker-boundary interference and modal resonances. The magnitude of both is related to the locations of the listener and the loudspeakers and how they couple with the room's pressure response. Thus the first and least expensive thing to optimize in a sound reproduction room is the low frequency response. RoomOptimizer™ allows you to automatically and optimally locate the listener and woofer positions.

Acoustical Treatment

Low Frequencies

Following optimal placement, you may wish to further improve the low frequency response by adding acoustical treatment. Most porous absorbing materials like fiberglass and foam have limited efficiency in the 20-300 Hz range, especially near a boundary surface where the particle velocity is low. Therefore, effective low frequency absorption can be obtained using an absorption mechanism that relies on the pressure, since the pressure is high near a room boundary. This can be accomplished using membranes or porous pressure-gradient trapping near walls where two room surfaces meet or in corners where three room boundary surfaces meet. Additionally, if the room's dimensions are such that the low frequency modal resonances are excessive and additional help is needed, or if physical relocation of the woofers is not possible or desired aesthetically, then electronic equalization in the modal frequency range may be the only other approach. If done properly, this can be effective.

Mid/High Frequencies

At mid/high frequencies the interaction between direct and reflected sound, when plotted on a linear frequency axis, takes the form of a severely notched response, like the teeth of a comb. This effect is appropriately called comb filtering. Comb filtering occurs across the entire frequency spectrum and is responsible for degrading the location and apparent size of sonic images, as well as the perceived frequency response. In general, electronic equalization of the mid/high frequency response is not advised, because in attempting to minimize problems associated with room reflections, you destroy the one thing which is good: the direct sound. Thus, the only choices you have are to limit the coverage of the loudspeakers so they do not interact with the walls or acoustically treat the boundary surfaces. Since all loudspeakers interact with the room in some portion of their frequency spectrum, appropriate acoustical room treatment seems the appropriate choice. RoomOptimizer™ indicates the locations of the first bounce positions for all loudspeakers from all boundary surfaces. At the moment these locations are for the low frequency woofers, however, these locations are close to those of the mid and high frequency loudspeakers and can be used as a general guide. If the mid and high frequency drivers are located above the woofers, as is usually the case, simply extend the height of the acoustical surface treatment wall coverage by the necessary amount above the geometrical reflection positions of the woofers. Ceiling treatment will extend closer to loudspeakers and floor treatment, if desired, will extend closer to the listener.

System requirements

The program requires a reasonable quality computer running Windows95™. The calculations are not particularly memory intensive, but are time consuming and will benefit from a Pentium PC or equivalent and 16 MB of RAM or more.

Room Optimizer™ is easily installed from CD, using the familiar Install Shield.

Installation and getting started

Room Optimizer™ is supplied on CD ROM. If you do not have a CD ROM drive, please contact RPG and we will supply a disk. Place the CD ROM into the drive. Select "Run" from the Start menu on the task bar. Run the program Setup.exe from the CD ROM and follow on-screen instructions. You will be prompted for your Name, Company and Serial Number. The Serial Number is very important and can be found on the enclosed registration card. Please keep track of this number after you return the registration card, because you will be asked to supply it for all upgrades and additions that may be made available via the internet. Room Optimizer™ will automatically install and create the necessary program groups. In addition, uninstall routines will be placed on the computer should you wish to remove the program. These can be run from the Add/Remove Programs icon found in the Control Panel. The Install program places the program in the default directory C:\Program Files\RPG Diffusor Systems Inc\Room Optimizer. To run the program, select Start from the task bar, then Programs and double click on the Room Optimizer icon. To create a shortcut, go to the directory C:\Program Files\RPG Diffusor Systems Inc\Room Optimizer, select roomoptimizer.exe with the mouse, select File and Create Shortcut. The Shortcut can then be dragged and dropped on the desktop for future use. Several room configuration files are supplied in C:\Program Files\RPG Diffusor Systems Inc\Room Optimizer\Examples. These can be loaded from the File menu once the program is started.

Limitations

The current version of Room Optimizer™ is restricted to rectangular (cuboid) rooms, with highly reflective surfaces. The optimization will suggest placement for the listener, loudspeakers and acoustical surface treatment. The application of acoustical surface treatment will improve on the results indicated in the Spectra screen. Many additional features are envisioned for future versions.

When viewing the SBIR and Modal response spectra do not be alarmed if

your room does not optimize to a flat line. This is impossible, because there will always be some degree of interference between the loudspeakers and their boundaries and all rooms have modal resonances. The objective is to minimize the standard deviation or average squared deviation from the ideal flat response as seen in the Error Parameter Progress Graph. Different locations for listener/loudspeakers will affect different frequencies in different ways. RoomOptimizer™ searches all of the possible locations in the room and finds the one that produces one of the best overall combined spectra in the room. You will notice that the best result has a significantly lower error than the worst result encountered during the search for the optimum solution. The program does not also search for the absolute worst result, which would make the comparative improvement even greater. Version 1.0 can accommodate 20 independent and 20 dependent loudspeakers.

RPG DIFFUSOR SYSTEMS INC. DISTRIBUTES THIS SOFTWARE AS IS, WITHOUT LIABILITY OR GUARANTEE REGARDING THE EFFECTS OF USING THE PROGRAM AND THE RESULTS OBTAINED.

2 Quick Tour

Starting Room Optimizer™ will introduce you to a new approach in determining the optimum acoustical design of your listening room. Using powerful image model and search algorithms, Room Optimizer™ determines the optimum placement for the listener, loudspeakers, and acoustical room treatment. The system is implemented as a Windows 95® package.

This manual provides a brief description of the operation and capabilities. We have arranged this manual so that you can easily add 8 1/2" x 11" pages from optimization printouts and Worksheets, web site downloads of new configurations, versions, etc. and as a reference for articles related to the subject of room optimization. An in-depth white paper is also provided in the Appendix. After loading the program, you will be asked for a name for the licensed program user. "Please enter the name of the company or person who purchased Room Optimizer™". The name you enter will be listed on the headers of all printouts.

*Select **Start** from the **Actions** menu.*

The quickest way to familiarize yourself with the program is to run it. This Quick Tour provides a quick overview of the program's main features. Room Optimizer™ is supplied with a pre-defined room configuration for a stereo loudspeaker pair. Begin the optimization of this stereo pair by selecting **Start** from the **Actions** menu. If the screen display, colors or wallpaper make it difficult to view the screen, then you can edit these from the Preferences sub-menu of the **Edit** menu. While the program is running, explore all of the different screens in the **View** menu. Examine the listener/loudspeaker locations and error in the Data view, the listener/loudspeaker locations in the Room view, the speaker-boundary interference and modal response in the Spectra view, the listener/loudspeaker room configuration in the Configuration view, the Wizard view is not until you open a Wizard as described later, the first order reflection points in the GRP view and the Error parameter progress graph in the Error view. You can either prematurely **Stop** the optimization from the **Actions** menu, or wait for the program to find an optimum solution. This is indicated by a message box. You can now go to the **File** menu to **Print** any of the **View** screens, **Save results** to file or **Save configuration** for later optimization.

*Select **Load configuration** from the **File** menu.*

RoomOptimizer™ comes with pre-defined configurations for all of the wizards. To complete this Quick Tour, try **Load configuration** from the **File** menu. Pick one of the configurations stereo (stereo1w.roi), stereo with 2 woofers/cabinet (stereo2w.roi), left/center/right (lcr.roi), subwoofer (sub1.roi), 5.1 multichannel music with 5 matching speakers (mcm.roi), or 5.1 THX®* with Left/Center/Right and dipole surrounds (THX.roi). Start the optimization of one of these room configurations by selecting **Start** from the **Actions** menu. As before, select the **Data**, **Room**, **Spectra**, or **Configuration** screen. When the optimization is finished you can **Print**, **Save results**, or **Save configuration** from the **File** menu.

Read the menu descriptions in sequence or as needed

To speed usage of the RoomOptimizer™, you can use the shortcut key combinations. To accomplish this, hold down the specified combination of ALT, CTRL and/or SHIFT keys with the underlined letter. Thus you can select any of the main menu items by using the mouse or the ALT + underlined letter keys. For example, to select the File menu, press and hold ALT + F, from the main screen. Hitting the ALT key alone will clear any pull down boxes. Once a pull down menu is available, you can select any of the options by hitting the desired underlined letter. For example, after selecting the View menu by holding ALT + V, hitting the E key selects the Error parameter progress graph. You can also directly select main menu options by hitting the indicated shortcut key strokes from the main screen. For example, you can choose the Error parameter progress graph directly from the main screen by pressing and holding CTRL+SHIFT+E.

*Select **ALT+ underlined** menu letter for short cut keys..*

* THX® is a registered trademark of Lucasfilm, LTD.

3 View Menu

*The **View** menu allows the main window to toggle between different information windows.*

Now that you have experienced the main features in this Quick Tour, we will describe the details of the **View** screens, how to **Edit** an existing configuration, or **Define** a new one with or without the assistance of room Wizards. Then we will describe the details of printing, saving, and loading pre-defined room configurations and exiting the program. The Appendix contains an advanced white paper describing the theory behind RoomOptimizer™.

