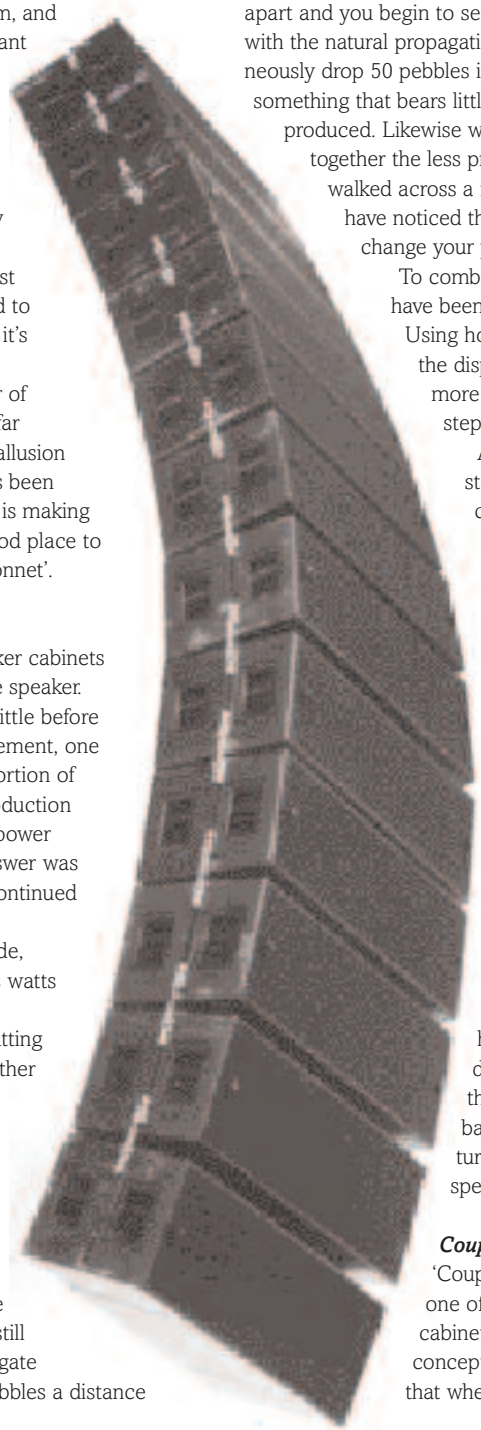
Line Arrays Explained

Line arrays are sure to play a large part of our sound reinforcement future. Christopher Holder explains what we're dealing with.

Line arrays: everybody's talking about them, and they seem destined to make up a significant part of our live sound future. It's worth laying bare the facts regarding this technology. We've seen everybody from Barbra Streisand to Metallica on tour with line arrays, and more and more performers are making a point of specifying these systems by name – finding applications in touring, corporate and special events, and theatre (West End stage production, *Mama Mia*, is rumoured to arrive in Australia soon using a line array). So it's worth knowing what we're dealing with.

I should note here that because the number of true line array systems are currently few and far between, you'll have to excuse the numerous allusion to L-Acoustics' V-DOSC system. V-DOSC has been around a while, has been proven to work, and is making its presence really felt in Australia, so it's a good place to start when understanding what's 'under the bonnet'.



What's a line array?

In a nutshell, a line array is a column of speaker cabinets designed to collectively function like one large speaker.

We should probably turn back the clock a little before we go on: in the early days of sound reinforcement, one speaker would normally be directed at one portion of the audience. As the demands of concert production increased, more power was required – more power than one cabinet could offer. The obvious answer was to set up more cabinets. This evolution has continued apace, to the point where a large production currently may entail 50 or more cabinets a side, dozens of sub woofers and tens of thousands watts of amplifier power.

While such a rig is impressive to behold, putting that number (or any number) of cabinets together inevitably causes a few sonic problems.

