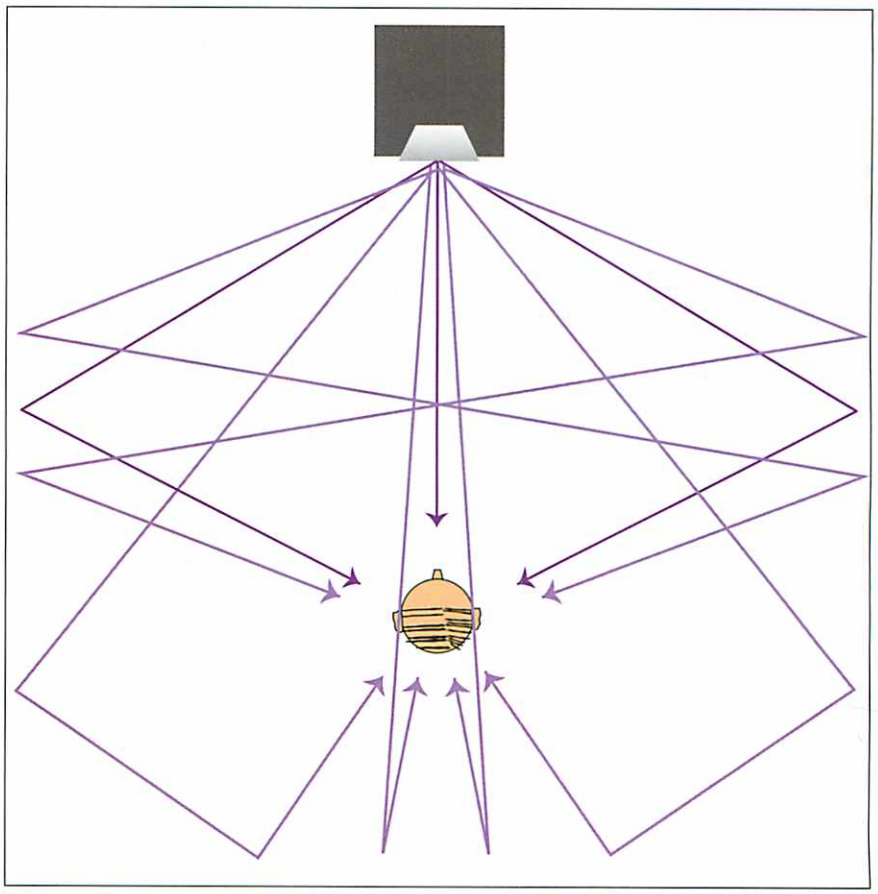
The direct approach

SPEAKERS TYPICALLY RADIATE SOME SOUND IN ALL DIRECTIONS. THE ONLY QUESTIONS ARE HOW MUCH AND AT WHAT FREQUENCIES. **ANTHONY GRIMANI** EXPLAINS THAT THERE'S ACTUALLY A SPECIFICATION CALLED THE DIRECTIVITY INDEX (DI) WHICH ANSWERS THESE QUESTIONS.

Not too long ago, a project came our way. The client had already picked out his speaker system based on a demo he'd heard in a manufacturer's experience centre, but he needed help with acoustic design.

We were happy to oblige, of course. After we got into the particulars, we discovered that he had, quite innocently, picked a speaker that was entirely wrong for his room. It was a good speaker; I'm sure it had sounded great when he heard it in the showroom. In another room, it would have been a great choice. But not here.

So, how did we know? And what do you need to know so that you can be the one making the right choice for speakers?



At the listening position you actually hear more reflected sound than direct. The room plays an important part in the sound you hear, and speaker directivity affects those reflected sounds.

WHAT IS DIRECTIVITY?

There's actually a specification called Directivity Index (DI) which is an important tool in figuring out the amount of reflection a speaker emits.

Never heard of it? I'm not surprised. Many manufacturers don't even calculate the directivity of their home cinema speakers, and even fewer publicise it. So what is it? In simple terms, DI is the ratio between the sound a speaker radiates on the listening axis (the axial response) and what it radiates in all other directions (the sound power response).

WHY IS DIRECTIVITY IMPORTANT?

At the listening position, the ratio between direct sound energy from the speaker and reflected sound energy from the room is one of the most important contributing factors to sound quality.

That ratio depends largely on the speaker's directivity. If the speaker's dispersion is broad, there will be lots of energy sprayed around the room and reflected back to the listening position. If the dispersion is narrow, there will be substantially less reflected energy around the room and at the listening position.