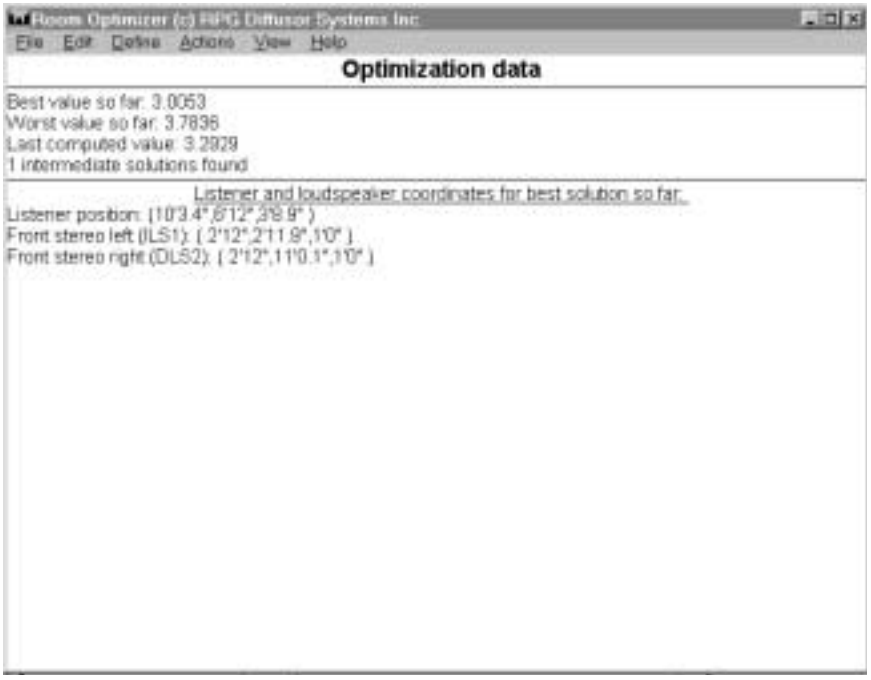
*Select **Data**, **Room**, **Spectra**, **Configuration**, **Wizard**, **GRP**, **Error** from the **View** menu.*

While the optimization is in progress you can choose different views from the **View** menu to evaluate the process.

View

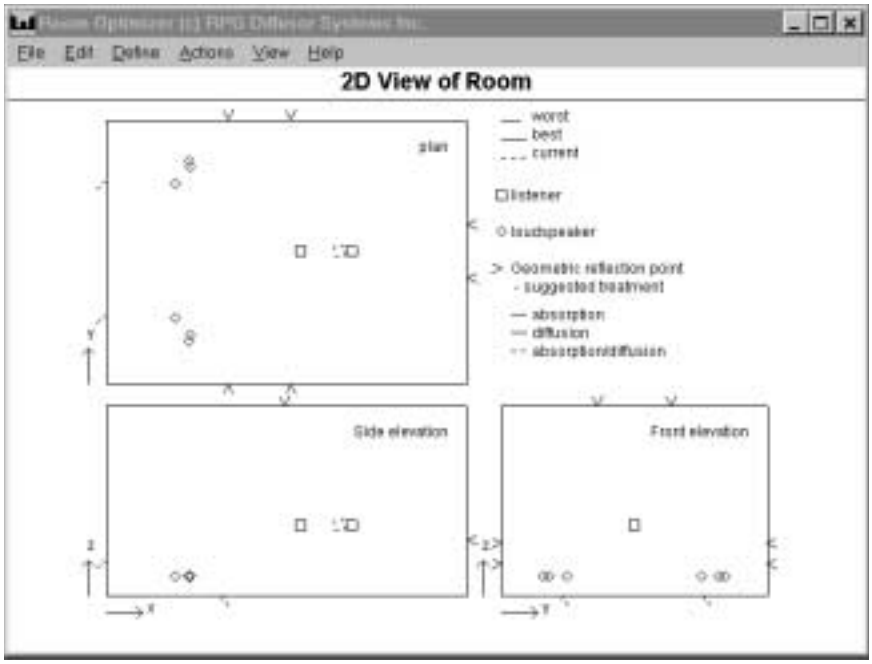
Data

shows how the error parameter, used to gauge the quality of the spectra, is changing. The lower the error parameter, the flatter the spectra. The errors for the solutions of the best value so far, worst value so far and last computed value are listed. This screen also indicates the number of solutions found and the listener and loudspeaker locations for the best solution thus far. All distances are measured from the front left lower corner where the floor meets the left and front wall.



View
Room

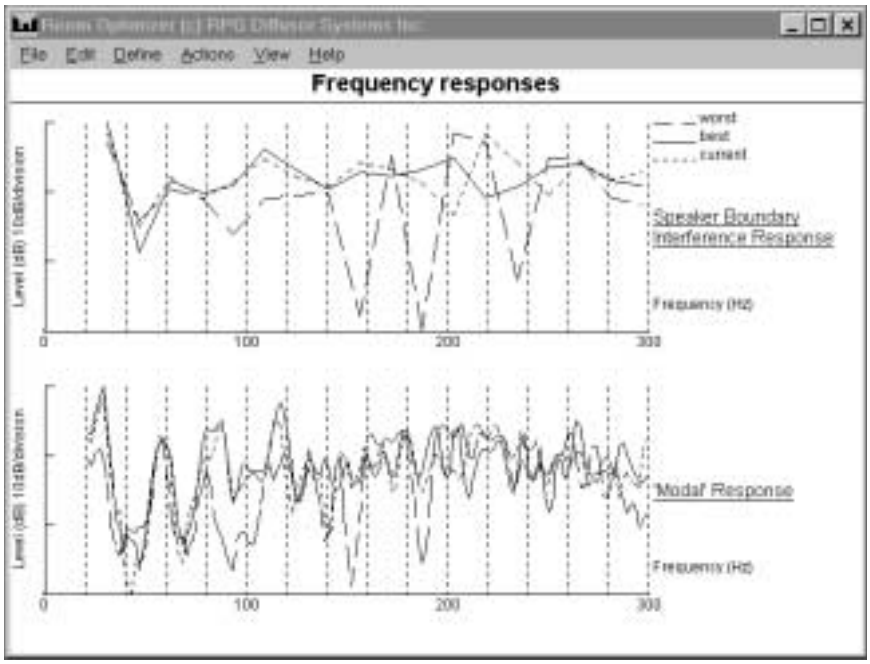
shows a drawing of the room in the form of a plan, front and side elevation. The worst, best and current positions of the listener and loudspeakers are indicated in the colors chosen with **Edit ▶ Preferences ▶ Colors**. The geometric reflection points on the walls, ceiling and floor are also shown as colored arrows (>) for the best solution. The colors for absorption, diffusion and absorption/diffusion mirror the colors for worst, best and current positions. These indicate optimum placement for diffusing or absorbing material to control first order reflections. The listener position is indicated by a box and the loudspeakers are indicated by a diamond symbol.



More details of the criteria used to gauge the quality of spectra is given in the enclosed scientific paper.

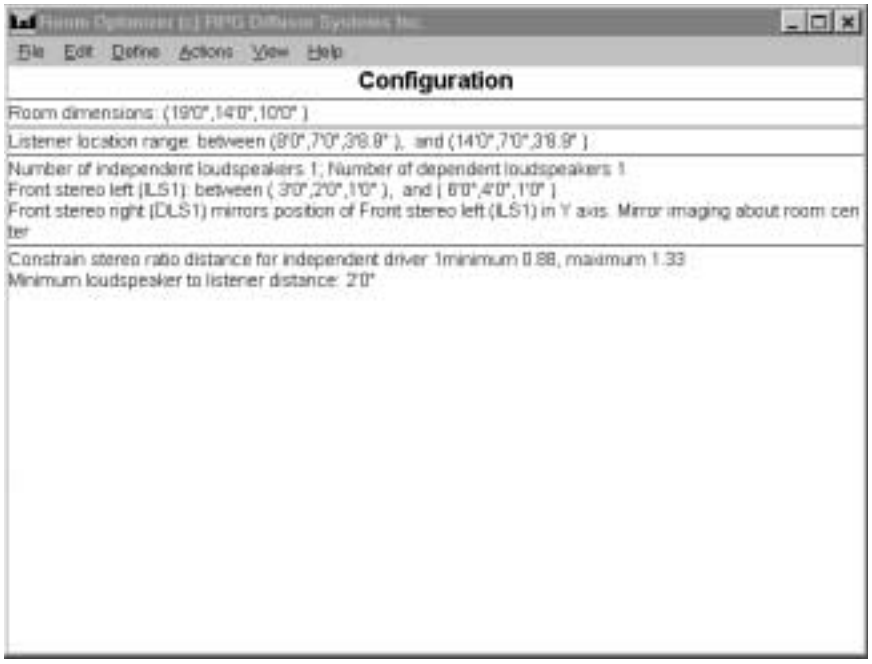
View Spectra

shows the Speaker-Boundary Interference Response (SBIR) and the Modal Response for the worst, best, and current positions. The SBIR reflects the coherent interference between the direct sound and first order reflections. The Modal Response reflects the room's standing waves. The program attempts to find the listener and loudspeaker locations with the flattest combined spectra.



View
Configuration

gives a display of the settings that define and limit the optimization. These include the room dimensions, the listener location range, number of independent (ILS) and dependent loudspeakers (DLS), limits for the independent loudspeaker positions, symmetry constraints between independent and dependent loudspeakers, stereo constraint and minimum listener-loudspeaker approach distance. More details on setting your own configurations is given later in this document.