The main one involves the overlapping nature of these speakers' coverage. When the sound from a number of speakers interact and overlap, a variety of phenomena occurs. You can file much of it under the label, 'Destructive Interference'. Consider the analogy of a speaker producing sound like the ripples a pebble makes as it's dropped into a still pond. Drop one pebble, and the ripples propagate outward without being impeded. Drop two pebbles a distance apart and you begin to see how the ripples interact and interfere with the natural propagation of an unhindered ripple. Now simultaneously drop 50 pebbles into that pond and you will witness something that bears little resemblance to what the single pebble produced. Likewise with speaker cabinets, the more you put together the less predictable the results. Anyone who has walked across a room during a concert, or at a club, will have noticed that the sound can alter markedly as you change your position.

To combat this phenomenon, PA manufacturers have been making their cabinets more directional. Using horns and waveguides they've been making the dispersion characteristics of their cabinets more predictable. Thus each speaker should step on each other's 'toes' a little less.

A line array takes this philosophy another step. The vertical dispersion of each of the cabinets is narrowed considerably. The idea is to have a vertical string, or array, of these cabinets, on top of each other and you get full coverage without interference – so goes the theory.

Line arrays are a new development?

No, the benefits of putting a number of cabinets together and have them function like one big speaker have been well known for some time. If you saw our interview with Bruce Jackson last issue you would have read about how he used Clair Brothers' new i4 line array system at Barbra Streisand's concerts in Australia. But, in fact, Clair has been advocating line arrays for some time. Likewise, EAW's KF860 line array has been around for the best part of a decade, and, if we look back even further, the JBL 4682 line array was on the market back in 1975. So these, and other manufacturers, recognised the benefits of coupling speakers to form line arrays for years.

Coupling? How do you mean?

'Coupling' is a phenomenon which describes one of the fundamentals of getting multiple cabinets to act together like one big speaker, a concept which line arrays are based on. It means that when you put a number of speakers close

enough together, they actually take on the characteristics of one speaker. Anyone who's owned a bass guitar 'quad box' will be familiar with this phenomenon. How can four relatively small speaker cones produce bass frequencies normally only reproduced by a 15- or 18-inch speaker? Coupling is your answer – in that case the four smaller speakers combine to take on the characteristics of a larger one.

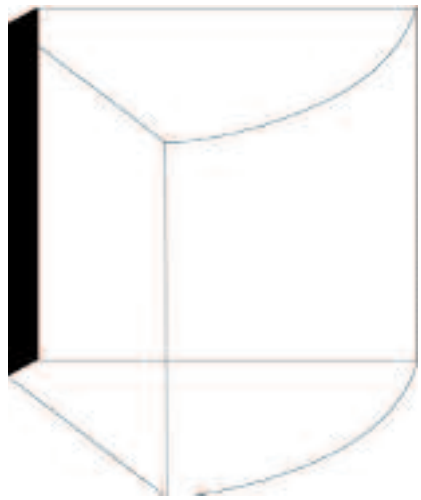
Okay, line arrays have been around for a while, so what's the big deal about the new line arrays then?

Putting speakers close together and using the resulting coupling phenomenon to form line array systems mightn't be new, but in the past the coupling of speakers was only possible for the lows and mids, while it wasn't possible to couple the high end drivers.

The problem is, if you don't couple the high end then the sound from your array will still tend to propagate outwards in all directions, i.e. 'spherically', like a conventional rig. But when you couple the high end as well as the lows and mids the whole array acts as a coherent line 'source' array, where the sound propagates 'cylindrically'.

Confused? To imagine what cylindrical propagation looks like, think of each cabinet in the array producing a 'cheese wedge' of sound.

Why's it so difficult to couple the high end to produce a line 'source' array?



Sound from a true line (source) array propogates cylindrically, rather than spherically, resulting in a 'cheese wedge' of sound.

L-Acoustics in their research found that, (whether it's the lows, the mids or the highs), there's an optimum distance which should be maintained between the acoustic centres of adjacent speakers/drivers. They called this distance the 'Step', and it's less

JPS's Wyn Milsom talks V-DOSC with Christopher Holder

The L-Acoustics' philosophy isn't so much about shifting boxes as imparting the whole L-Acoustics' ethos to new clients. For example, before a new system is shipped, the network partner's staff needs to attend training courses to become accredited V-DOSC certified engineers (VCEs). Furthermore, systems are shipped as a complete package with all necessary rigging, cabling, dollies… in fact, every widget, grommit and wopple sprocket comes with the system to ensure that what L-Acoustics 'vision' is carried out to the letter. Which all sounds a bit high-handed and anally retentive really. That is, until you learn of the degree of precision which L-Acoustics is demanding to achieve the V-DOSC rig's full capabilities. I had a chat with Senior Sound Designer, Wyn Milsom, who's heading up Jands' line array program, to learn some more.

