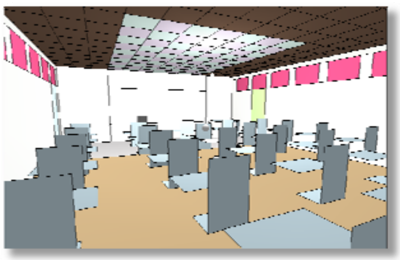
CARI, LLC Workshops, Seminars and GoToMeetings:
Each presentation is roughly 30 minutes.

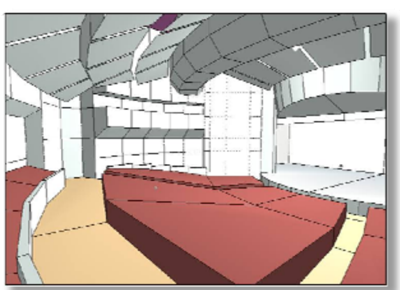
Workshop Topics: Applications

Optimizing the signal to noise ratio in speech rooms using passive acoustics: Better core learning environment design



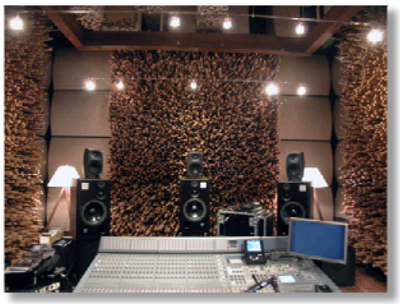
Adults with normal hearing require roughly 0 dB signal-to-noise ratio for good speech intelligibility in classrooms and lecture halls. However, significantly higher values may be needed to compensate for neurological immaturity, sensorineural and conductive hearing losses, language proficiency and excessive reverberation. ANSI 12.60 addresses ways to lower the noise interference due to background levels and reverberation time. However, it is also possible to increase the signal, by reflecting or diffusing early reflection. While speech power is delivered in the vowels which are predominately in the 250-500 Hz frequency range, speech intelligibility is delivered in the consonants, which occur in the 2– 4 kHz frequency range. Therefore, effective core learning designs can incorporate scattering surfaces, rather than surfaces that absorb in the 2 – 4 kHz region, on the front wall, lower side walls and central ceiling areas, to increase the speech signal. The decay time can be controlled with broadband absorption on the perimeter of the ceiling and upper wall surfaces. A computer model analysis of various speech environments will be presented.

Music Room Design



Dedicated or multipurpose rooms are an important part of schools, performance and rehearsal spaces, etc. This session focuses on the acoustical design of these spaces along with a description of the RPG® products that can be used to enhance their acoustical performance. Computer models will be presented to illustrate the improvement in selected objective measures these designs and products offer. Wall treatment options will be presents and the advantages and disadvantages of ceiling cloud versus deck diffusion will be discussed. A proposed design for music rehearsal spaces providing appropriate reverberance, support and ensemble will be presented. In addition, a design for individual music practice rooms, which prevent excessive loudness, harshness and flutter, as well as good support to assist with intonation, tone production and technique will also be presented. Several installations using RPG products will be presented as examples of the design approaches suggested.

From Mono to Surround: A review of critical listening room design and a new immersive surround design proposal



As our critical listening rooms have evolved from mono to stereo to an ill fated attempt at Quad to full surround, many approaches have been taken in the design of these spaces. This presentation will review significant milestones in this evolution including the early compression ceilings, reflective front-absorptive rear, absorptive front-absorptive rear non-environment, absorptive front-diffusive rear, spatio-temporal reflection free zone front-diffusive rear and reflection rich zone in front-diffusive rear. Recently there has been a renaissance in the evaluation of the importance of specular and diffuse reflections in auditory perception. The presentation will conclude with a proposal for a new immersive surround environment, which can be described as an ambient anechoic or ambechoic environment. Fully enveloping diffuse room reflections are 30 dB below the direct sound, as in an anechoic environment, yet the room feels ambient, provides precise localization and offers a creative work environment for recording and monitoring. An example of a proof of concept room will be illustrated and described.

Worship Space Design

The modern day worship space encompasses a myriad of designs from the intimate meeting houses to the evangelical mega churches. In addition, each denomination has special acoustical requirements. In some sense the worship space is the most difficult space to design because it must provide high speech intelligibility and also good sound reproduction for both acoustic and reinforced sound, as well as providing good ensemble for congregational response and singing as well as ensemble for performance musicians. This session deals with the various acoustical issues in worship space design and offers some suggestions using RPG® products.