View

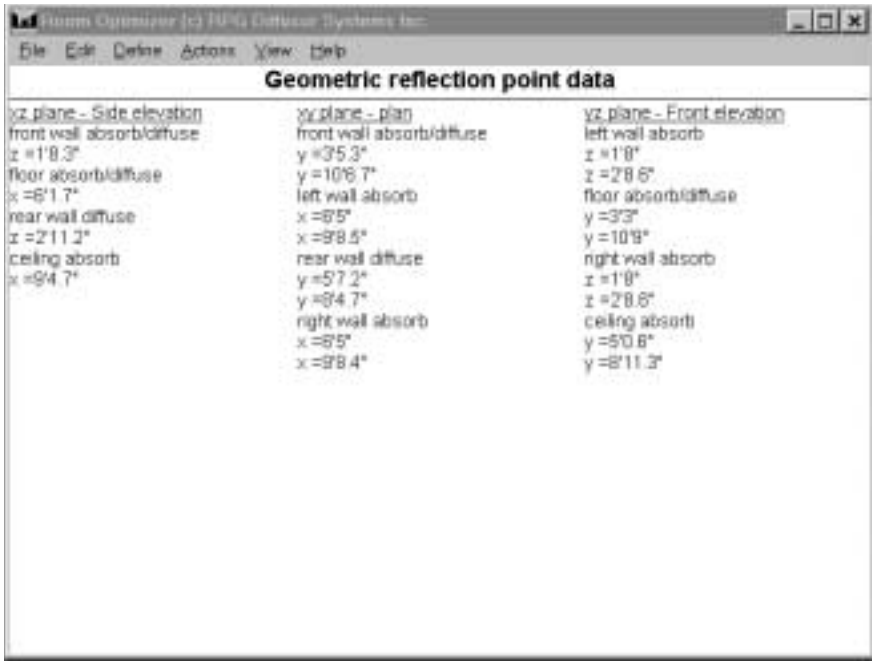
Wizard Information

is used to simplify the creation of room configurations. After one is selected, a Wizard Information screen can be accessed that details what the wizard has done. The screen shows the listener and independent loudspeaker search limits. It also describes the symmetry and displacement constraints relating the independent and dependent loudspeakers. The stereo angular constraint and the minimum listener/loudspeaker approach distance are also listed.

View

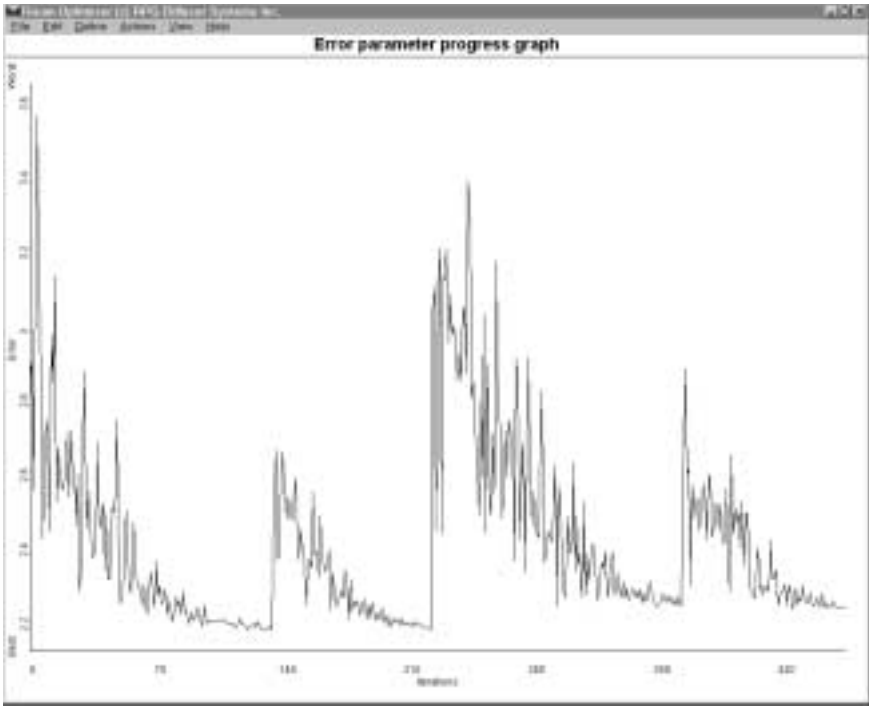
Geometrical Reflection Point (GRP) Data

lists the geometrical reflection points associated with the first-order reflections of the woofers. These points are indicated by colored arrows (>) on the side elevation, plan view and front elevation of Room View. The GRP data are sorted according to these three views and further sorted by boundary, i.e. front, side and rear wall, ceiling and floor. The type of acoustical treatment is also suggested. Remember all coordinates are referenced to the lower left front corner. x is the distance from the front wall, y is the distance from the left wall and z is the distance above the floor.



View
Error

displays a plot of the error versus iteration number. The error is the combined standard deviation of the speaker-boundary interference and modal responses. It gives the user a good sense of the improvement the program is achieving. In the graph below the program has found 4 solutions. At the beginning of each search, the program assigns random starting points. Hence the initial large error. As the program optimizes the listener/loudspeaker positions the error can be seen to decrease. When a solution is found, the error plot rises again, because the program assigns initial random starting points for the next cycle. In this example, the program was asked to confirm solutions. Thus the second iteration process starts with a lower error, because the initial points are only slightly different from the previous solution which was found. After the second solution, the program assigns random starting points and the error rises once again. After the third solution is found, it is confirmed as evidenced by the last section of the plot. Note that the Room Optimizer™ found the best of the four solutions at the end of the second iteration cycle.



4 Edit Menu

Edit
Preferences
has several options for changing the appearance of the program. This can also be accessed by clicking the right mouse button while the cursor is over the program window.

Edit
Preferences
Metric units
allows you to choose between meters and feet and inches.

Edit
Preferences
Display
The **Display** sub-menu allows you to choose a **Color**, **White on black** or **Black on white** display. You may wish to switch to **Black on white** for screen captures and printing. If part of the display is missing check that the window for the application is maximized. The program display works best with a maximized window.

Edit
Preferences
Colors
The **Colors** sub-menu allows you to choose the **Background color**, **Best spectra color**, **Text color**, **Worst spectra color**, **Current spectra color**, **RPG logo color**, and **Frequency grid**. If the default color scheme makes it difficult to see the chosen view, the configuration may be changed.

Edit
Preferences
Font
The **Font** option allows you to select the font. The font size selected is for the normal text size- that used for the data display for example.

Edit
Preferences
More wallpaper

The **More wallpaper** sub-menu allows you to select between more or less wallpaper. If the wallpaper interferes with the view chosen, you can select less wallpaper.

Edit
Preferences
Frequency grid

The **Frequency grid** sub-menu allows you to choose whether or not to display a grid in the **Spectra** view.

Edit
Preferences
Save Preferences

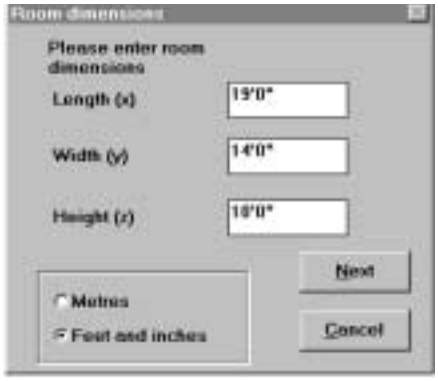
To store your choices for the display preferences, select the option **Save Preferences**, otherwise the settings will be lost when you exit the program.

Edit
Whole configuration

If you are starting a new configuration, you may find that one of the wizards can be used to simplify the process of defining the configuration. If there is something about the current room configuration, such as room dimensions, search ranges, constraint relationships between independent and dependent loudspeakers, etc., that you would like to change, you can do so from the **Edit** Menu. If necessary, stop the optimization by choosing the appropriate item from the **Actions** menu. By choosing **Whole configuration** you can page through all of the edit screens to modify any aspect of the configuration that you wish, before re-starting the optimization.

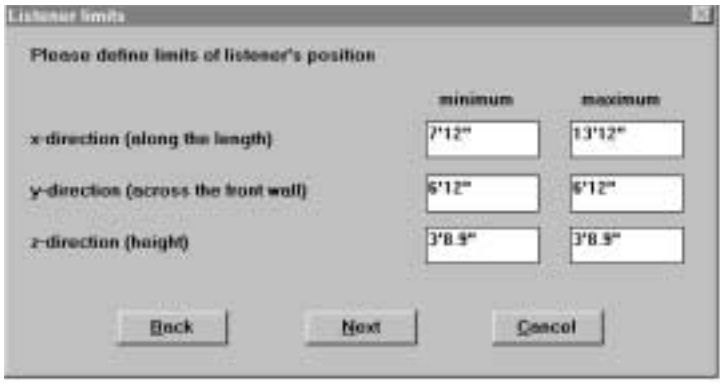
Room dimensions

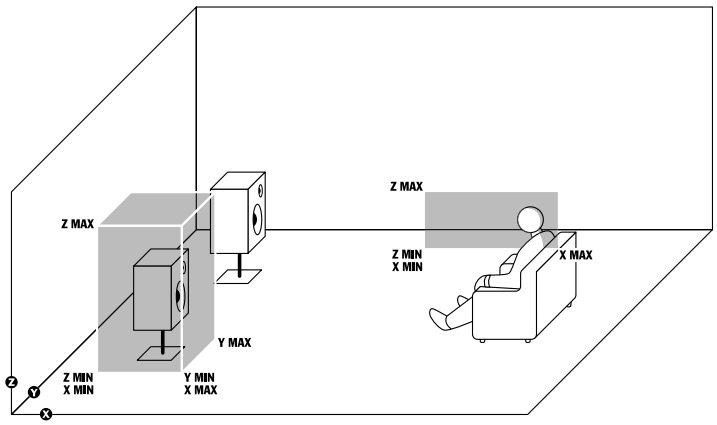
The first edit screen you encounter is the room dimensions. You can edit these in feet and inches or meters. If you choose feet and inches, you can enter the dimensions as decimal feet, e.g. 18.5’, or in feet and inches, e.g. 18’ 6”, or all inches 222”. If the foot symbol (’) is omitted, the program assumes the number is in feet, e.g. 18 is the same as 18’. When using metric units, no unit identifier is used and all dimensions must be in meters.



