Sound System Modelling Software

Philip Giddings, P. Eng.
Engineering Harmonics
9 Edgewood Avenue
Toronto, Ontario
M4L 3G8

Introduction

Sound System Modelling Software is becoming commonplace in the design of sound systems for arenas, concert halls and other large rooms. There are a number of loudspeaker manufacturers that provide this software. They include: AcoustaCADD from Mark IV; CadP2 from JBL; Ease and Ease JR from Renkus-Heinz; and Modeller from Bose.

The software packages range anywhere from five hundred to several thousand dollars. All of the programs allow for basic room acoustics analysis and loudspeaker design. Most of the programs are specific in the loudspeaker components that they will allow you to use. However, the Renkus-Heinz system has a database that includes loudspeaker components from more than 20 different manufacturers.

The following is a description of the AcoustaCADD offering:

Entering the Model

A wire frame model of the room to be analyzed must first be entered. The wire frame model can be either open or closed. Rooms such as auditoriums and arenas are closed models as they have a roof (and a reverberation time). Football and baseball stadiums, with no roof, are open models. Obviously, reverberation time cannot be calculated in an open model.

The first step of the process is to determine all the planes needed to describe the model. For example, the walls, the ceiling, the floor, the balconies, the stage, the playing field, the ice, are all planes in space and have XYZ coordinates which are used to define the plane. Three XYZ coordinates define each plane.

Once all the planes have been entered, those surfaces that define the room must be identified and are called boundary surfaces. A boundary surface is defined by a plane and the planes it intersects.

With the planes and the boundary surfaces entered, the wire model can be viewed. Figure 1 shows the model for the Ottawa Triple A Stadium. There are a number of diagnostic devices to aid in correcting errors in entering the plane and boundary surface data. AcoustaCADD software has received some criticism about the difficulty of entering the wire frame model. The author has entered several models and, with experience, it takes less than three hours to enter a model for an arena or a stadium of less than 20,000 seats.

Acoustic Analysis

Once the wire frame model is entered, if acoustic analysis is desired, it is necessary to assign absorption coefficients to each of the boundary surfaces. A database exists for a number of typical surfaces; however, new data can be entered with its octave band absorption coefficients. Once all the boundary surfaces have been assigned an absorption value, the reverberation time is easily calculated. It can be calculated for any octave band. Another common acoustic analysis capability of these programs is ray tracing. Although this author doesn't use it commonly, it's available in the AcoustaCADD package.

Designing the Loudspeaker System

The initial step is to select, locate and aim the loudspeakers. The loudspeaker components include the manufacturer's model number of the horn, the driver and, in the case of AcoustaCADD, the filter module which would be used in the amplifier. AcoustaCADD includes loudspeaker data for Altec, EV and University products. The location is the XYZ co-ordinates in the model and the aiming is the elevation, azimuth and rotation. With this information entered, an isobeam is projected onto the surface of interest. The isobeams can be in the -3, -6 or -9 dB. down points of the horn at any octave band frequency from 125Hz. to 8kHz. The various suppliers of the software measure data in various ways for the isobeam and polar responses. AcoustaCADD uses measured data on five degree increments for every point on a sphere. Other suppliers of the software use ten degree increments and in some cases only measure data on a hemisphere and assume the other half of the sphere will be identical.

The projection of the isobeam onto the surfaces is where the usefulness of these programs becomes obvious. It becomes extremely obvious when the location of the loudspeaker, its type and the aiming have been properly selected. AcoustaCADD also allows a multiple isobeam mode where isobeams of six loudspeakers can be projected onto the model at a given time. Figure 1 shows two isobeams projected. This allows adjusting the relative aiming of various loudspeaker components. Once finished with this process the designer is confident that the aiming of the loudspeakers is accurate and the need to allow for field adjustments is minimized.

Once the loudspeakers have been entered and aimed in the model, we can then go to the next step which is to map the SPL. This involves specifying which surfaces are the critical ones to the sound system design. Typically, these include those where the patrons are seated. Once the surfaces have been selected, the resolution to be used in mapping the sound pressure level must be selected. Obviously, the density of the mapping grid determines the number of discrete points for which a sound pressure level must be calculated and has a large impact on the times taken by the program to determine a sound pressure level map.