Modern School Acoustics

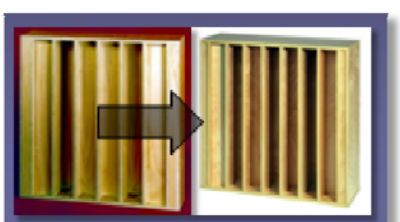
The modern school represents a microcosm of all of RPG's markets. The school whether primary, secondary or university may include core learning environments, sports facilities, an auditorium, a swimming pool, a library, rehearsal spaces for band and choir, offices, common areas, meeting rooms and a physical plant. This session explores the acoustical needs of all of these spaces and offers design as well as product suggestions to improve their performance. The session will consist of three parts. Part 1 reviews the problems with current learning environments and suggests general solutions as well as a review of LEED for Schools V3. Part 2 deals with the absorptive and diffusive acoustic tools options that can be used to design better learning environments and Part 3 systematically explores the problems and solutions in all of the various spaces with examples of successful installations.

Sports Floors

This session will discuss a solution to isolating the airborne impact noise in sport and fitness facilities. This problem can be compounded when the facility is above a commercial business, with a floor having a low resonant frequency of its own. We will discuss how to avoid exciting this floor resonance, while offering a low system resonance typically roughly 2-3 times higher than the floor resonance and 3 or more times lower than the lowest disturbance frequency, which offers a high isolation efficiency using the DPM™ system. To determine the frequency bandwidth of the associated disturbance, an experimental study will be discussed in which an accelerometer, located a half meter away from a dribbling basketball, measured the vibrational spectrum and a real time analyzer measured the spectrum of the transmitted airborne sound in a space directly below the sports floor. A solution using DPM elastomers on sleepers to lower the air stiffness will be presented.

Workshop Topics: Product Systems

Modffusor™: The Evolution of the QRD®

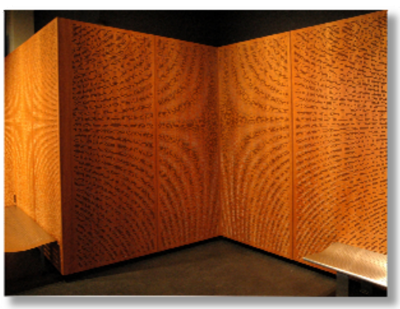


In this session we review how Shape Optimization and Aperiodic Modulation have resulted in the current evolution of the number theoretic QRD® into the Modulated Optimized Diffusor or Modffusor™. As effective as the venerable QRD has been, it contains three limitations, namely limited bandwidth, quantized well depths leading to specular reflection at selected frequencies and periodic grating lobes, which compromise uniformity. This session will describe how the use of Shape Optimization and Aperiodic Modulation minimize the quantized well flat plate scattering and periodic grating lobes for significantly higher performance. As with the QRD, the bandwidth can be significantly expanded using the patented concept of a diffusing fractal, using nested, scaled elements, forming a Modffractal. Proof of performance data will be presented to support the significant performance improvement of the Modffusor™.

Waveform™: Curve optimized diffusive shapes

In the early 1980s, RPG introduced the first commercial sound diffusors in the form of number theoretic surfaces whose form followed their function. These reflection phase gratings have had a profound influence in architectural acoustic design. To some they are aesthetically attractive to others they offer too strong of a visual impact. Therefore, RPG developed two new technologies, namely shape optimization software and aperiodic modulation technology that have allowed the development of curvilinear, attractive shapes which complement contemporary architecture in the way that statuary and relief ornamentation complemented classic architecture. This session explores the new design methodologies and discusses the new product range, called Waveform that is now available. In addition to standard shapes, RPG also offers the capability of evaluating and improving if necessary, shapes proposed by an architect or acoustician, and also experimentally evaluating these custom shapes using scaled models which are fabricated with RPG's rapid prototyping 3D printer.

BAD™: Binary Amplitude Diffusers

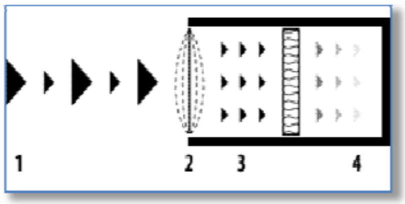


The success of RPG reflection phase gratings led to the question by the architectural community - "Can you make a flat diffusor that we can cover with fabric and make disappear?" RPG solved this problem by creating the binary amplitude diffsorber, affectionately called the BAD panel. The BAD panel is a variable impedance surface which consists of a template with a hole distribution determined by an optimal maximum length sequence. This template is placed over an absorptive backing of desired depth forming the amplitude grating. This can then be covered with a fabric or the template can be fabricated from wood or metal and exposed. This session will review the theory behind the BAD panel and also discuss its performance characteristics and applications in which its use enhances the acoustics of the space.

