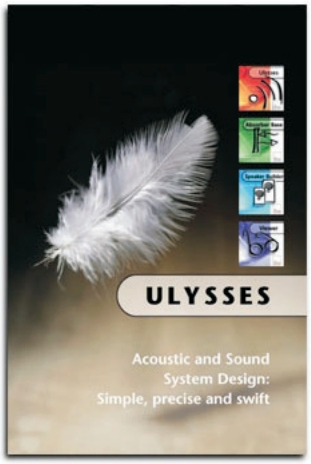


A Tool for the System Designer

Good system designers understand the basics of acoustics and electroacoustics. They also understand that room/system parameters must be traded-off to reach a workable solution for a project. The main tool of the designer is the thought process, and the most effective way to think about a problem is to possess the ability to quickly and accurately create scenarios regarding various ratios between system variables. This is the role of the electroacoustic design application. In the hands of a competent system designer, it can be of tremendous help in reaching the best set of compromises.

What can I know about a system at the drawing board stage?

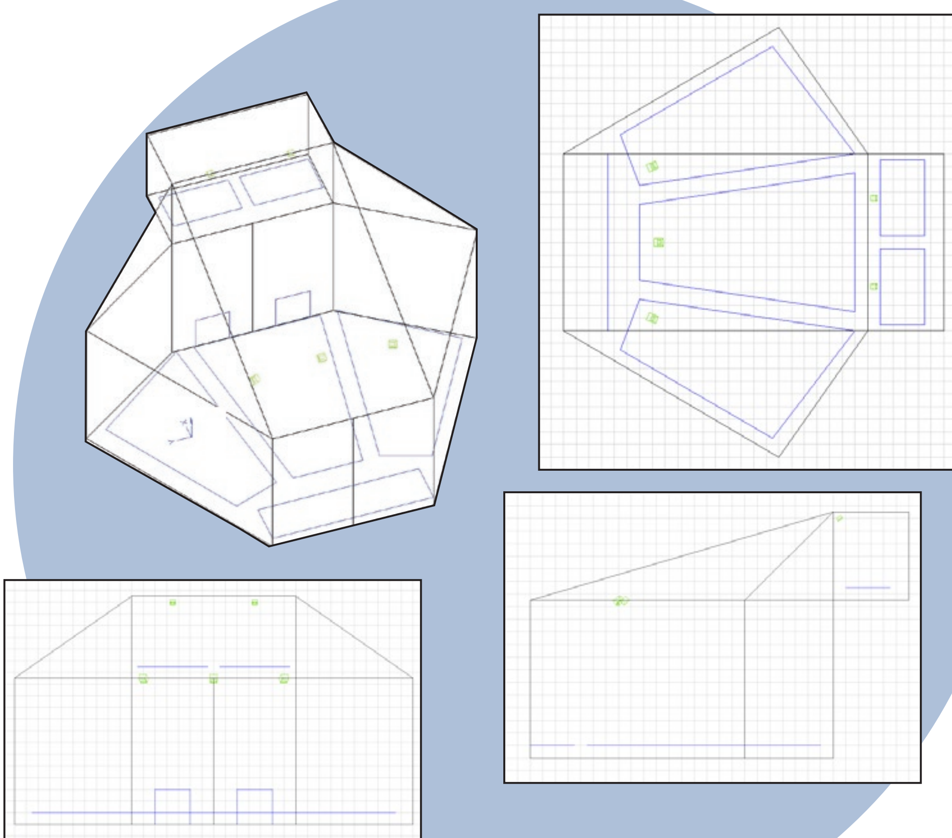
The list includes:

- the evenness of the direct field coverage
- problem seating zones dominated by phase interference between multiple drivers
- whether a reverberant field exists and what its level should be
- whether the direct field will dominate that level
- the arrival time and level of low order reflections at key seating positions
- an impression of what the system might sound like

These are what the system designer can and must know to assure that the design will be successful. The myriad of variables necessitates the use of powerful computational algorithms and a means to perform them. ULYSSES™ is one such tool. This Windows™ application is a system designer's calculator. It can calculate everything mentioned, and more. It's designers chose to limit its scope to the most important aspects of sound system design - the things that really need to be known and that can be calculated with reasonable accuracy. The result is a program that is as straightforward to use as it is fast in its computations.

The following pages contain an adequate picture of ULYSSES to convey its capabilities to the reader. The next step for interested parties is to acquire the demo from the website listed at the end of the article and have a go at it.