Listener search limits

The next edit screen contains minimum and maximum positions for the listener, along the room's length or x-direction, across the front wall or width, the y-direction, and the height, the z-direction. The coordinates displayed for the listener represent the center of the head. When the listener is on the center line of the room, the actual receiver position used in the calculation is displaced 10 cm (3.94") from the center line. This then represents the position of one ear. By including a small displacement from the center line, the program allows for the slight differences in the sound that arrives at the ears of the listener. The program uses the front lower left corner as the origin. That is, all distances are measured from the front left lower corner, where the floor meets the front and left wall facing the loudspeakers. The optimum solution for the listener position may be in a location that is not practically or ergonomically acceptable. By using these search limits, you can instruct the program to find a solution in a physically acceptable rectangular volume. Use the mouse or Tab key to move from box to box. You can move to the next screen or back to the previous screen if you want to correct a previous entry. Or you can cancel the edit. The data is read and stored when Next is selected. If Back is selected, the entry is not updated.





Room Optimizer™ allows you to examine the existing configuration or vary the x, y or z coordinates. For example, if the minimum and maximum position are different, the program will find the optimum location. However, if

the minimum and maximum position in the x, y or z direction are the same, then Room Optimizer™ will maintain that position. For example, if the minimum and maximum listener z coordinate are both set to 3’ 8.9”, then the program assumes that the listener’s ear height is fixed. However, if you are shopping for a favorite chair, you may ask Room Optimizer™ to search for the best ear height, within the limits of your chair selections. In general the y-direction is set to the center of the width of the room to maintain symmetry. If there is a reason this is not desired, you can also vary the y-direction minimum and maximum. The minimum and maximum x direction can be set to coincide with desired positions for a sofa or recording console. The program also allows you to set a stereo angular constraint, which maintains the ratio of the distance from the speaker plane to the listener and the speaker separation between specified limits. If the ratio is set to 0.88, for example, the listener will lie at the apex of an equilateral triangle determined by the two loudspeakers and the listener. This constraint is accessed from the **Define** ▶ **Advanced** menu described later in the manual.

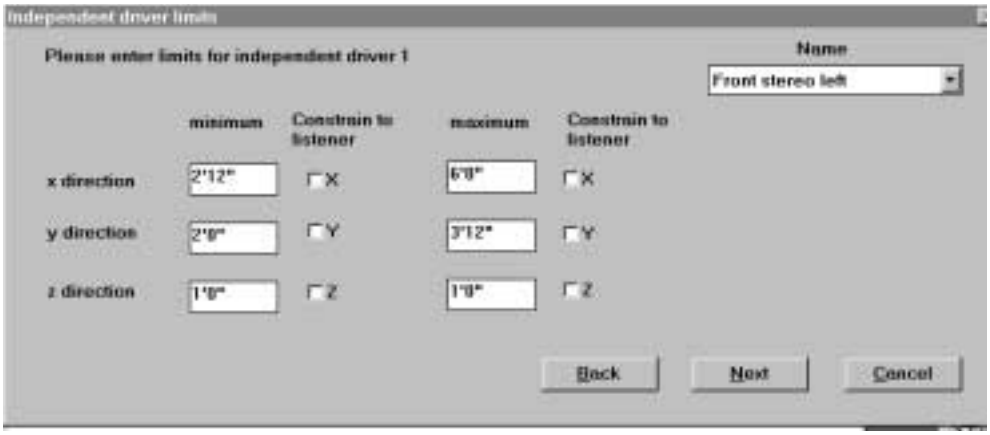
Number of loudspeakers

In any multidimensional optimization, there will be many good solutions that the program can find. To reduce the complexity of the optimization and to insure that one of the best solutions is found, the program divides the number of loudspeakers into independent and dependent types. The locations of all independent loudspeakers are actually varied. The locations of all dependent loudspeakers are determined from the positions of the independent loudspeakers. A simple example will illustrate this difference. In a typical stereo listening room configuration, the left front loudspeaker can be selected as the independent loudspeaker. Because the right speaker is related by mirror symmetry across the plane running down the center of the room (the xz plane), its position is dependent on where the left independent speaker is located. Thus we can simplify the optimization by only varying the left loudspeaker.

Independent loudspeaker limits

As with the Listener limit ranges, you can select search limits for all of the independent loudspeakers. In this way you can customize the search to find the best solution within the rectangular volumes which are physically acceptable for each independent loudspeaker. For example, if there is a door way or a structural column you need to avoid, you can simply set the x, y and z minimum and maximum limits appropriately.

In the upper right hand corner of this screen you will notice a Name combo box that allows you to name the independent loudspeaker from a selection list or to type in a new name. For example, left front or right rear.



Also next to the minimum and maximum limit boxes you will find x, y and z check boxes which allow you to constrain the x, y, or z distance of each independent loudspeaker to either the x, y or z coordinate of the listener. The power of this feature can best be explained by considering the rear dipole speakers in a THX surround configuration. In this arrangement, the listener is typically located at the null of the dipoles. Thus as the optimization proceeds, it would be useful to constrain the left rear dipole's x position to follow the x position of the listener. In this way, regardless of the listener's x distance, he/she will always be in the null of the dipole.

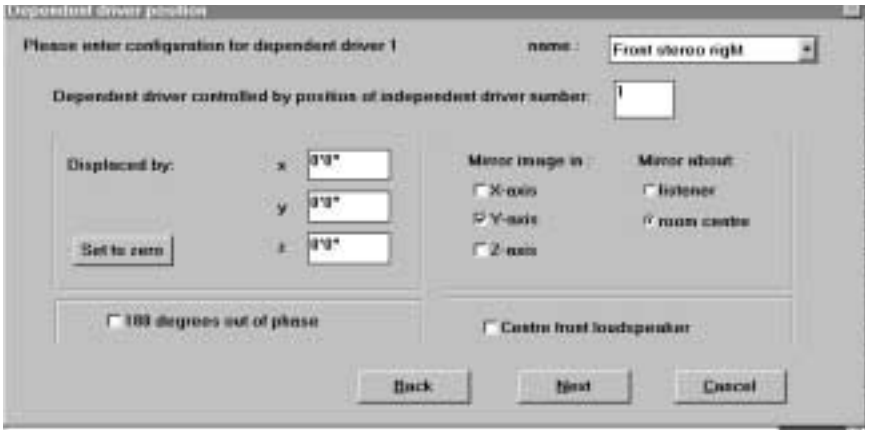
For floor standing loudspeakers, you may wish to fix the z coordinate at its actual distance above the floor. In other cases, if you are designing or purchasing a stand, you may wish to vary the z coordinate to find the best height for the stand. Please bear in mind that you may have to make a trade off between optimal woofer height for good bass response and optimal mid/tweeter height for good imaging. Life is a series of compromises!

If you have set the search limits for each independent loudspeaker, you can

go to the next screen (Dependent driver positions) and edit the symmetry or displacement relationships between the dependent loudspeakers and the independent loudspeakers they are related to. If you choose to go back and edit a previous screen you may do so by choosing **Back**. You can also **Cancel** the editing session.

Dependent driver positions

In the upper right Name dialog box you can select a name for the dependent driver from the pull down menu or enter a name of your choice. You must also enter the number of the independent driver that controls the position of



the selected dependent driver. To change the number of the independent driver simply click in the dialog box with the mouse and enter the desired independent driver number.

There are 4 additional rectangular dialog boxes. On the left side of the screen you have the x, y and z displacement constraints and the 180 degree out of phase check box.

Displacement

When there are more than one woofer in a loudspeaker cabinet, you can select one as the independent loudspeaker and the others as the dependent loudspeakers. To accomplish this you can set the x, y or z displacement of each dependent woofer from the independent one. For example, in a two woofer loudspeaker in which the woofers are vertically displaced by 18”, you would enter 18” or 1.5’ in the z dialog box. this will insure that as the independent lower woofer varies, the upper constrained dependent woofer will accompany it, only displaced by 18” vertically.

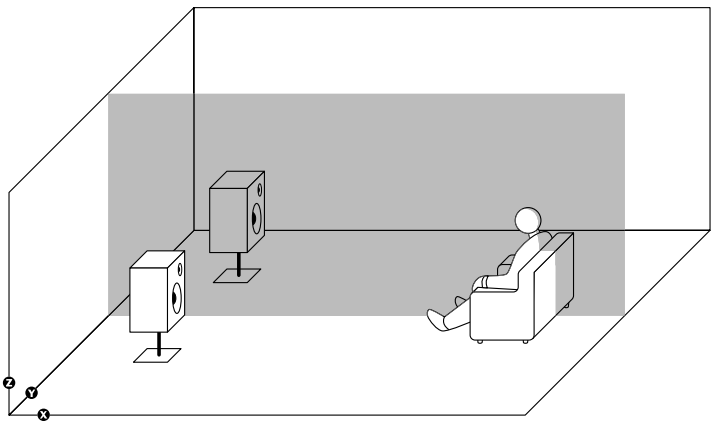
180 Degrees out of phase

If one of the dependent woofers is out of phase with the independent woofer, you can select this check box.

On the right side of the screen you have the x, y and z check boxes for mirror symmetry constraints and the radio buttons which determine whether the mirror plane is with respect to the listener or the room center. You can also select the center front constraint which maintains that the dependent loudspeaker will be restricted to be on the center line of the room, equidistant between the left and right front and, and also maintained at the same vector distance as the independent speaker it is controlled by.

Mirror symmetry

Mirror symmetry is an effective means of relating independent and dependent loudspeakers. If you are unfamiliar with this concept, place your left and right hand on a flat surface. The right hand is the mirror image of the left about the line (or plane perpendicular to the flat surface) separating the two. In a similar way the right speaker and left speaker are mirror images of each other about the vertical plane passing through the center of the room. Thus, two parameters need to be specified: the direction which is affected by the mirror symmetry and the plane or mirror which is being used. The distance is determined by selecting the appropriate check box and the mirror is determined by the listener or room center radio button. In our stereo example, you would select the y check box for the right dependent loudspeaker and the room center radio button. If the listener is located off the room centerline, then select Mirror about: Listener (default setting), so the Y-Mirror follows the listener.



