# Harpex Ltd

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## Flat 3D microphones: Ambisonics

While it may be counter-intuitive that a flat microphone array can produce a 3D ambisonic signal, it turns out that they can actually do the job very well. Intuitively, it can be understood as the combination of two different phenomena:

1. In the plane of the array, time delay provides information about the source direction.
2. On the axis normal to the array, the baffle provides a boost of up to 6 dB for the microphones facing the source (the boundary effect) and an attenuation of 3 dB for those on the shadow side. The level and time difference provides information about the source direction.

A more detailed analysis will need to take the precise scattering pattern into account. While complicated, it is perfectly linear and predictable. These effects can therefore be harnessed to produce an ambisonic signal of any order, only limited by the size of the baffle and the number of microphones. The conversion process is linear and time-invariant, and therefore has no artifacts, short latency and low computational cost.

All higher-order ambisonic microphone arrays are subject to the same design trade-off: The microphones need to be close together to avoid aliasing at high frequencies, but also have to be far apart to give a good low-frequency response.

In tetrahedral arrays, a similar trade-off exists in that a small array radius, needed for the high end of the spectrum, dictates the use of small capsules, which are less sensitive and hence noisier than larger ones.

A flat array addresses this fundamental conundrum by providing access to several radiuses. The microphones closest to the center are used at high frequencies, and the ones at the edge are used at low frequencies, providing low noise and high spatial resolution across a wide frequency range.

An example of how this translates into practice: A flat array with 84 IM-69D130 microphones placed on a 17 cm diameter baffle can emulate a theoretical tetrahedral array whose capsules have a self-noise of 13 dBA / 21 dB CCIR-468 with an array radius of 2 mm. This is at the same time quieter than any existing array and about an order of magnitude more compact.

For a more in-depth treatment, please refer to

Berge, Svein. "Acoustically hard 2D arrays for 3D HOA." 2019 AES International Conference on Immersive and Interactive Audio. Audio Engineering Society, 2019.

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