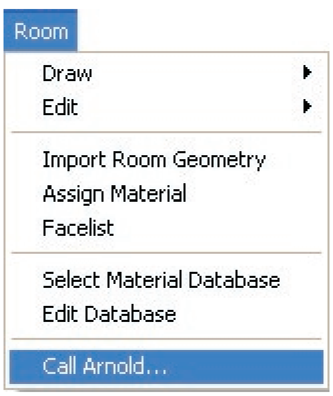
I will proceed in the order that one would proceed with a system design - first characterizing the room, achieving direct field coverage, and finally considering reflections and reverberation that result from my choices.



The room is mapped using an X, Y, Z, coordinate system familiar to those who have used other modeling programs or Autocad™.

The Room

The room detail required for calculations is determined by what the designer wants to know. In the simplest case, and audience area can be quickly drawn and a loudspeaker(s) placed above it. A direct field-only map can be quickly generated. This may be sufficient for scenarios where the designers needs only to know "what device, where, and what angle." If acoustical information is to be considered, the entire room must be constructed and appropriate absorption data applied to the room faces. This is done using a drawing engine that includes the usual geometric shapes. Rather than specifying vertices on a point-by-point

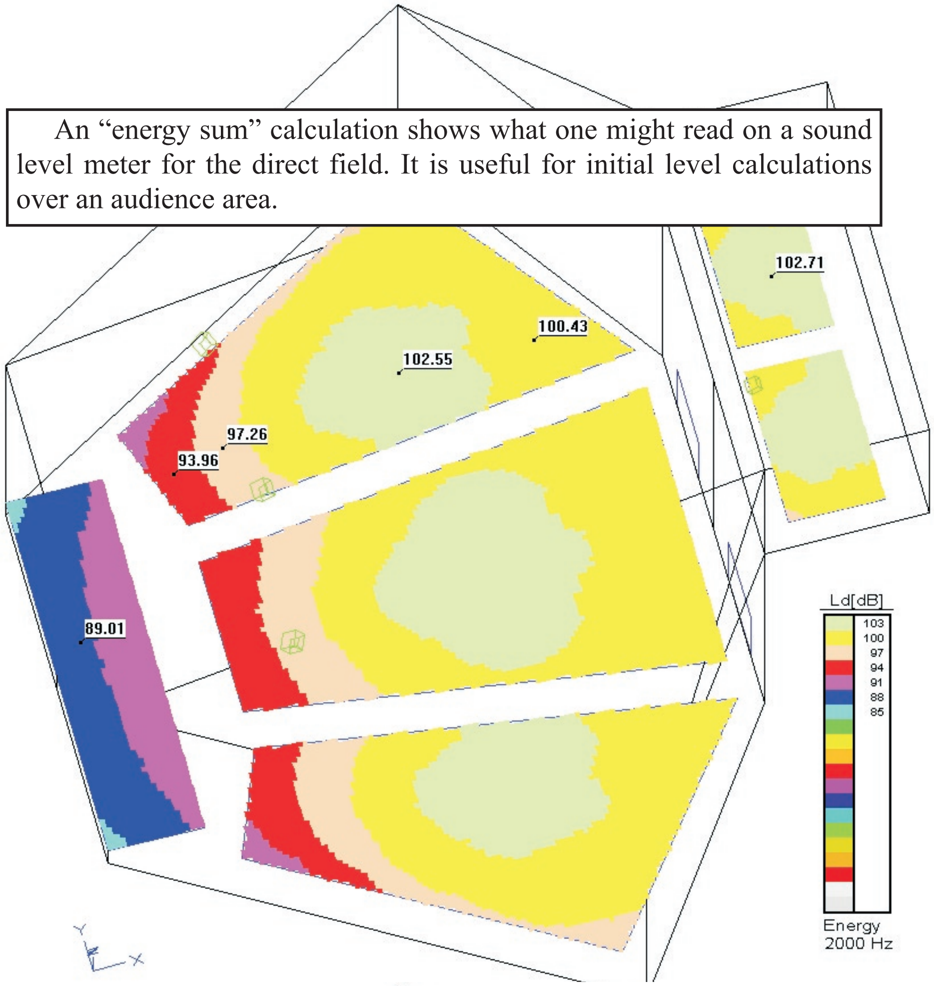


basis, the model is generated by drawing faces directly. These can be copied, mirrored, extruded, etc. to generate the room model. I found this method of data entry to be quite efficient after a short learning curve.