In a small room, fairly wide dispersion is desirable to increase spaciousness and keep the soundfield from being too in-your-face and potentially even collapsing into the speakers. In a large room, you want a speaker with more focused dispersion to prevent the soundfield from becoming so spacious that directional and imaging cues are lost.

Ultimately, the desired ratio of direct-to-reflected sound energy in the small and large rooms is the same; it must be achieved differently using wide dispersion in one and narrow dispersion in the other.

HOW DOES DIRECTIVITY WORK?

Audio academia uses a concept called a 'pulsating sphere' to explain directivity.

A pulsating sphere is a theoretical device that is infinitely small and radiates all audible frequencies in all directions. Put that pulsating sphere in a cabinet and you get a perfectly hemispherical radiation pattern above

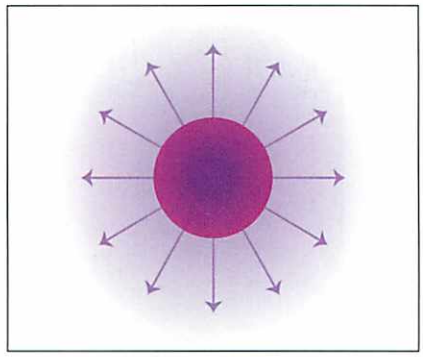
the frequency where the cabinet baffles the sound waves. Transducers behave just like a pulsating sphere over some of the frequency range, but they reach a point where the length of the sound waves becomes small compared to the transducer diaphragm. Above this point, the diaphragm itself focuses the sound.

As frequency increases, the sound waves get more and more focused until they reach a point where all sound is radiated on a very tight beam. Because of this beaming problem, multiple transducers are used in full range speakers. The larger units play the low frequencies where large volumes of air need to be displaced but beaming is not a problem because the wavelengths are long. Smaller transducers are used at high frequencies to avoid beaming.

These basic principles mix in different ways to determine the directivity of a speaker. Depending on the cabinet dimensions, transducer size and transducer arrangement, the directivity of speaker can vary dramatically.

HOW IS DIRECTIVITY SPECIFIED?

Usually, directivity is specified as a single number called DI that represents the difference, in dB, between the axial response and sound power. A low DI means a speaker sprays sound pretty evenly in all directions. A high DI means a speaker focuses sound in a very tight pattern. A pulsating sphere would be 0. Typical home cinema speakers usually weigh in at about 6. A THX-certified home cinema speaker is a little higher at 8. A big cinema speaker for a large auditorium would be something like 12.



A pulsating sphere and its flat axial response radiates sound evenly in all directions.

REASONS FOR DIRECTIVITY

Since most home cinema speakers have relatively low DI, you should take note when one doesn't. There are typically two reasons for it. Neither is inherently good or bad.

The first is that the designer understands the importance of balancing direct-to-reflected sound in a room and is designing the speaker for large rooms to generate less reflected sound energy. This type of speaker will typically also have excellent off-axis frequency response, since the designer is obviously concerned about room acoustics. This makes such a speaker an excellent all-around choice for a large room.

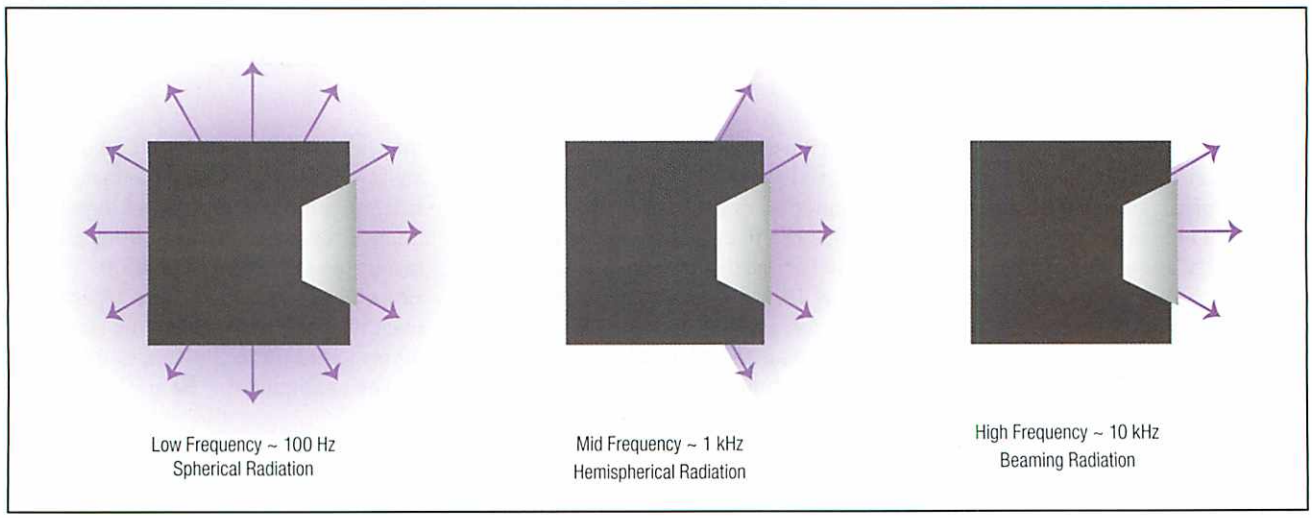
The second reason is that the manufacturer is trying to build a speaker with high sensitivity to achieve extremely loud SPLs. If you take a transducer in a cabinet, its sensitivity might be 85dB @ 1W. Load it with a compression horn, and that can jump to 100dB! Same power, 15dB more output. The DI of the speaker is also increased, but that may not be the primary goal of the design. Such a speaker may also work very well in a large room, but you should carefully investigate other parameters like off-axis response.