One of these V-DOSC systems seems like quite a commitment.

Well, it is a commitment. It's the first time we've had a system that's been so completely designed in every detail by the manufacturer. The V-DOSC cabinets, or 'elements' as they call them, are only part of the investment. For example, we've needed to buy laser range finders and digital inclinometers to ensure the angle of the rig is spot on to the nearest 0.75 degree. While we've also had to invest in new fully shockmounted Crown MA5002 amp racks which we can fly.

Fly? Why's that?

L-Acoustics, to achieve the required damping factor, will only recommend a maximum 25m cable (on 4mm-squared conductors) between amps and speakers, so in some cases we'll need to fly the amps. But on top of that there's the CAD spreadsheet software, which allows us to predict with a great degree of accuracy the performance of a system in any given venue. No other system has required me to fully survey a venue before I specify the rig – that's the sort of level of detail required to get the most out of the V-DOSC system. Gone are days where you could 'eye-ball' a rig and 'guess-timate' how it should look like based on experience.

What are some of the advantages you see this V-DOSC system having?

There's quite a few, but a significant difference comes out of the fact that a V-DOSC array behaves as one continuous time point – it holds true down the full length of the array. Traditionally, if we go into theatres, we might put up a number of clusters and each one of those has to be independently time aligned to time zero (i.e. originating from a predetermined point on stage) – because if you don't do that you get certain areas which sound horrible. But with V-DOSC you don't have to worry about it. It's all one point source.

The other thing, not so readily noticeably, is that because it's such a defined sound source, if you're out of the sound field horizontally or vertically, the isolation drops off rapidly – the level drops off 20dB almost instantaneously. So, as an artist with a mic, you can get a lot closer to this system – just so long as you don't walk directly in front of it. The array doesn't have to be right out in front of the stage, in fact we've had instances where we've flown behind performers. A lot of the limitations of conventional systems have been removed.

So you're obviously enthusiastic about the sort of impact a system like this can have?

Look, once you hear it, you can't go back. When you're mixing with V-DOSC, it's like having nearfield monitors on your desk. They give you that nearfield sound where they reproduce everything on your desk, you can hear every change you make. It sounds clear and even across the whole audience, along with an enormous amount of headroom… you take that away, and it's frustrating.

Honestly, I think a line array technology like V-DOSC will give the sound industry a new lease of life – it's a pleasure to mix again on these systems. Sometimes as a sound engineer, you can be given the greatest gear around but the venue will stick you under a balcony or in the back corner, and you think, "what's the point of making the effort". Then to suddenly find you're given some tools where you can get around those inevitable constraints – it's almost like revenge after all these years! I want to go back into those venues and use this system, because I want to prove that the limitations in the past were just the technology. For me that's the best part about V-DOSC – the power is put back into the hands of the engineer, no longer are there a bunch of problems beyond his or her control. Which is exciting stuff.

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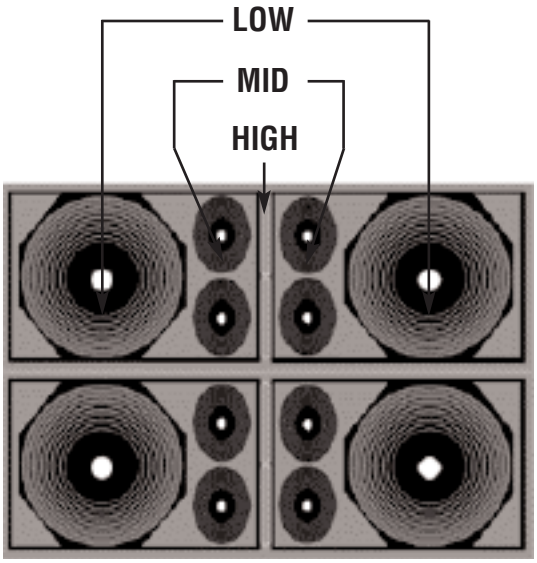


A diagram of the V-DOSC. Notice the co-planar symmetry.