Mapping the SPL can be time consuming as an great number of calculations are required. For each point selected on the grid, the program takes the contribution of every loudspeaker in the system and does a summation. This involves taking the sensitivity of each loudspeaker, the off-axis response and the loss with distance. The author uses a 486-66 PC and with 18 horns this calculation can take up to 20 seconds.

AcoustaCADD provides two forms of mapped SPL output. One is a colored map and the other is isobars. Either of these can be plotted at 1, 2, 3 or 4 dB per increment. See Figure 2 for an example of the output.

The performance of the loudspeaker system can be quickly determined in a mode of operation where a point on a surface is selected and the program then calculates the direct and reverberant sound pressure levels and the articulation loss of consonants. This applies to closed models and is obviously a key element to a good sound system design in a reverberant space such as an arena or a concert hall.

A Case Study

As seen in the figures, AcoustaCADD was used in the new Ottawa Triple A Baseball Stadium. A primary concern in the design of the loudspeaker systems was control of noise intrusion to a neighborhood just beyond left field. Several potential sound system designs were modeled and evaluated. The program was used to accurately compare the relative impact of the various designs at a distance of about 1000 feet from the stadium. The result of the final design is shown in Figure 3. With a sound system concept selected a detailed design was specified and tendered. The evenness of coverage of the installed system was good and no loudspeaker re-aiming was required during commissioning. There have been no complaints from the neighbours that the author is aware of.

Figure 1

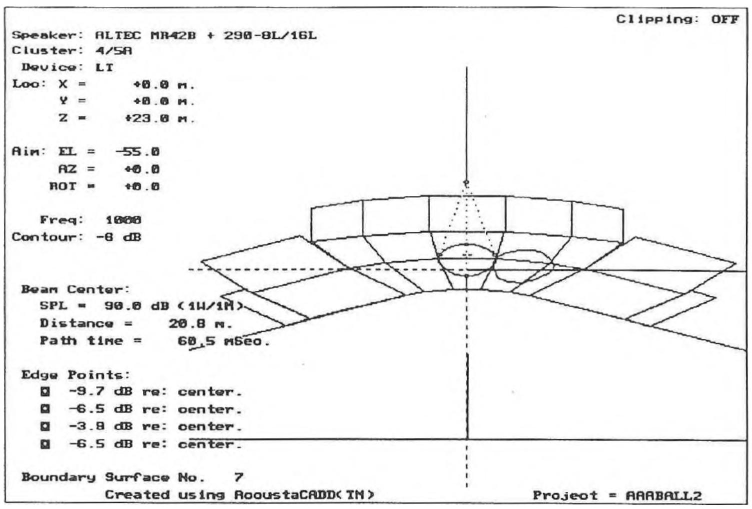

Figure 3

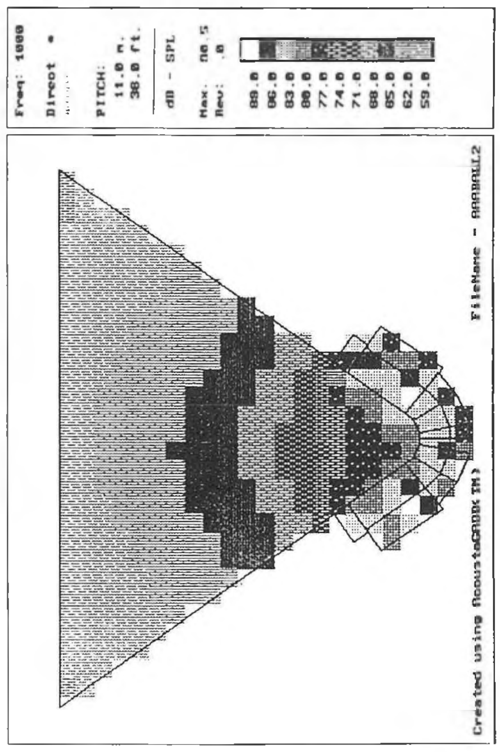

Figure 2