You would select the listener as the mirror symmetry plane when describing dependent rear loudspeakers. For example, in the emerging multi-channel music 5.1 room configuration that uses 5 matching loudspeakers, you can constrain the left rear speakers to be a mirror image of the left front about the

x plane passing through the listener. The right rear can be constrained by two mirror planes: one x plane about the listener and another about the y room center. Then, as the left front speaker is varied, the left rear and right rear will move with the appropriate symmetry relationships to the independent front left speaker.

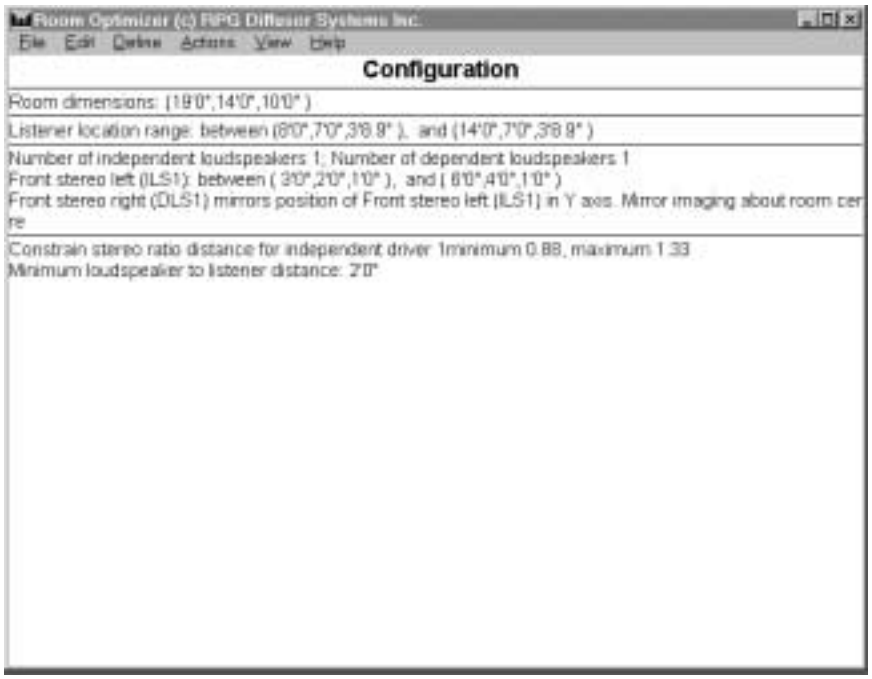
Center front loudspeaker

The use of a center loudspeaker is gaining popularity in home theater configurations, because this allows multiple listeners to hear the dialog from the center of the screen as opposed to a movable phantom center image. Room Optimizer™ allows you to choose this center loudspeaker as an independent loudspeaker or a dependent Center Front Loudspeaker. When you choose the Center Front Loudspeaker check box, you insure that the left/center/right front loudspeakers lie on a circle with the listener at the center. This choice makes the arrival times from all front loudspeakers equal.

You can now go **Back** to a previous screen, go to the **Next** dependent speaker or **Cancel** the editing session.

Configuration

After all dependent loudspeakers are edited you will be presented with the Configuration screen from which you can examine all of the changes that were made. At this point you may wish to go to the **Actions** menu and **Start** the optimization using this new configuration. You can also go to the **File** menu and **Save configuration** for future use. You will be prompted to save the configuration filename in a standard Windows 95™ dialog box.



The new configuration won't run

If the configuration is defined so that there are no possible starting points for the optimization, the program will inform you of this via the message "The optimization routine has failed to find any suitable starting points"?. Errors may be generated either during data entry or the optimization process. A couple of common causes of such problems are:

The displacement of a dependent loudspeaker from an independent loudspeaker puts the dependent loudspeaker out of the room.

The stereo constraints, which put limits on the angle subtended by the loudspeakers at the listener, can not be obeyed within the defined listener and loudspeaker volumes. More details on setting the stereo constraints is given in the Advanced Options section. Also please see the FAQ section on page 43.

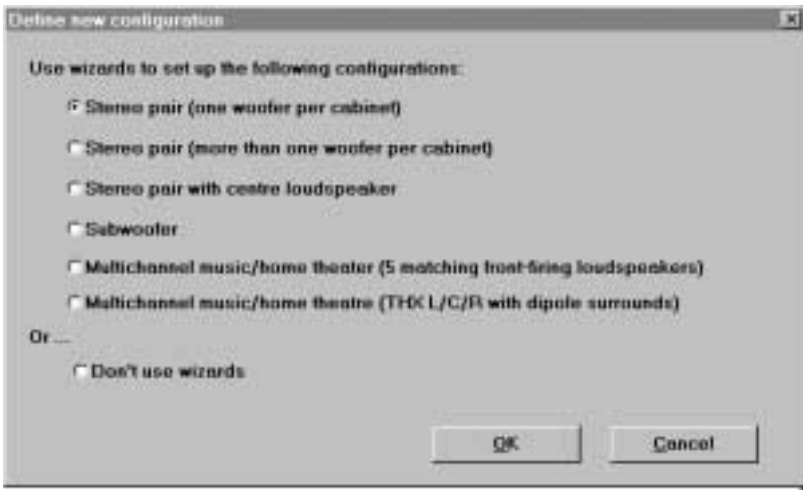
5 Define Menu

You have three ways to obtain a desired room configuration. You can Load a previously defined configuration from the **File** menu and edit it if necessary, you can choose a pre-defined Wizard configuration and edit if necessary or define a completely new room configuration. To define a new room configuration, you use the **Define** menu.

Define

New configuration

Under the **Define** menu, the **New configuration** option allows you to define a new room configuration. The new room configuration can be determined from a set of pre-defined room wizards or experienced users can choose to define the new room without the help of the pre-defined wizards.

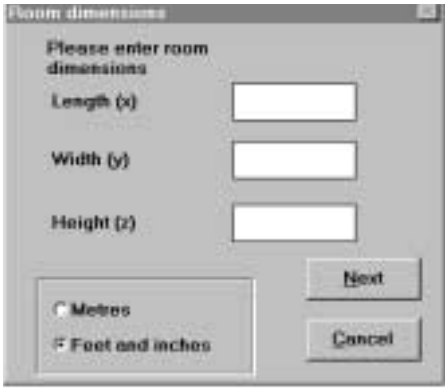


Pre-designed Wizards allow you to quickly define a new room configuration.

Use Wizards

You will be warned that the existing room configuration will be lost. It is suggested that new users select an appropriate wizard radio button, which best fits the desired room configuration. The new room configuration is entered via a series of dialog boxes that prompt you for the necessary input.

The first screen requests the room dimensions. Following this, in all cases except the stereo with multiple woofers, you will see the Wizard Information screen. You can review this screen to determine if this is the room configuration you want to optimize. If so you can **Start** the optimization from the



Actions menu. If not, you can **Edit** the **Whole configuration**. In the case of the multiple woofer Wizard you will also be prompted for the number of woofers in each cabinet and the displacement between their centers. In the case of the subwoofer Wizard, you will be prompted for the desired frequency range of the optimization. Remember, the origin of the room and the location from which all distances are measured, is in the front lower left corner. The arrows in the **Room** view reflect this.

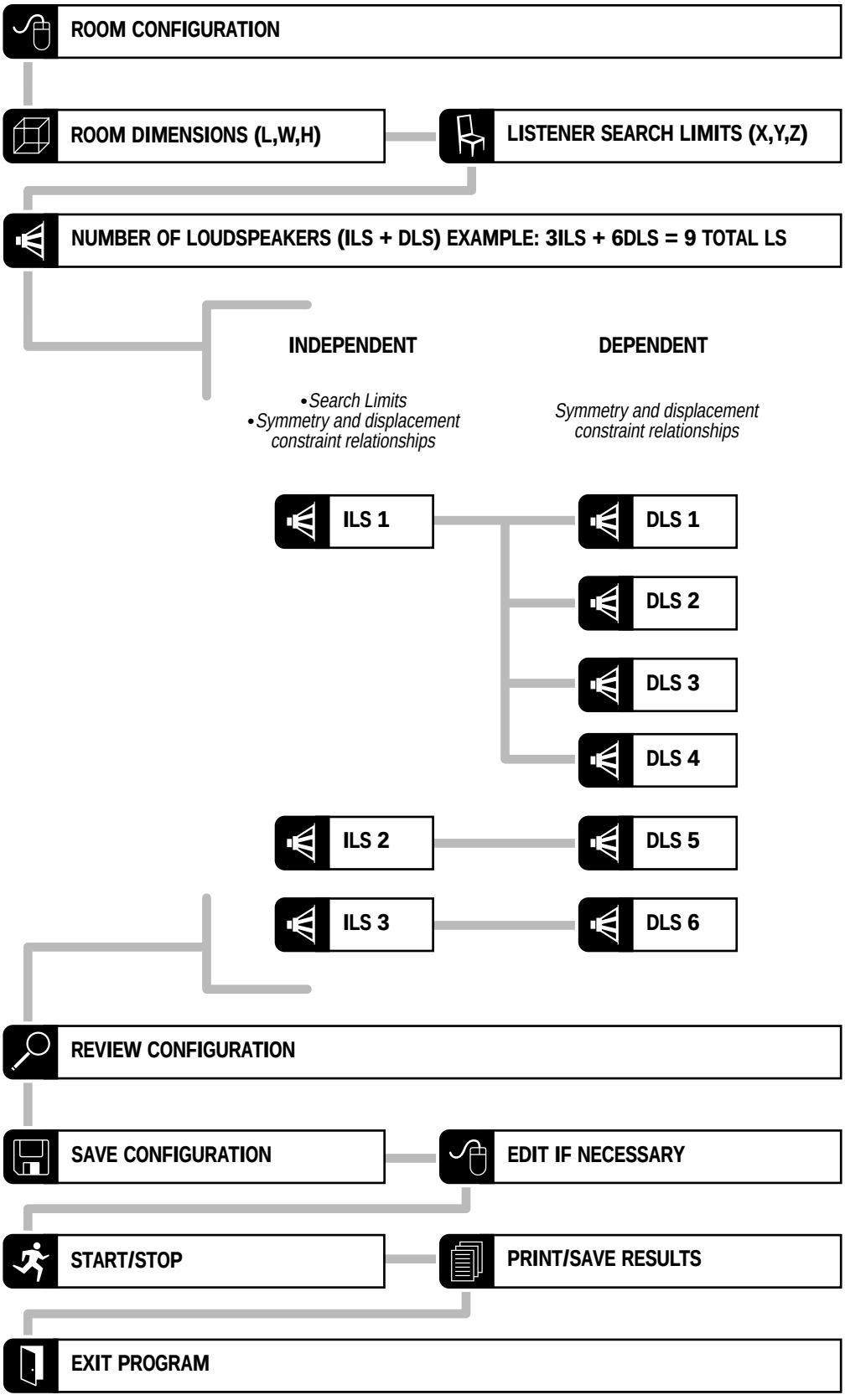
Define a new room configuration not provided by a Wizard or a previously saved configuration. Up to 20 woofers can be optimized. The more woofers , the longer the optimization time.