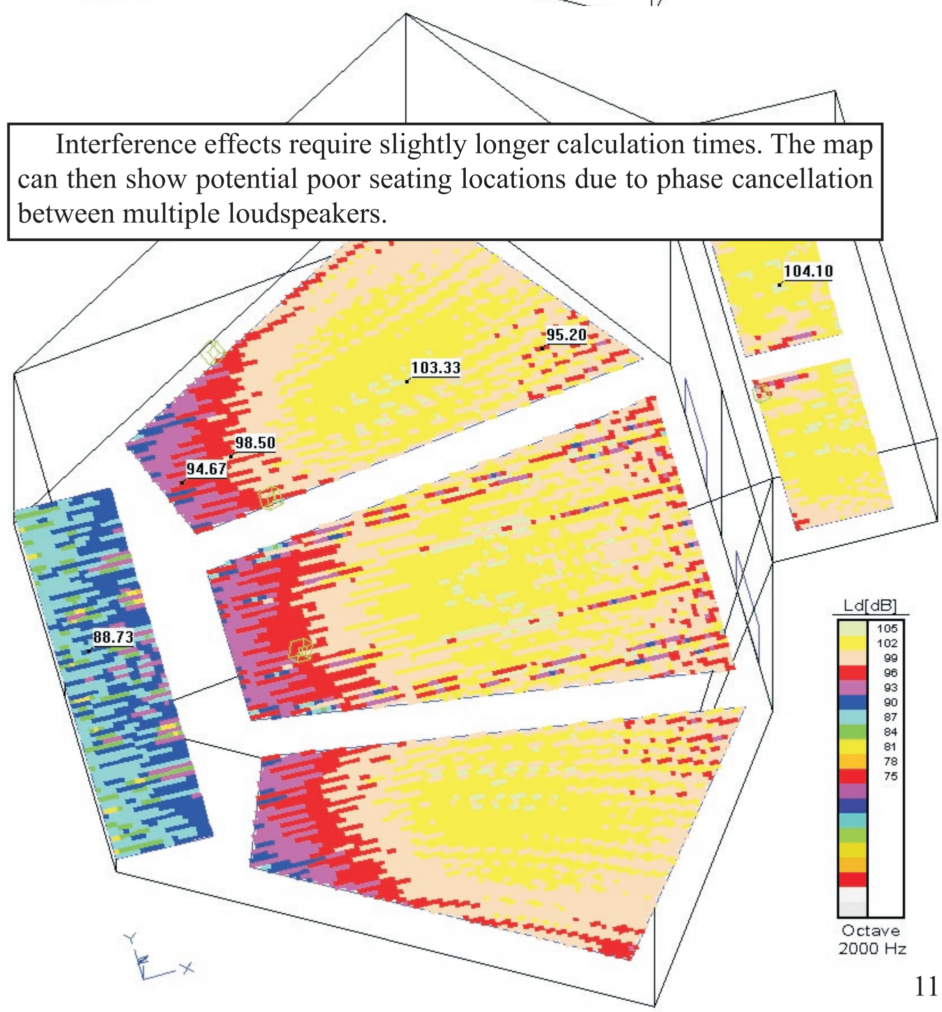
An additional drawing menu is included to add detail that does not affect the calculations, like text blocks or symbols.

There is no need to manually close the room upon completion of the data entry. One simply "Calls Arnold" and he tells you if the room is complete. He also helps fix any problems. I learned to lean on Arnold pretty heavily during the room construction process.

An "energy sum" calculation shows what one might read on a sound level meter for the direct field. It is useful for initial level calculations over an audience area.



Interference effects require slightly longer calculation times. The map can then show potential poor seating locations due to phase cancellation between multiple loudspeakers.