DiffusorBlox®: The complete acoustical block

In 1917 the CMU was developed and has blossomed into a standard building material and a large industry. In 1965 an acoustical CMU was introduced using slots on the face forming a Helmholtz resonator. This was quickly accepted, but the resonant frequency is limited and there is still a significant portion of the block face that is reflective, providing interfering reflections and mid-high frequency reverberance that makes this approach ineffective for rooms which are use for speech, music and sports. In 1990 a final solution to the acoustical CMU was introduced by RPG®, called DiffusorBlox®. In this session we will describe the theory behind the DiffusorBlox®, it performance characteristics and applications.

Specialty Membrane Low Frequency Absorbers

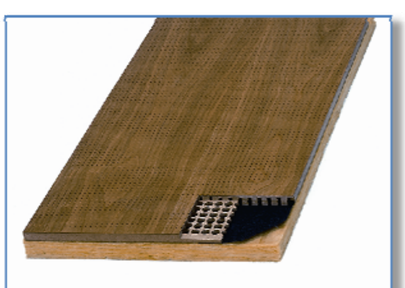


The acoustics of enclosed spaces is significantly affected by modal problems, below the Schroeder frequency. There are essentially only two know ways to minimize these resonances by absorption using either Helmholtz resonator designs or diaphragmatic membranes. RPG offers two types of low frequency membrane absorbers in its Modex line. The Modex Module or Corner offer absorption in select frequency bands of 40, 50, 63, 80 and 100 Hz. These can be used when a problem exists in a certain frequency region or several of these modules can be use to broaden the absorption range. There is also another approach using a damped metal plate resonator, which provides either low frequency shelving absorption from 40 to 300 Hz (Modex Plate), or broadband (Modex Broadband) absorption from 50 – 5000 Hz. In this session the Modex theory for all products will be discussed and absorption data will also be presented.

Clearsorber®: Light-transmitting, micro-perforated absorbers

The use of ACT and fabric wrapped panels can no longer address the complex environments present in today's architecture. Glass is a very desirable building material; however, it introduces strong interfering specular reflections and long reverberation times. The Clearsorber® range, consisting of micro-perforated foil and micro-slit transparent panels, offers a solution to these problems, while maintaining visibility. Since these surfaces are plastic and not porous materials, they are also fiber-free. This session will describe the science behind the design of these novel absorptive approaches, review the parameters affecting the absorption frequency bandwidth, review product options and mounting details.

TopAkustik®: Decorative sound absorbing wood paneling system



This session will describe the wide and diverse range of parallel grooved, Topakustik®, and perforated, Topperfo®, absorptive wood options in this product line, which is the most extensive in the industry. This session will review these products, available finishes, and wall mounting and ceiling suspension details. RPG® has also grown into the leading supplier of custom engineered specialty systems and this session will review the details of a few very successful difficult projects that RPG® has engineered and provided detailed shop drawings for. We will also introduce the newest addition: Topperfo® Micro™, the industries only micro-perforated broad bandwidth absorber.

CDM®: Innovative noise and vibration products

DPM™: Conventional roll out isolation mats consist of fiberglass mats, which require gloves and respirators for the contractor and relatively high resonant frequency embedded plastic encapsulated fiberglass pads. RPG has developed the next generation of distributed pad mat (DPM™) consisting of recycled polyester mat with a variety of low frequency natural rubber, polyurethane or cork rubber isolators. In addition, a new element has been developed, called the distributed pad strip (DPS™) to effectively support the perimeter of the floor when the walls and ceiling (if lid construction is used) rest on it. This session will describe the DPM™ system, describe how to calculate the applied floor loads and select the appropriate elastomer and review typical installation options using a non-vented and vented floor to lower the system resonance. The ISO-LAT® system will also be illustrated.