Don't Use Wizards

Essentially the program will prompt you for input with all of the same screens you have already experienced in the **Whole configuration**. The flow chart on page 31 illustrates the steps necessary to define a new room configuration from the **Define ▶ New configuration** menu. You will be prompted to enter the room dimensions, the listener search limits, the number of independent (ILS) and dependent loudspeakers (DLS), the ILS search limits and symmetry/displacement relationships, and the DLS symmetry/displacement relationships. At this point you can review the room configuration, **Edit** if necessary, and **Save** the room configuration for future use. You can then run the optimization, **Print** and **Exit** the program if you have the answer you were looking for.

The most efficient way to design a new room configuration is to fill out the Room Optimizer Worksheet. You will find a blank Worksheet in the Examples section of this manual. Please make as many photocopies as you wish and place them in the Examples section for future use. This manual is designed as a Workbook, so you can conveniently add 8 ½" x 11" inserts of Worksheets, RoomOptimizer™ printouts, downloaded website updates, white papers, etc.

To describe how to design a new room configuration, we will use a surround sound example. The loudspeaker configuration consists of front left and right loudspeakers each containing two vertically displaced woofers separated by 13.5", a center channel woofer, two dipole surrounds mounted on the side


ROOM CONFIGURATION
ROOM DIMENSIONS (L,W,H)
LISTENER SEARCH LIMITS (X,Y,Z)
NUMBER OF LOUDSPEAKERS (ILS + DLS) EXAMPLE: 3ILS + 6DLS = 9 TOTAL LS
INDEPENDENT
DEPENDENT
•Search Limits
•Symmetry and displacement constraint relationships
Symmetry and displacement constraint relationships
ILS 1
DLS 1
DLS 2
DLS 3
DLS 4
ILS 2
DLS 5
ILS 3
DLS 6
REVIEW CONFIGURATION
SAVE CONFIGURATION
EDIT IF NECESSARY
START/STOP
PRINT/SAVE RESULTS
EXIT PROGRAM

PROJECT: *My room* **DATE:** *1/1/2000*

COMMENTS:

ROOM DIMENSIONS	LENGTH: *19'*	WIDTH: *14'*	HEIGHT: *10'*
LISTENER SEARCH LIMITS	X MIN: *8.5'* X MAX: *13'*	Y MIN: *7'* Y MAX: *7'*	Z MIN: *42"* Z MAX: *42"*

Variables	*Independent*		*Search limits*			*Dependent*	
WOOFERS	ILS	CONSTRAINTS	X MIN - X MAX	Y MIN - Y MAX	Z MIN - Z MAX	DLS	CONSTRAINTS
LLF	*1*		*2'-6'*	*1.5'-3.5'*	*15"*		
ULF						*1*	*Z= +13.5"*
LRF						*2*	*Y-Mirror*
URF						*3*	*Y-Mirror + Z= 13.5"*
C		*Center Channel*				*4*	*Z= +35"*
DLS	*2*	*Listener X*	*Listener*	*4"*	*6.5'-8'*		
DRS						*5*	*Y-Mirror*
RLS	*3*		*15'-17'*	*1.5'-4'*	*3'-6'*		
RRS						*6*	*Y-Mirror*

walls opposite the listener's position and left and right dynamic surround rear loudspeakers.

We have filled in the Project Name (My Room), Date (1/1/2000) and Room Dimensions (Length = 19', Width = 14' and Height = 10'). Remember, all dimensions are measured from the front, left, lower corner. X is the distance from the front wall, Y is the distance from the left wall and Z is the height above the floor.

Listener

The only information you need to enter for the listener is the Listener Search Limits: xmin-xmax, ymin-ymax, zmin-zmax. These define the rectangular volume within which you will search to find the optimum location for the listener's ears. In most cases, you will place the listener on the room's centerline, where the y coordinate equals half the room's width. When you enter the same number for ymin and ymax, you are indicating to the RoomOptimizer™ that this position should be fixed and not optimized. On the Worksheet we entered xmin-xmax = 8.5 - 14', ymin-ymax = 7' and zmin-zmax = 42". Thus the middle of the listener's head is fixed on the room centerline at y= 7' and at a seated height above the floor of 42". Room Optimizer™ will search for the best distance from the front wall between 8.5' and 14'.

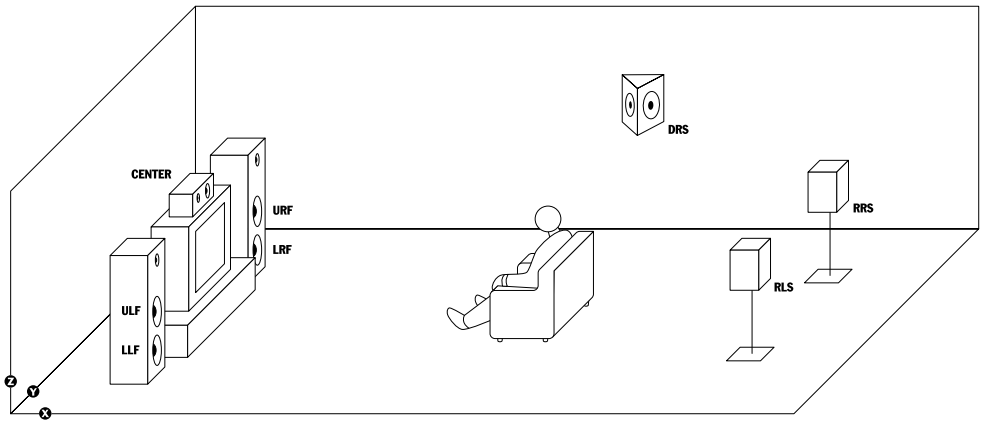
Woofers

We begin by simply naming all of the woofers. The lower and upper woofers in the left front loudspeaker (LLF) and (ULF), the two woofers on the right side of the room's centerline, i.e. the lower right front (LRF) and the upper right front (URF), the center loudspeaker (C) sitting on the rear projection monitor, the left and right dipole surrounds (DSL) and (DSR) and finally the left and right front-firing dynamic rear surrounds (RSL) and (RSR). For the sake of this example, let's assume that between 80 and 300 Hz the two dipoles mounted against the wall act as a hemispherical point source so we can treat them as one. We have listed a total of 9 woofers, which we will distribute into independently varying loudspeakers (ILS) and dependently varying loudspeakers (DLS).

Independent loudspeaker 1- ILS1 (LLF)

Consider the relationships between the left, center and right front woofers. If we identify the position of the LLF woofer, we can immediately identify the positions of the remaining 4 woofers. The ULF is 13.5" above the LLF. The LRF is a mirror image of the LLF about a y mirror located on the room's

centerline at half the width. The URF is located by a mirror of the LLF about the room's centerline and a vertical displacement of 13.5" in z. The center loudspeaker (C) will also be controlled by ILS1 as well, by constraining the center loudspeaker-listener distance to be equal to the LLF-listener distance.



This insures that the arrival time between the left, center and right speakers will be equal.

Now lets number the ILSs and the DLSs. We can define the LLF as the first independent loudspeaker. The other 4 front drivers can be determined from this. Thus the LLF is ILS1 and the other four front woofers are DLS1, DLS2, DLS3 and DLS4. Enter a 1 in the Worksheet in the ILS column next to LLF and 1, 2, 3 and 4 under DLS in the ULF, LRF, URF and C rows, respectively. Notice that the ILS and DLS numbering is independent and runs from 1 to the number of independent and dependent speakers. The total number of woofers is simply the sum of the number of independent and dependent woofers. To review, dependent loudspeakers DLS1, DLS2, DLS3 and DLS4 are related to independent loudspeaker ILS1.

ILS1 (LLF) Constraint

Since the front left and right speakers will be floor standing, the height of the front 4 woofers will be fixed in Z. The LLF woofer is fixed at 15" above the floor and therefore, zmin and zmax will be set at 15".

ILS1 (LLF) Search limits

The LLF woofer will be allowed to vary between 2' and 6' from the front wall, 1.5 - 3.5' from the left wall and is fixed at a height of 15" above the floor.

