The RPG Story: The Full Story 1983-2017

Every company has a story. The RPG Diffusor System story begins in 1980, in the conference room of the Laboratory for the Structure of Matter at the Naval Research Laboratory (NRL) in Washington, DC, where Peter D'Antonio was employed as a diffraction physicist. Knowing Peter's interest in music, a colleague handed him the latest issue of Physics Today with a cover photo of Manfred Schroeder seated in an anechoic chamber. The article suggested using number theoretic diffusers in concert halls. While Peter's interest at the time was not in concert halls, he became fascinated with the thought of using these diffusers in a renovation of Underground Sound, a private studio he originally built in 1972 with Jerry Ressler. The acoustic renovation utilized a new concept called Live End Dead End™ proposed by Don and Carolyn Davis, of Synergetic Audio Concepts (Syn-Aud-Con), and implemented successfully by Chips Davis. At that time, Peter was examining the 3-dimensional structure of matter in various phases, using electron and x-ray diffraction techniques. Peter shared the article with John Konnert, a colleague at NRL, and it became apparent that the "reflection phase gratings" suggested by Schroeder were in effect 2-dimensional sonic crystals, which scatter sound in the same way that 3-dimensional crystal lattices scatter electromagnetic waves. Since the diffraction theory employed in x-ray crystallographic studies were applicable to reflection phase gratings, it was straightforward to model and design the reflection phase gratings.

At this time, Peter's only link to the field of acoustics was a love of composing, recording and performing music. Having scientific backgrounds, John and Peter approached acoustics as they did the field of diffraction physics, and began researching and publishing findings in the scientific literature. The Audio Engineering Society and Syn-Aud-Con offered a unique forum and community for discussing the research. In October 1983, at the 74th AES Convention in New York, Peter met Bob Todrank following a presentation of Peter and John's first paper on Schroeder diffuser. Bob was designing a new studio for the Oak Ridge Boys in Hendersonville, TN and was interested in utilizing these new acoustical surfaces. The studio was a resounding success and turned out to be a harbinger of many exciting things to come.

In 1983, Peter and John measured quadratic residue and primitive root diffuser with a TEF 10 analyzer at a Syn-Aud-Con seminar in Dallas, Texas, with the assistance of Don Eger of Techron. Here Peter and John met Russ Berger, who was a pioneer in the use of new products into his firm's recording studios. In 1984, an intensive measurement program was carried out using Richard Heyser's time delay spectrometry implementation. Farrell Becker was very helpful in our initial evaluation of these exciting new surfaces. Not having access to an anechoic chamber, a boundary measurement technique was developed. These measurements were initially carried out at full scale in large spaces like open fields and parking lots, eventually moving indoors to a sports arena, a motion picture sound stage, and a local high school gymnasium. The measurements enabled the theories to be validated.

The Oak Ridge Boy's Acorn Sound Recorders project was celebrated with a Syn-Aud-Con control room design workshop in 1984. This project led to many others and collaborations with a growing community of new studio designers were undertaken. Neil Grant was an early staunch proponent of the research and products. Some of his milestone designs include Peter Gabriel's Real World Studios, Box, UK, Reba McEntire's Starstruck Studios, Nashville, TN, Sony Music, New York, NY, The Hit Factory, NY and Cinerama Theater, Seattle, WA. In 1989, John Storyk integrated diffusive technology in many of his designs, including Whitney Houston Studio, Mendham, NJ, Electronic Arts, Vancouver, BC, Jungle City, NY and Jazz at Lincoln Center, New York, NY to name a very few. Over time our collaborations with the music industry's leading designers continued to grow. Chris Pelonis employs RPG products in all of his designs, which include many of the gaming companies, including Sony Computer Entertainment and Valve. Other notable designers include FM Designs and Wes

Lachot Designs incorporate RPG technology in their designs. Today much of the music you hear is created in music facilities utilizing RPG technology. These fledgling years established relationships that continue to this day and produced many acoustical landmarks.

Interest in recording facilities naturally spread to broadcast facilities, where diffuser technology is commonplace. Facilities, include, BBC, NPR, NBC, CBC, and most of the broadcast networks, due to Russ Berger's innovative designs. Being musicians and audiophiles, led to significant involvement in residential high end audio listening rooms, as well as production studios.

In 1989, Peter was introduction to Jack Renner, President of Telarc Records, the company that started the classical high-end recording industry on a digital journey. Jack was recording the Baltimore Symphony Orchestra at the Meyerhoff Symphony Hall and asked if RPG could assist him. Following initial experimentation, Telarc graciously credited RPG® as Telarc's exclusive acoustical system for control room and stage use for the Berlioz Symphonie Fantastique in 1990. The somewhat accidental stage use and overwhelming acceptance by musicians and conductor prompted an objective and subjective investigation of stage acoustics and acoustical shells both with small ensembles and with the Baltimore Symphony Orchestra. These chamber group studies were conducted with Tom Knab at the Cleveland Institute of Music, where Peter has been adjunct professor of acoustics, since 1990, at the invitation of Jack Renner. In November of 1989, RPG was privileged to provide a custom number theoretic surface for the rear wall of Carnegie Hall, New York. This installation, along with the new diffusive acoustical shell development, launched RPGs involvement into performing arts applications, which eventually included the Fritz Philips Muziekcentrum, Eindhoven and the Corning Glass Center, Corning, NY.

Many of the acoustical consultants involved in the design of worship spaces, began to include the use of diffusers for rear wall applications and acoustical shells. While RPG has collaborated with many acousticians, the relationship with Mike Garrison is noteworthy for the sheer number and size of the successful worship spaces produced using diffusers. The crown jewel of this collaboration is the 9,000 seat South East Christian Church in Louisville, KY.