V-DOSC Fact File

• V-DOSC: the 'V' refers to the V-shaped acoustic lens configuration, employed for the mid and high frequency sections. The 'DOSC' stands for Diffuseur Onde Sonore Cylindrique (French for 'Cylindrical Wave Generator').

• At the heart of the V-DOSC system is the DOSC waveguide, which permits higher frequencies (above 1.3k) to propagate from the array cylindrically rather than spherically.

• V-DOSC is designed as a system consisting of identical, vertically-arrayable 'elements'.

• Each V-DOSC element is a three-way full-frequency box, comprising two by 15-inch woofers, four midrange units and two HF waveguides. The driver configuration is symmetrical for uniformity of sound across the full 90 degree horizontal coverage.

• Each element radiates a flat, constant, phase coherent wavefront (or 'cheese wedge' of sound), allowing the overall array to produce a single extended sound source (i.e. one big speaker).

• The smaller dV-DOSC element is two-way (two by eight-inch drivers and one HF waveguide), mostly configured as a 'threesome' at the base of the V-DOSC array for down-fill duties. The dV-DOSC has a 120 degree horizontal dispersion rather than 90 degrees.

• The ARCS cabinet is a two-way system employing a 15-inch driver and one HF waveguide. It's designed to provide narrow coverage in the horizontal plane rather than the vertical. It offers 22.5 degree horizontal coverage, while in the vertical plane it provides 20 degree coverage down and forty degrees coverage upwards (or vice versa). The ARCS is built to be used in non-array applications where coverage by the V-DOSC cabinets is impractical – e.g. in-fills or front-fills.

• The SB218 subs woofers make up the range and use two by 18-inch drivers, they are conventional in their design, but can be flown in vertical columns.

• The maximum angle of separation between individual V-DOSC elements is 5.5 degrees. Beyond that the coherency of the array starts to break down.

• L-Acoustics only spec their own LA48 amplifier, or Crown 5000w amplifiers. JPS use the Crown 5002 amps. Their flown amp racks are packaged in racks of four, with each bank of two amps functioning independently of each other. Each bank of two amps can drive either: three V-DOSC, six dV-DOSC, six ARCS, or four SB3218 subs.

than half the wavelength of all frequencies in those speakers' bandwidth.

For example, a three-way line array would need approximate spacing like this – low end speakers: 18 inches; mids: nine to 10 inches; while the HF drivers should be around one inch apart.

As you can see, there's no probs getting the lows and mids close enough, but it's a much tougher prospect jamming the HF drivers closer enough to couple. (If the HF drivers are too far apart, a coherent summation won't be possible and, as a result, interference occurs throughout most of the high frequency range.)

First cab off the rank to successfully address this curly issue was L-Acoustics with their V-DOSC system. Using their proprietary Wavefront Sculpture Technology (WST) they got around this problem by developing a clever waveguide for each of the two HF compression drivers in their V-DOSC cabinet. The waveguide allows the HF drivers of the cabinets in an array to effectively couple, allowing the highs to propagate outwards like, you guessed it, a cheese wedge, along with the lows and mids – the result is a coherent sound source. Something never done before.

So the clever stuff isn't in the transducer, or some fancy electronic processing then?

Not so much. Although L-Acoustics use their own customised components and drivers, it's the DOSC waveguide which has been patented and is top secret.