Calculations

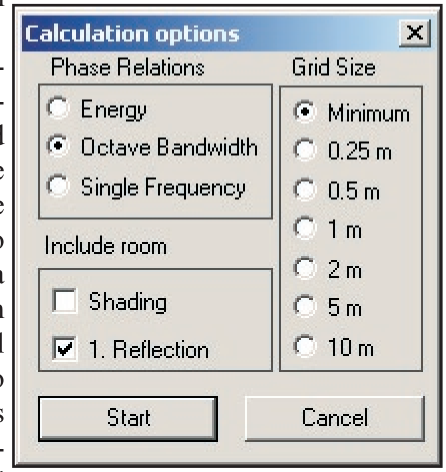
Once the room model is constructed, the user can perform a variety of sound field calculations. This is done in the same module that is used to construct the room. A direct field calculation is performed by selecting "Level + Time" under the Calculation menu. Phasing effects between loudspeakers can be considered or ignored, and the "patch size" (resolution over the audience area) can be varied as desired. An "Energy" calculation does not include phase effects, and is useful for observing the overall energy being projected on an audience area. An "Octave" calculation considers the phase relationship between multiple transducers, and consequently will show the effects of interference. An option is included to allow the shading from obstructions to be considered. A "Reflection" toggle allows the first order reflection from each device to be considered, along with the direct field. This is especially useful for showing the useful or detrimental effects of boundaries near loudspeakers or listeners. I evaluated this feature by varying the distance between loudspeakers and the ceiling, noting the interference produced by the reflection. I repeated the process by varying the listener height from the floor boundary. The coverage maps and real-time auralizations (see Auralization section) showed the expected artifacts from these placements.

The Calculation menu

Direct field calculations are performed simultaneously for all seven one octave bands. After the calculation, the user can simply toggle between octave bands with mouse clicks, noting changes in coverage due to loudspeaker directivity, etc.

The additional calculations provided are dB Total (the total of the direct and indirect levels), Time (first arrival from loudspeaker), L_D - L_R (energy ratios using the Hopkins-Stryker equation), %Alcons, and the Speech Transmission Index.

While other metrics exist for estimating sound fields and energy ratios, those included should be more than sufficient to determine whether a given design approach will yield useful results. They will also provide a solid basis for comparing loudspeaker selections and placements.

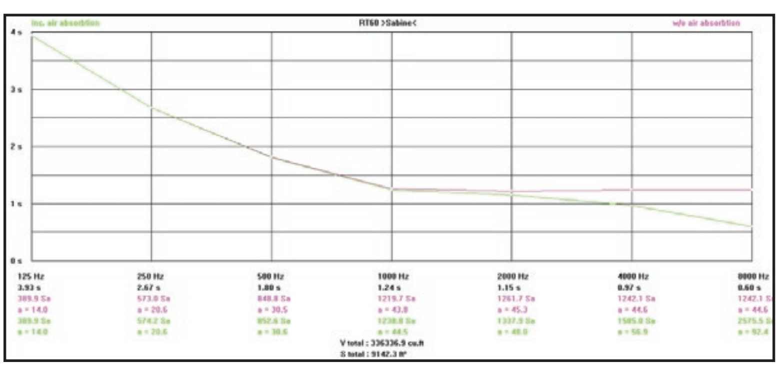


The Calculation Properties submenu.

Reverberation

Once the model is generated, the room surfaces can be coated with materials using the standard octave-spaced absorption coefficients. This is necessary for performing reverberation studies on the space as a whole, and for reflection studies for specific listener seats. The absorption data can be entered manually, or imported from other major design applications.