QRW™ and QRC™: Wall and ceiling drywall isolation clips

There are many drywall isolation clips on the market and more entering regularly. However, they all suffer from the same three problems. They use a stiff neoprene elastomer with a high resonant frequency, the same clip is used for walls and ceiling when the loading is totally different and none of them offers a positive mechanical capture of the hat channel. RPG has developed a separate wall, QRW™, and ceiling, QRC™, isolation clip with different low resonant frequency polyurethane elastomers to address the different loading conditions, with a positive capture mechanism, which also offers a fail- safe mechanism guaranteeing the elastomer is pre-compressed to its optimal load range assuring the lowest resonant frequency. This session will describe the new isolation clips and their respective wall and ceiling application, describe why they offer significantly higher performance than current designs and also describe why having a lower resonant frequency offers a higher isolation efficiency.

PHR/PHS/PRJ/PSJ

There are many ceiling suspension spring isolators on the market. While RPG offers comparable spring isolators, PHR, and joist mounted spring isolators, PRJ, with typically 4-5 Hz resonant frequency, we also offer another range of ceiling isolators using a wide range of elastomers, PHS and PSJ, which offer resonant frequencies in the 10-12 Hz range. The elastomer isolators offer a substantial cost saving, when the higher resonant frequency is suitable. This session will review the designs of both spring and elastomer isolators, discuss their application, review how to select the appropriate isolator based on ceiling loads for center, perimeter and corner locations.

Spring vs. Elastomer Theory
Most acousticians are familiar with the combination of Hooks law (which indicates the restoring force is equal to the spring stiffness times its static deflection) with the harmonic oscillator equation (which indicates the resonant frequency is proportional to the square root of the static stiffness divided by the mass) to yield an equation which relates the resonant frequency of a spring to its static deflection. With elastomers the resonant frequency is not determined from the static stiffness! In predicting the resonant frequency one needs to determine the dynamic stiffness, the ratio, called r, of the dynamic/static stiffness and the shape factor (ratio of area force is applied to the bulge area). This session will describe this theory, how to measure dynamic stiffness and shape factor and illustrate why the CDM natural rubber and polyurethane elastomers, used in our isolation products, have the lowest r factor, resulting in the lowest resonant frequencies in the industry.

ISO-Float vs. ISO-Mont
For high isolation concrete floors the jack up system (ISO-Mont) is generally preferred. RPG offers its version of the jack up system with either springs (nested springs as well) or elastomers, which can be replaced in the field after installation if the loading changes. While the jack up system offers high isolation, it can be expensive and cumbersome. To address these issues, RPG offers the CDM-ISO-Float system, with either springs or elastomers. This system consists of 2’x2’ MDF modules with springs or elastomers attached at the corners on a junction plate and low density fiberglass on the underside. These modules are individually identified to address different loading conditions in the room. Installation is as simple as laying them side by side, attaching, placing a plastic waterproof sheet and applying concrete to the desired thickness. This session will discuss the design and application of these two systems.

Workshop Topics: Research

Determining the directional scattering coefficient from polar responses
A method to measure the random incidence scattering coefficient has been described in ISO 17497-1. The method involves averaging the impulse responses for the sample in different orientations to isolate the specular component of the scattering. As such, the method does not distinguish between samples in which there is depth variation in only one direction, as in a cylinder, and textured surfaces with depth variation in many directions. Since computer model algorithms currently do not distinguish between these two types of surfaces, this may be an acceptable approximation. However, as computer models evolve to distinguish between these types of surfaces, directional scattering coefficients will be required. It is possible to calculate or measure the directional scattering coefficient from scattered polar responses, using either the correlation scattering coefficient described by Mommertz, in which the polar responses of a scattering sample and a flat surface are correlated or the ratio of the energy in the specular zone and the total energy. Examples of calculated and measured directional scattering coefficients will be presented and discussed.

Proposed method to measure the diffusion coefficient

A method to measure the uniform diffusion coefficient has been published as an AES Information Document [AES-4id-2001, JAES, Vol. 9(3), pp. 148-165 (March 2001)]. The method utilizes 37 fixed pressure zone microphones separated by 5 degrees located on a 1 m semicircle and a loudspeaker located on a 2 m concentric semicircle. A sample array sits at the origin. Under computer control 37 impulse responses are collected for the sample, background without sample and a reference flat panel of similar size. The data reduction procedure will be reviewed to include all developments since the 2001 publication. In addition, experimental data will be presented along with the current presentation format. Currently the method is in the final stages of review for incorporation as Part 2 of ISO 17497-1, which describes the procedure to measure the random incidence scattering coefficient. A review and comparison between the scattering and diffusion coefficients will also be presented. A summary of this research can be found in the reference text [T.J. Cox and P. D'Antonio, Acoustic Absorbers and Diffusers: Theory, Design and Application, Spon Press 2004, Second edition in Press].