Independent Loudspeaker 2- ILS2 (DSL)

If we locate the dipole surround left (DSL) we can also determine the dipole

surround right (DSR) by a y mirror image about the room's centerline. Thus DSL is ILS2 and the DSR is DLS5.

ILS2 (DSL) Constraint

The x coordinate of ILS2 will be constrained to the x coordinate of the listener, so that the listener can be positioned in the null of the dipole directivity pattern. This is an example of a dynamic constraint. As the listener's x coordinate moves though the Listener Search Limits, the x coordinate of the DSL will follow.

ILS2 (DSL) Search Limits

ILS2 will be constrained in x to the listener and also attached directly to the wall so that the center of the woofer array is about 4" from the wall. The height above the floor will be allowed to vary between 6.5' (to clear the head of people walking by) and 8'.

Independent Loudspeaker 3- ILS3 (RLS)

In the rear of the room we will optimize the location of the rear surrounds. If we locate the RLS we can determine the position of the right rear surround (RRS) by a y mirror about the room's centerline. Thus (RRS) will be DLS6.

ILS3 (RLS) Constraint

The x search range will begin beyond the maximum listener search limit, so the side dipoles and rear surrounds do not get too close. This can be modified in a subsequent optimization, once you gain an idea of where the optimum listener position is located.

ILS3 (RLS) Search Limits

Since the rear surrounds can be mounted on stands, we will search in z as well as x and y. The z coordinate can be used to determine the most appropriate height of the stand for good low frequency response.

Dependent loudspeakers are related to the independent loudspeakers by symmetry and displacement constraints..

DEPENDENT LOUDSPEAKERS

The dependent loudspeakers aare related to the independent loudspeakers by symmetry and displacement constraints.

DLS1 (ULF)- The upper front left woofer (ULF) is related to the ILS1 (LLF) woofer by a vertical displacement or translation of 13.5".

DLS2 (LRF)- The lower right front loudspeaker (LRF) is related to ILS1 (LLF) by a y mirror image about the room's centerline.

DLS3 (URF)- The upper right front loudspeaker (URF) is related to ILS1 (LLF) by a y mirror image about the room's centerline and a vertical translation of 13.5".

DLS4 (C)- The center woofer (C) is related to the ILS1 (LLF) by the center loudspeaker constraint, which maintains equal distances between the listener and the left/center/right front loudspeakers. In this example the center loudspeaker will be placed on top of a rear projection monitor, so its height will be fixed. To place the center woofer 50" above the finished floor, we introduce a 35" z translation above the 15" height of the LLF woofer along with the center loudspeaker constraint.

DLS5 (DSR)- The dipole surround right (DSR) is related to ILS2 (DSL) by a y mirror image about the room's centerline.

DLS6 (RRS)- The rear dynamic surrounds (RRS) is related to ILS3 (RLS) by a y mirror image about the room's centerline.

Now that we have the Worksheet filled out, we can transfer the data into the RoomOptimizer™. Select **Define ▶ New configuration** from the menu bar. You will be prompted that the "Existing room configuration will be lost". Select OK to continue. You will see the "Define new configuration" screen with a list of Wizards and the Don't use Wizards option. Select the Don't use Wizards radio button and hit OK. You will be prompted for the room dimensions. Enter them in feet and inches (default) or meters. Use the tab key to advance to the next entry box. After you have entered the x, y and z room dimensions, hit NEXT to advance to the Listener limits screen or CANCEL the room configuration definition. The minimum and maximum x, y and z boxes refer to the xmin-xmax, ymin-ymax, and zmin-zmax entries on the Worksheet. Transfer the information using the Tab key to advance to the next entry box. If you enter a number without feet (') or inches (") unit markers, the numbers will be interpreted as feet. If you enter a compound dimension, such as 8' 6", you need to enter the ' and " units. If you enter just inches, such as 15", you must enter the " units or the program will interpret the number as feet. When you are finished you can go BACK to correct a previous error, go to the NEXT screen or CANCEL the room configuration definition.

The next screen prompts for the number of independent drivers (ILS) and dependent drivers (DLS). Count the number of ILS and DLS from the Worksheet and enter the respective totals into the appropriate boxes. You can

then go BACK, advance to the NEXT screen or CANCEL the room configuration definition. The next screen prompts input for the independent driver search limits. These are the xmin-xmax, ymin-ymax and zmin-zmax limits you entered on the Worksheet for the ILSs. At the top RoomOptimizer™ will indicate the specific independent driver, e.g. ILS1, ILS2, ILS3, etc. You can Name the driver with a convenient user-defined name or choose from the pull down menu. Enter the name LLF assigned to ILS1 in the Worksheet. We will not need to constrain ILS1 to any listener x, y or z coordinate. For ILS1 enter 2' for the minimum and 6' for the maximum x search limits, 1.5' and 3.5' for the minimum and maximum y coordinate search limits and 15" for the minimum and maximum z coordinate. By selecting NEXT you will be prompted for the Search limits for ILS2. You can enter DLS for the name of ILS2 using the Name pull down menu. Then transfer the search limits from the Worksheet into the appropriate boxes. The x coordinate will be constrained to the listener's x coordinate by checking the minimum and maximum x boxes under "Constrain to Listener". The y coordinate will be fixed at 4" by entering 4" as the minimum and maximum value, and the minimum and maximum z value should be entered as 6.5' and 8', respectively. Select NEXT to advance to the entry screen for ILS3. Enter the name RLS in the Name pull down menu. The x search limits will be between 15' and 17', so as not to interfere with the side dipoles. The y coordinate will vary between 1.5' and 4'. The z coordinate will vary between 3' and 6', so we can determine an appropriate stand height.

Select NEXT to advance to the Dependent drive position (DLS) entry screens. This is where the Worksheet will be especially helpful. You will have to relate the appropriate DLS numbers with the appropriate ILS numbers. For example, DLS1, DLS2, DLS3 and DLS4 are controlled by ILS1, DLS5 is controlled by ILS2, and DLS6 is controlled by ILS3. First name the DLS1 as ULF in the Name pull-down menu. Then enter a "1" in the box next to the prompt "Dependent driver controlled by position of independent driver number". This means that DLS1 is controlled by ILS1. Enter 13.5" for the z coordinate in the Displaced by: sub-entry box. Since DLS1 is not 180 degrees out-of-phase with respect to ILS1 do not check this box. Check the NEXT button to advance to the entry screen for DLS2. Enter LRF for the Name and enter "1" next to the prompt for the ILS which controls DLS2. DLS2 is obtained from ILS1 by a y mirror about the room center. Select Mirror image in: Y-axis box and room center radio button. If you enter zero or a larger number than the number of ILS entered earlier, you will get an error "Cannot identify independent loudspeaker". Select NEXT for the entry screen for DLS3. Enter the Name URF

and enter "1" for ILS1 as the controlling independent loudspeaker. Select the Mirror image in: Y-axis, room center radio button and also enter 13.5" for the z displacement in Displaced by: Select NEXT to enter information for DLS4. Name this driver C and enter "1" for the controlling ILS. Now select Center Front Loudspeaker box to indicate that this center channel and the LLF will be equidistant from the listener . Select NEXT to advance to DLS5. Enter the Name DSR and enter "2" as the controlling ILS. Select Mirror image in: Y-axis box. Select NEXT to advance to the last dependent loudspeaker screen DLS6. Enter RRS as the Name and select the Y-axis box in Mirror image in:

The next screen will display the Configuration for review. Look it over to verify the data entries. If there is an error, select **Edit ▶ Whole configuration** and advance through the screens in order making appropriate corrections. Once the corrections are made, you can select **Actions ▶ Start** to begin the optimization.

Define
Advanced
Error parameter calculation

This option allows the relative importance of the SBIR and Modal Response to be varied. Increasing the percentage error due to the SBIR will mean the optimization will take more notice of how flat the SBIR is when it tries to find the best positions in the room.

Define
Advanced
Frequency range

The **Frequency range** of the optimization can be varied. This might be useful if a sub-woofer system is being optimized. This should be run as a separate optimization from the left/center/right speakers which cover a different frequency range.

Define
Advanced
Number of solutions

The **Number of solutions** can be varied. With any multi-dimensional optimization procedure every solution given by the program may not be the global minimum - the best possible positions in the room. By carrying out more trials it is more likely that the global minimum will be found. In our experience, Room Optimizer™ tends to find several solutions that are equal-

It is recommended that the option to confirm solutions is used unless time is a premium.

ly good and have similar error parameters. By asking for more solutions you may get a larger number of good positions to choose from, but it takes longer to optimize. If you check the **Confirm each solution** box, you will get twice the number of solutions selected, because each solution is confirmed by re-optimizing from locations close to the solution.

It is suggested that the extreme starting positions menu item is checked.

Define
Advanced
Extreme starting positions

When this menu item is checked, it forces the starting loudspeaker and listener points to be near to the edge of the volumes which define possible loudspeaker and listener position. This helps the optimization program to carry out a thorough search of all possible positions.

It is suggested that the repeatable starting positions menu item is unchecked.

Define
Advanced
Repeatable starting positions

Every time a particular configuration is tried, the starting points for the optimization are chosen at random. In the case where there are a variety of good positions in the room, this may mean that the optimization solutions will be different each time the program is run. It is possible to ask for **Repeatable starting positions** by checking this menu item.

Define
Advanced
Simplex termination criteria

The **Simplex termination criteria** sets the criteria that the optimization routine uses to determine when a solution is found.

Define
Advanced
Stereo constraints

The **Stereo constraints** has two options. It enables:

1. the minimum distance between the listener and any loudspeaker to be set.

2. the setting of the angle subtended by the loudspeakers at the listener to ensure proper stereo imaging. The stereo constraints are in terms of the ratio of the distance from the listener to the center line between the loudspeakers and the separation of the loudspeakers. This option can only be applied to independent loudspeaker 1.