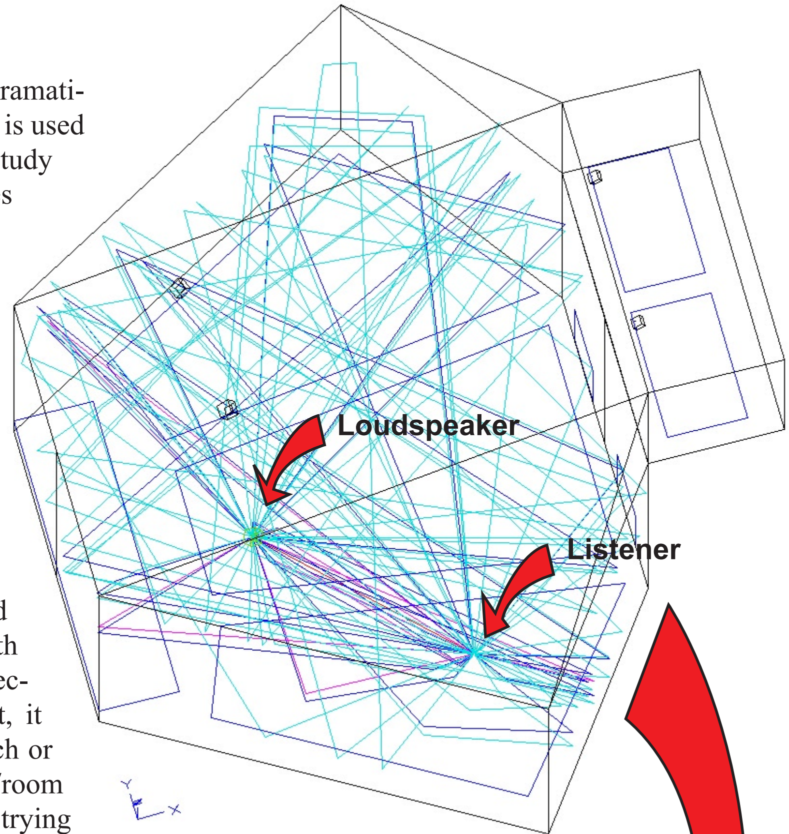
Statistical reverberation times can be estimated using the major classical formulas. The Sabine equation works best for rooms with very low absorption that is uniformly distributed throughout the space. The Eyring equation is an attempt to improve on the Sabine equation's accuracy for rooms with higher absorption. The Fitzroy equation considers the effects of some major room surfaces that have significantly more absorption than others. Ulysses provides calculations for all three, as well as an input box that allows the user to enter measured values. This provides an excellent opportunity for comparing the algorithms, and allows intelligibility calculations to be performed with the last one selected.



Octave-band RT60 and absorption data is presented in graphical format. The RT60 calculation methods include Sabine, Eyring, Fitzroy and a manual process for inputting measured values. Frequency-dependent losses due to air absorption are also predicted.

Reflection Studies

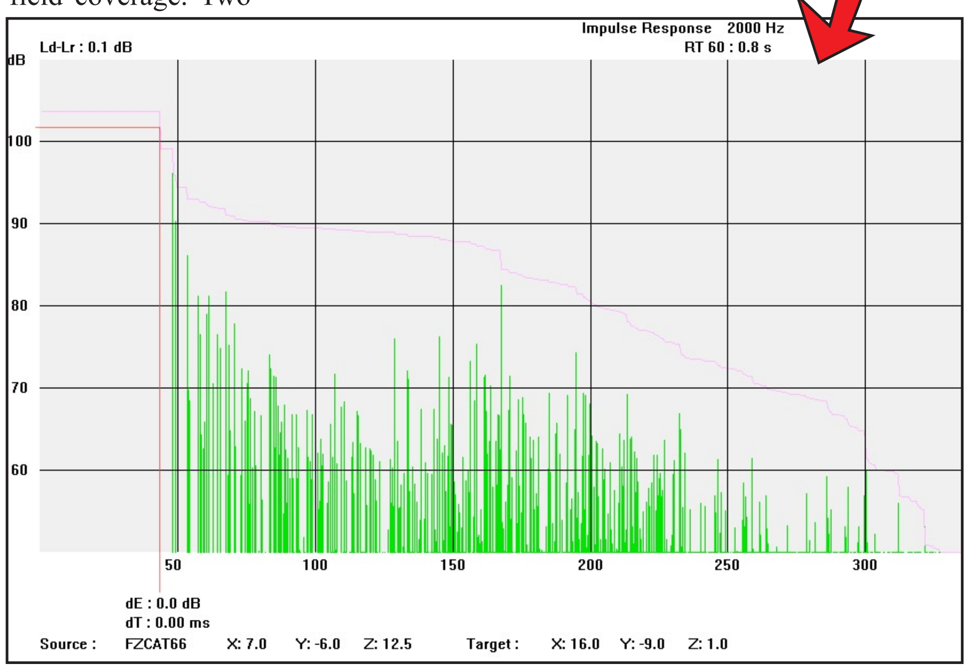
The performance of any sound system is dramatically affected by room reflections. Once Ulysses is used to map the direct field coverage, a reflection study can be performed for any point in the room. It uses a very accurate image/source routine for the low order reflections, and a faster, ray tracing routine for the late energy. The combination of the two methods produces a nice compromise between speed and accuracy, and is likely to make reflections studies routine for a design project rather than a high-end afterthought.