Acoustical optimization of shapes and materials used in modern architecture
Classic architecture or classically inspired architecture benefit from the fact that scattering surfaces, in the form of columns, statuary and relief ornamentation, was an integral part of the architecture. As architecture evolved into using less ornate surfaces in smooth rectilinear and more recently curvilinear forms, this created a need to design scattering surfaces that complement modern architecture. When contemporary scattering surfaces are required, shape optimization, using any reflective material, has proven to be mutually useful for the acoustician and the architect. A shape drawn by the architect is parameterized and then optimized maintaining the desired motif. An iterative computer program that combines the benefits of boundary element and multi-dimensional minimization techniques will be described and examples will be shown. When absorption is required, microperforation and micro slit designs offer a novel solution, using light transmitting plastics and metals. Microperforated wood veneer panels are also available in which the perforations are barely visible at normal viewing distances. A summary of the theory and application of these ideas can be found in the reference text [T.J. Cox and P. D'Antonio, Acoustic Absorbers and Diffusers: Theory, Design and Application, Spon Press 2004].

The use of coded signals in the measurement of diffusing surfaces
Following the introduction of quantifiable number theoretic, reflection phase grating diffusing surfaces by Manfred Schroeder in 1975 [M.R. Schroeder, J. Acoust. Soc. Am., Vol. 57, No. 1, 149-151 (1975)], several approaches have been used to measure and characterize them. In the early 1980s, Time Delay Spectrometry, developed by Richard Heyser, was used to measure the temporal, spatial and spectral responses of diffusing surfaces. Once Maximum Length Sequences were introduced as an excitation signal, they were adopted in the late 1980s. These explorations led to the creation of a measurement standard for the diffusion coefficient, which is the circular autocorrelation of the third octave polar responses. The limitations of periodic number theoretic surfaces, namely bandwidth, grating lobes and flat plate effects, were addressed by computer optimization, which combined the power of boundary element and multi-dimensional minimization techniques, and modulation. Both one-dimensional (phase variation in one direction) and two-dimensional (phase variation in two orthogonal directions)

surfaces were characterized. The data collection and reduction procedures will be reviewed with several examples of diffusing surfaces. A summary of this research can be found in the reference text [T.J. Cox and P. D'Antonio, Acoustic Absorbers and Diffusers: Theory, Design and Application, Spon Press 2004].

Overview of Low Frequency Control Options in Room

Low frequency control of modes and speaker boundary interference in rooms has been a persistent problem that affects the sound field in rooms. However, many innovative techniques have been developed to address these problems. This presentation will be an overview of approaches that address the optimization of room dimensions to provide the flattest room response and speaker/listener placement to minimize speaker-boundary interference; the mechanism and design of passive absorption devices based on Helmholtz resonators, diaphragmatic limp mass membranes, plate resonators and microperforated panels will be described and characterized; as well as electro-acoustic approaches, using equalization, active absorbers and the optimal placement of multiple in-phase subwoofers.

Canopy arrays: density, size, shape and position

The reflecting surfaces around a stage area play an important part in enabling ensemble amongst musicians. Energy must be reflected back to the stage to enable musicians to hear themselves and others and so achieve the correct rhythm, intonation, balance, and timbre. Gade[i] summarized the current understanding of stage acoustic requirements; in particular, when stage reflections should arrive, and how loud they should be. The study presented in this paper concentrates on the design of overhead canopy arrays, in particular investigating effects of density, size, shape and position. This aspect has surprisingly been little researched, although work by Rindel[ii] investigated similar questions to those being posed here. The advent of modern computer processing power allows stage canopy arrays and towers to be optimized using iterative algorithms, based on wave-based acoustic prediction models. A shape optimization program has been developed to optimize both the shape and tilt of overhead canopy arrays. Previously, the height and density have been inputted based on experimental evidence and lighting/scenery considerations. The program has recently been updated to address the question of optimal canopy density and size, and some preliminary results from this work are presented below.

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[i] M. Barron, "Auditorium acoustics and architectural design," E & FN Spon, 55, (1993).

[ii] . H. Rindel, "Design of new ceiling reflectors for improved ensemble in a concert hall," Applied Acoustics, 34, 7-17, (1991).