APPLICATIONS OF DIRECTIVITY

You can use directivity to help choose the right speaker for every application. You already know generally what to do in a large or small room, but let's talk specifics.

What about a room with no acoustical treatment? Acoustical treatments lower the amount of reflected sound energy, so you can select a speaker with a lower DI. This is true regardless of room size, but critically important in large rooms. It is well-documented in psychoacoustics research reports that ceiling and floor reflections are the most detrimental to imaging accuracy, so speakers with focused vertical dispersion are always a good idea in a room with no acoustical treatments.

What kind of speaker has focused vertical dispersion? Look for something



A variable dispersion model.

with vertically-arrayed transducers, such as a 2- or 3-way D'Appolito array – particularly one with a horn-loaded tweeter. In the case of a large room, focused dispersion provides an additional advantage: the speaker experiences less sound pressure loss over distance. D'Appolito arrays and horns work very much like a nozzle on a garden hose. Without the nozzle, water pours randomly from the hose. With the nozzle, water is focused in a tighter pattern and projects much further. Sound works the same way.

Let's say you're working on a really well-treated room. What kind of speaker should go in there? One with a high DI may sound too sharp and tight, so think about a speaker with broader dispersion. A traditional 2-way might be the best choice for smaller rooms. Still, in a really large room where the listeners are far away from the speakers, you should head back toward a focused D'Appolito array, although less focused than you would in a comparably-sized room with no treatment.

Directivity can go a long way toward solving the surround speaker conundrum that people endlessly debate these days. Our hearing's directional delineation does not remain constant around the head in a 360 degree circle, so surround speakers positioned to the sides and back of the head should not necessarily have the same directivity as LCR speakers positioned in front of the head.

In a small, treated room, several methods can be employed to reduce the directivity of surround speakers so that they disappear into the soundfield, yet form nice clear images with the LCR speakers. One method is to use a surround speaker with broader dispersion, such as a dipole or bipole.

Large rooms naturally enhance the reverberant field of a speaker, so dipoles or bipoles are often unnecessary. Surround speakers can be more directional without becoming distracting and without integrating poorly with the LCR speakers.

The traditional 2-way speaker is okay in larger rooms. The sound is dominated by reflections from 3kHz down.

Multi-channel music and film may need more envelopment in smaller rooms to avoid distractions. Use dipoles and bipoles.

The traditional 2-way speaker is the magic balance for 2-channel music and for multi-channel sound in a small room. It produces good envelopment and sufficient directional cues at high frequencies.

Multi-channel music and film in a larger room may need more focused front speakers to avoid cacophony.

DIRECTIVITY IN THE REAL WORLD

In the case of our client, he had picked a speaker with a DI of 12. The room where he auditioned them was big – at least 9m long. In that room, they were great. However, he was building a much smaller room slightly less than 30m². In that room, those same speakers would sound like they were trying to crawl down his ears. We provided him with comparative demonstrations of speakers with high and low DI, and eventually, he picked speakers with a DI closer to 8 on his own; perfect!

Using the little bit of information I've provided on directivity, you can do this same kind of thing for your clients and avoid big disappointments when they finally sit down to listen. I won't say it will always be easy – in fact, it's extremely difficult and sometimes impossible to get DI values from your favourite speaker manufacturer. However, it's knowledge and experience like this that make your rooms sound better than everyone else's, and that makes happy clients! CH

MSR Acoustics is represented in Australia by Wavetrain (www.wavetrain.com.au). Chase Walton contributed to this column.