Define

Advanced

Frequency based Modal calculations

In a rectangular room the spectra can be calculated via the impulse response or an exact frequency overlap modal calculation. For perfectly reflective room boundaries the two approaches are equivalent as described in the accompanying White Paper in the Appendix. This option allows the optimization to use the frequency based calculation. This option is not recommended, unless you have a sufficiently fast processor, as it is much slower than the impulse response approach. The frequency based approach can also be used to calculate the modal response of a room configuration by inserting room dimensions and fixed locations for listener and loudspeakers.

6 File Menu

File

Save results (CTRL + S)

The program enables the results from the optimization to be saved to a comma delimited text file. This text file can be imported into most spread sheets for publication quality spectra plots and further analysis. In Microsoft Excel, for example, open the saved file and choose “delimited” as the Original data type. Then select “comma” delimited. The data are then available for plotting and analysis.

The saved file includes the following information:

The configuration for the optimization

And for each solution:

The best and worst error parameter values

The SBIR and ‘Modal” response for the best and worst positions

And for the best position:

The co-ordinates of the listener and loudspeakers

The locations of the geometric reflection points.

The **Save results** option can be selected before the optimization is started or after it has ended. Before beginning the optimization you are presented with a Save all results and configuration dialog box and an option to Save Results? and Set Filename. After an optimization comes to a natural or user-terminated completion the **Save results** dialog box offers you the choice to save results from the previous terminated run or the next run that will be initiated.

Making a screen capture

In addition to the **Save results** feature which allows you to prepare publication quality graphics, you may wish to include screen views as illustrations in report documents or proposals.

Windows 95™ allows you to capture the active screen and place it on the clipboard. This image can be pasted into the Windows Paint program or other image editing software to create bitmap images. You can also use dedicated screen capture utilities which allow you to save the images in various file formats. As a suggestion, our experience indicates that *.tif works well for images and *.eps works best with professional Postscript publishing pro-

grams such as Quark Express or Pagemaker.

To capture a color screen view to the clipboard, make sure the window you want is active, hold down the Alt key and press the Print Screen (PrtScrn) key. The image is pasted onto the clipboard, although you will not be given any indication of this. To paste the image into Windows Paint program, open the program from the Windows Accessories folder and Paste the image from the edit menu. To save the entire image as a new *.bmp file, select Copy To from the edit menu, and choose a destination filename.

Dark color screens may prove a problem when the images are included into documents and printed in black and white. Therefore, you may wish to select **Black on white** as the **Display** color from the **Edit ▶ Preferences** menu prior to hitting Alt + PrntScrn.

File
Load configuration

You can load pre-defined configurations, from the **File** menu. The load configuration dialog box prompts you for the “filename.roi”.

File
Save configuration As

Any configuration that you set up in the RoomOptimizer™ can be saved using the **Save configuration As** option of the **File** menu. The **Save configuration As** filename prompts you for the file name. You can use this option to save different room configurations, consisting of different dimensions, different loudspeakers, different listener and loudspeaker search limits, and different displacement and mirror symmetry conditions.

File
Print (CTRL + P)

You can print any or all of the seven **View** screens from the **Print** option. From the Print Screens dialog box you can choose the print font, the print color, the screens desired, and a check box which only prints the best solution information on the room and spectra view.

File
Printer Setup

The **Printer Setup** dialog box allows you to choose the desired printer.

File

Exit (ALT + F4)

The **Exit** sub-menu allows you to exit the program. Alternatively you can use the close window cross in the top right corner of the window. If your results have not been saved, you will be prompted with an Exiting program dialog box.

7 Workbook

We begin the Workbook section with some example room configurations for you to experiment with and a blank RoomOptimizer™ Worksheet for you to photocopy. On your RoomOptimizer™ program disc there are also some sample configuration initialization files (*.roi) that you can load from the file menu and run. When you create a new room configuration it will be useful if you file the Wooksheet here and save the configuration for future use.

	ILS#	ILS NAME	CONSTRAINTS	DLS#	DLS NAME	CONSTRAINTS
STEREO	1	Left	None	1	Right	Y Mirror about room center
STEREO *with 2 woofers.*	1	Lower left	None	1	Upper left	Z Displacement
				2	Lower right	Y Mirror
				3	Upper right	Y Mirror + Z Displacement
STEREO *with 4 woofers per loudspeaker: 2 in front baffle and 2 in rear.*	1	Lower left front baffle	None	1	Upper left front baffle	Z Displacement
				2	Lower left rear baffle	X Displacement + or - polarity
				3	Upper left rear baffle	X and Z Displacement + or - polarity
				4	Lower right front baffle	Y Mirror about room center
				5	Upper right front baffle	Y Mirror plus Z Displacement
				6	Lower right rear baffle	Y mirror plus X Displacement
				7	Upper right rear baffle	Y mirror plus X and Z Displacement
STEREO *with 1 woofer plus center loudspeaker.*	1	Left	None	1	Right	Y Mirror about room center
				2	Center	Equal left front listener distance
5.1 THX *with dipole surround.*	1	Left front	None	1	Right front	Y Mirror about room center
				2	Center front	Equal left front listener distance
	2	Left dipole rear	Constrained to listener X	3	Right rear	Y Mirror about room center
5.1 THX *with 2 vertically displaced front woofers, 2 horizontally displaced center speaker woofers and dipole surrounds.*	1	Lower left front	Z height fixed	1	Upper left front	Z Displacement
				2	Lower right front	Y Mirror
				3	Upper right front	Y Mirror plus Z Displacement
	2	Center left	Z Displacement from lower left	4	Center right	Y Mirror about room center
	3	Left dipole rear	Constrained to listener X	5	Right dipole rear	Y Mirror about room center
5.1 *multichannel music with 5 matching speakers*	1	Left front	None	1	Right front	Y Mirror about room center
				2	Center front	Equal left front listener distance
				3	Left rear	X Mirror about listener
				4	Right rear	X and Y Mirror about listener
5.1 *multichannel music with 5 matching speakers*	1	Left front	None	1	Right front	Y Mirror about room center
				2	Center front	Equal left front listener distance
	2	Left rear	X Limit starts at listener max X	3	Right rear	Y Mirror about room center

PROJECT: **DATE:**

COMMENTS:

ROOM DIMENSIONS	LENGTH:	WIDTH:	HEIGHT:
LISTENER SEARCH LIMITS	X MIN: X MAX:	Y MIN: Y MAX:	Z MIN: Z MAX:

Variables	*Independent*		*Search limits*			*Dependent*	
WOOFERS	ILS	CONSTRAINTS	X MIN - X MAX	Y MIN - Y MAX	Z MIN - Z MAX	DLS	CONSTRAINTS

8 Appendix

Frequently Asked Questions

Q. Why does the listener/woofer optimize at one of the search limits?
A. If the listener or woofer positions are optimized at the extreme positions of the search range, then you may wish to increase this range and repeat the optimization. RoomOptimizer™ is attempting to locate the listener/woofer outside its allowed range.

Q. What point of the woofer do I use to measure from?
A. The answer is the acoustic center, which is that imaginary point from which all sound originates. In practical terms, the center of the woofer can be used to determine the height above the floor and the distance from the left wall. The distance from the front wall is less obvious. The acoustic center of a woofer varies with the woofer. As a rule of thumb, however, measure to the face of the dust cap (the dome at the bottom of the woofer cone).

Q. Do you have a Macintosh version?
A. Sorry, we do not.

Q. Will there be future upgrades?
A. Yes. RPG intends to continue the development of RoomOptimizer™ to include several new features: rectangular room dimension optimization, multiple listening positions, non-rectangular room shape, etc.

Q. If I repeat an optimization using the same room configuration I do not get the same answer.
A. In a multi-dimensional optimization there are many good answers. Each answer is valid. You can select among several solutions by either choosing the lowest error or the most ergonomically desirable configuration.

Q. How do I interpret the error message “A dependent loudspeaker moved too close to the listener or a room boundary”?
A. This error may arise when a center loudspeaker is constrained to be at an equal distance from the listener as the left/right speakers. The center loudspeaker may be closer to the front wall than the left/right independent speaker, thus triggering the error. The solution is to increase the minimum X limit

for the independent speaker, which in turn moves the center loudspeaker away from the front wall.

Q. How do I interpret the error message “The optimization routine has failed to find any suitable starting points”?
A. The program uses a stereo angular constraint to insure that the listener is located at an appropriate distance from the loudspeakers for good stereo imaging. The listener search range is forcing the listener outside these limits. The solution is to change the listener limits or disable the stereo angular constraint (Define/Advanced/Stereo Constraints).

Q. Why am I experiencing problems printing in color?
A. Problems with printing in color are usually due to the way in which the Win95 API interprets the colors on the screen. The dark background is interpreted as white, white line do not show up, and yellow lines are very faint. A simple solution is to reverse the color scheme. Set the background to be a light color and the text and lines to be dark colors. Don't forget to save preferences so the color scheme reappears when the program reloads.

Q. Can I resize the program window during optimization?
A. Resizing issues are dealt internally by Win 95. We have experienced some lockup during resizing, so we suggest resizing before beginning optimization.

Please send in your questions to info@rpginc.com or fax to 301-249-3912 and we will add them to this list. You will also be able to consult www.rpginc.com for a listing of FAQ by other users and download new room configurations.

Troubleshooting

If you encounter problems when operating the program, it helps in tracking down the cause if the following information is given:

1. Brief details of the computer the program is being run on,
2. A description of the problem,
3. The configuration file for the optimization causing problems (if applicable),
4. A sample of the saved output file.

Send inquiries to info@rpginc.com or fax to 301-249-3912