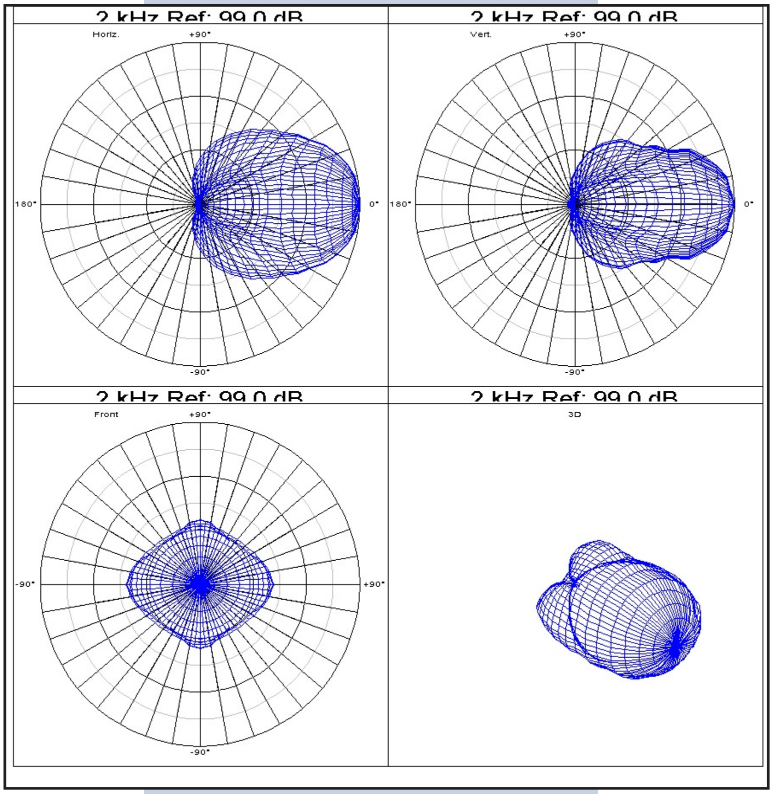


Reflection studies require the user to select a sound source(s) and a single listener position. The result is representative of what would be measured at the listener position using an omnidirectional microphone with flat frequency response.