In 1990, RPG funded the DISC Project in an attempt to devise a standard methodology for evaluating diffuser quality. In 1991, Peter proposed a directional diffusion coefficient and the AES invited him to chair standards committee SC-04-02 to formerly develop an information document describing these procedures.

In 1993, David Quirt Associate Editor of the Journal of the Acoustical Society of America asked Peter to referee a paper by Trevor Cox entitled "Optimization of Profiled Diffusers". (Trevor's research journey had started a few years earlier in 1989 when, under the direction of Raf Orlowski and Y. W. Lam he completed a Ph.D. on Schroeder Diffusers). The paper outlined a process that combined boundary element and multi-dimensional optimization techniques to make better diffusers. In Peter's view this paper represented a creative milestone in diffuser development, on a par with Schroeder's seminal contribution. Peter and John's review of the paper consumed many months. It required the writing of boundary element codes and developing the first automated goniometer to measure these optimized surfaces. During the summer of 1994 Paul Kovitz helped to complete the measurement software. Trevor's revised paper, accompanied by a refereed paper of Peter and John's review were published in 1995. Since this was nearly 3 years after Trevor submitted the paper to JASA, this must have seemed to be the peer review from hell, especially as the referees' comments were 36 pages long.

Peter finally met Trevor in Amsterdam at an AES SC-04-02 standards committee meeting in 1994 and again in Arup Acoustics' office in London during a luncheon presentation. Our strong mutual interests led to an informal collaboration. In 1995, Trevor became a research consultant to RPG Diffusor Systems, Inc. This relationship started with developing an automated program to optimize loudspeaker and listening positions in a critical listening room and blossomed to generate much of the contents of this book.

Realizing that good acoustical design results from an appropriate combination of absorptive, reflective and diffusive surfaces, Peter began developing absorption technologies as well, including hybrid abffusive (absorptive/diffusive) systems, diffsorptive (diffusing/absorbing) concrete masonry units, low frequency absorbing arena seating risers, nestable open-cell foam systems and dedicated absorptive low frequency membrane systems.

In 1995, we became aware of the diffusion research of James Angus on amplitude gratings and modulated phase gratings. James has made significant contributions to the field of diffuser design and we both have great respect for his insight and enjoy our collaborations with him. Also in 1995, we met Eckard Mommertz and Michael Vorlander at the 15th ICA in Trondheim, Norway. It was at this meeting that we learned of their work developing a procedure to measure the random incidence scattering coefficient. We have maintained close collaboration to this day, especially as members of the ISO WG 25, chaired by Jens Holger Rindel.

To further the development of the diffusion coefficient, RPG co-funded a three year grant with the Engineering and Physical Sciences Research Council of the United Kingdom, beginning in 1996. Trevor, Yiu Wai Lam and Peter were the investigators and Tristan Hargreaves was the doctoral student. This research was very fruitful in that it produced the first 3D measurement goniometer and yielded a robust diffusion coefficient which has since been published in AES-4id-2001.

This diffusion coefficient (later standardized as ISO 17497-2) has since been used as a metric to develop a range of new diffusing surfaces, including optimized welled diffusers, profile diffusers, 1-D and 2D curved diffusers, baffled diffusers, genetic binary hybrid surfaces, flat and curved binary amplitude gratings, fractal and modulated surfaces. These new optimized custom curved surfaces have found application in performance spaces like Kresge Auditorium, Boston, MA, Hummingbird Center, Toronto, Canada, Edwina Palmer Hall, Hitchin, UK and also recording facilities like Sony Music's premier mastering room M1, in New York.

Things began falling into place and all of the relevant diffusion research was collected into a special edition of Applied Acoustics, entitled "Surface Diffusion in Room Acoustics", guest edited by Yiu Wai Lam and published in June of 2000. Lam also organized a symposium in Liverpool that year. In September of 2001, a special structured session on Scattering in Room Acoustics was organized by Michael Vorlander at the 17th ICA in Rome. Having played a pioneering role in making Schroeder's theoretical suggestions a practical reality, it was personally very gratifying for Peter to be part of a session dedicated to a topic which started as an intellectual curiosity, and has now turned into a diffuser industry and a field of research actively being studied by the leading acousticians of our time.

There have been many significant accomplishments over the past 30 years. We now know how to design, predict, optimize, measure, characterize and standardize the performance of scattering surfaces. While there is still much to do, there is a general consensus in the architectural acoustics community that a solid theoretical and experimental foundation has been laid, that diffuser performance can now be quantified and standardized and that diffusers can now be integrated into contemporary architecture, taking their rightful place along with absorbers and reflectors in the acoustical palette. The future holds many exciting possibilities.

Peter and Trevor consolidated developments in the past three decades into the first reference textbook incorporating everything that is currently know about acoustical materials in three editions of "**Acoustic Absorbers and Diffusers: Theory, Application and Application**", Spon Press 2004 1st Ed", "**Acoustic Absorbers and Diffusers: Theory, Application and Application**", Taylor & Francis 2009 2st Ed" and "**Acoustic Absorbers and Diffusers: Theory, Application and Application**", CRC Press, 2017 3rd Ed"

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Evolution: RPG's Mission is to "Expand the acoustical palette through a continuing commitment to fundamental acoustics research". In the past 30 years RPG's has stayed true to this mission and evolved its product line and testing capability to measure the absorption, scattering and diffusion characteristics of architectural acoustic materials. In the next few slides we present the evolution of RPG's high and mid frequency (MF-HF) absorbers, low frequency (LF) absorbors and diffusors, as well as its current research testing suite to evaluate these products.