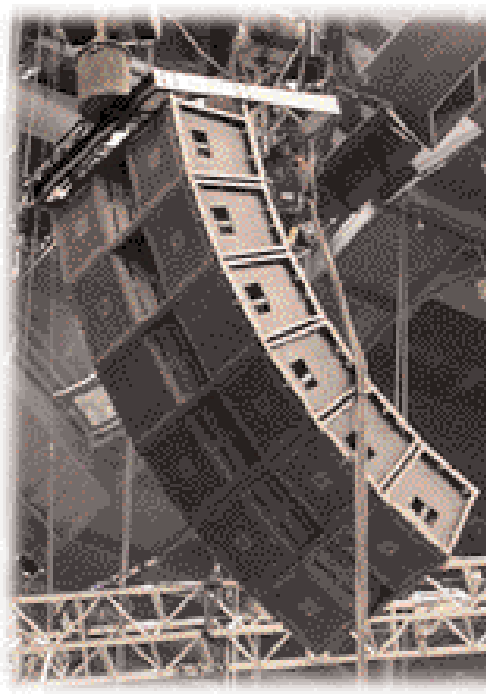
You use the 'cheese wedge' analogy, but if you're sitting out near the edge of the 'wedge', you're not going to get the same levels as if you're sitting in the middle of the 'wedge', surely?

The idea is that you do. For example, the V-DOSC cabinets have been designed to use what they call 'Coplanar Symmetry'. It's a term which describes the way in which L-Acoustics aims to achieve perfect coherence and consistency at any angle within the horizontal coverage area – 90 degrees in the case of V-DOSC. That's the reason why a V-DOSC cabinet is built with the HF outputs of the waveguides placed vertically in the middle of the enclosure, the midrange drivers symmetrically aligned on each side of these outputs, and the LF drivers on the outsides of the mid drivers.

That's all well and good but one thing which your cylindrical 'cheese wedge' can't escape from is the 'inverse square law'. I mean, you can have perfect coherence and coverage but the sound pressure level is still dropping as a square of the distance – if I'm in 'the gods' with only one box pointed at me, I'm not going to be hearing much.

This is a tricky one to explain, but a coherent line (source) array like V-DOSC doesn't play by the same inverse square rules. When you look at the nature of how sound levels decrease as you move further from a speaker, you can observe that there are two discrete fields – the near field and the far field – and therefore two discrete rates of level attenuation over distance. Traditionally, we've been used to how PA speakers function in the far field – this is where the inverse square rule reigns supreme. Meanwhile, in the near field, sound intensity decreases proportionately with the distance from the speaker (naturally), but *not* by the *square* of the distance, i.e. level doesn't drop nearly as quickly in the near field.

Unfortunately the near field as it pertains to a conventional speaker is very near indeed – i.e. before the sound makes it to the audience in most cases. The near field zone is calculated as extending proportionate to the square of the relevant dimension of the sound source. So,



A new JBL VerTec line array system, fresh off the production line.

you know how we've been discussing how these speakers in the array effectively form one large speaker? Well, the knock-on benefit is that a huge speaker has a very large near field indeed – in fact, way out into the audience. So, rather than the SPL dropping 6dB at double the distance from the cluster, a coherent line (source) array only drops by 3dB. Of course, after a distance, the line array signal will enter the far field, whereupon the inverse square law again rules with an iron fist. But, when you think about the ramifications of this extended near field, the advantages are considerable – fewer cabinets required, less amps required, often no delay systems would be required, etc.

These line source arrays sound almost too good to be true, what's the future for conventional speaker cabinet technology?

Line arrays certainly look here to stay, and few would disagree that they can only become more popular. It's true that many of the PA manufacturing 'big guns' are pouring considerable resources into developing their own line array systems, and we are seeing 'new' players currently entering the fray. So why are PA giants like Clair, JBL, EV and (undeniably) others following the lead of L-Acoustics, a comparatively tiny French company residing in a farmhouse outside Paris? In many applications there's a quantifiable increase in sound quality; the cabinets are more compact with quicker setup times; and a line array rig can typically occupy half the truck space of a conventional system. Much of this keeps the accountants happy. Also the slim-line nature of a line array setup excites the promoters because there's improved sight lines to the stage – so the cabinets aren't obscuring lighting and staging designs so much.

Currently many leading rental companies worldwide believe line array technology will eventually phase out conventional systems. Obviously, this won't happen overnight, and depending on the application there is certainly a place for both technologies.