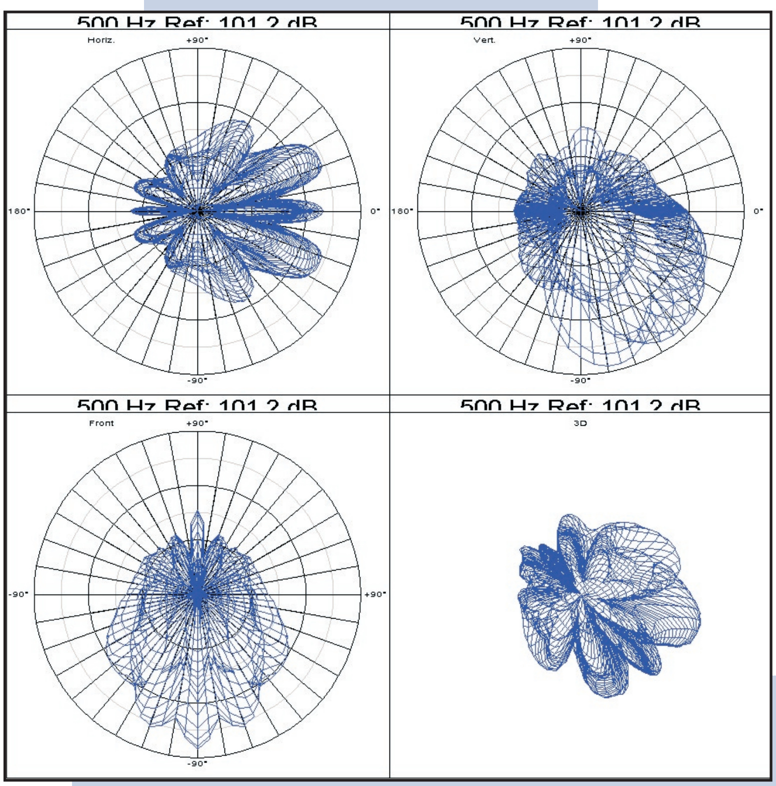
Auralization

Many sound designers do not use auralization as a design tool because it can be complicated and expensive. Ulysses makes it fast and simple with its included auralization engine. Once the reflectogram is generated for a specific listener seat, it can be used to process monaural anechoic speech or music to get a representation of what the system/room might sound like. This can be a great asset when trying to sell the client on rear wall or balcony face treatment. The auralization engine is very fast, and does not require the purchase of additional software modules. Two methods are included. A quick "real-time" auralization can be performed by right-clicking on any point in an audience area. It includes the direct field and first order reflections, as well as some dithered reflections based on the statistical reverberation time. The quick auralization is useful for showing things like what happens as you move off-axis from a loudspeaker, or up into a balcony that has no direct field coverage. Two additional auralization routines are available after the generation of a reflectogram. The APF method performs the convolution without any algorithms to increase speed or reduce data file sizes. It is a post-process and the result is saved to a file. The RTA process limits the number of pulses to 500, and adds a statistical tail as per the most recent RT60 calculation. It is a nice compromise between the right-click and APF methods. All of the methods are very fast and simple to implement, making it more likely that they will actually get used to evaluate the design.

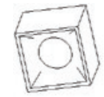




The 500 Hz octave band balloon of a single loudspeaker

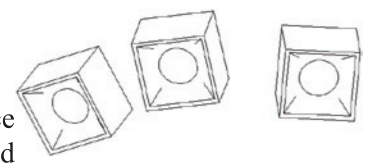


The 500 Hz octave band balloon of a three-loudspeaker array



Loudspeaker Data

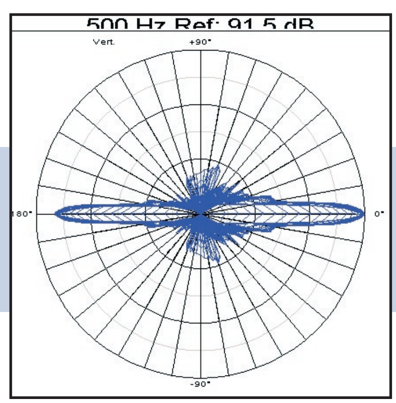
Ulysses uses five-degree spherical mapping data to describe loudspeaker performance. A separate module is included to manage and review this data, which can be measured and entered directly, or imported from other design application databases. I had no problem quickly importing data from several platforms. Loudspeaker cases can be drawn using a subset of the standard Ulysses drawing commands. Shown at left is the 500 Hz balloon for a loudspeaker of moderate physical size. Is five-degree one-octave resolution high enough? I believe that it is for the purposes of sound system design. Higher resolutions mean more data and longer processing times, not to mention the additional burden on manufacturers to supply it. Most design issues that require higher resolution (i.e. signal alignment, equalization) should be handled in situ using measurement rather than with prediction tools.



Arrays

Array performance can be calculated by selecting a group of loudspeakers from the room model. ULYSSES calculates its geometrical center from the geometrical centers of all loudspeakers selected and scans a sphere of 100 m radius around the new center in 5° steps. The calculation generates a complex L_P sum of all selected loudspeakers in the octave bands from 125 Hz to 8 kHz. Each octave band is calculated by the mean complex value of its three 1/3 octave bands.

Line arrays can be modeled in Ulysses by creating arrays of discrete devices. Below is the side view of the 500 Hz balloon of a vertical stack (10) of low-Q sources spaced at 0.5 meter intervals.



Conclusion

Like any engineering application, ULYSSES has a learning curve that must be endured by the designer. Fortunately, the curve is neither steep nor long, and those well-grounded in their basics should be correctly building rooms in a few hours. The help files are built into the application, and a short tutorial is available. ULYSSES has many hidden features and time-saving keystrokes that one is unlikely to find by intuition alone.

In the same way that a good sound system is one that forms a good compromise between the variables, ULYSSES' developers have reached a good balance between what *can* be predicted about a sound system and what the system designer needs to know. There is not a lot of "fluff" outside of the basics, but those basics are implemented in a very powerful and usable manner. The ability to *quickly* generate reflectogram studies and auralizations move the use of these simulations into the mainstream. They are an intuitive next step in the design process rather than a complicated and expensive esoteric feature. ULYSSES presents a nice "middle ground" between the more basic applications that cost much less and the "pull no punches" applications that can cost much more.

ULYSSES is not a new program for our industry. It has been around for several years, and has enjoyed a larger following in Europe than in the United States. Support from a major US manufacturer and a more mature design marketplace will likely make this application much more common among designers.

Ulysses is available online from www.ifbsoft.de. Distribution in the US and Caribbean is through Community Professional Loudspeakers. Contact them at www.loudspeakers.net or email info@loudspeakers.net. *pb*