



# Directional Noise-Embedded Audio (DNEA): Targeted Sound in a Noisy World

This presentation delves into the fascinating world of Directional Noise-Embedded Audio (DNEA), exploring its potential to deliver targeted sound in a world increasingly filled with noise. DNEA offers a more practical approach to "lazer audio transmission" than purely theoretical fantasies, using noise embedding to achieve directional sound.



**by Marc Tuinier**

# Focusing Sound: The Directional Foundation of DNEA

## Phased Array of Speakers

DNEA relies on the power of phased arrays of speakers. This involves multiple small speakers, arranged in a specific configuration, to create and steer sound waves in a precise direction. The speaker positions are not just random; they are carefully chosen to ensure that sound waves emitted from each speaker interfere constructively or destructively, depending on the desired direction of the audio beam.

## Beamforming Principles

Beamforming is a core principle behind DNEA. By strategically controlling the timing and phase of sound waves emitted from multiple speakers, we can create narrow sound beams, concentrating the audio energy in a desired direction. This is achieved by exploiting the interference patterns created by the overlapping sound waves, leading to a focused sound experience.

## Beam Steering

DNEA utilizes electronic control to dynamically steer the sound beam. The technology allows for real-time adjustment of the audio direction, whether it's tracking a moving listener or adapting to changing environments. This dynamic control is a crucial aspect of DNEA, enabling flexible and responsive audio delivery.

# The "Snowing Sound" Carrier: Blending In, Carrying the Message

## 1 Engineered Ambient Noise

DNEA employs a carefully crafted "structured ambient noise" profile as a carrier wave. It's no longer just a random "snowing sound" but a refined noise designed to blend seamlessly with the environment it's used in. This noise acts as the "carrier" for the desired audio message, ensuring the message gets delivered discreetly within the existing sound environment.

## 2 Frequency Shaping

The carrier noise in DNEA is not just "white noise." It's meticulously shaped across different frequencies to maximize its effectiveness for directionality. The higher frequencies in the carrier noise profile contribute to the directional nature of the sound beam, while the lower frequencies help mask the desired message within the ambient noise spectrum. This frequency shaping is critical for both efficient directionality and effective masking, ensuring the message is delivered discreetly within the existing sound environment.

## 3 Subtle Temporal Structure

The carrier noise is not merely a static, random signal. It often contains subtle temporal structures, such as imperceptible rhythms or patterns, to further enhance the modulation of the desired audio message. These subtle variations in the carrier noise enhance the effectiveness of the embedding process, making the message more resistant to interference and easier to extract for the intended listener.

# Strategic Noise Masking: Less is More for Effective Targeting

## Adaptive Masking

The noise masking in DNEA is adaptive, meaning it's not a static, pre-defined noise level. The system constantly analyzes the ambient noise environment and dynamically adjusts the masking noise spectrum to ensure optimal delivery of the desired audio message. This dynamic adaptation is crucial for effectiveness in diverse and changing environments.

## Perceptual "Gaps"

DNEA aims for subtle perceptual shifts, not stark "holes" in the noise. The masking noise is carefully shaped within the target zone, creating a "gap" in the perceived noise level that enhances the clarity of the desired audio message. This approach minimizes the potential for discomfort or annoyance caused by overly distinct masking noise.

## Context-Aware Noise Selection

The type of noise used in DNEA isn't always just "white noise." The system uses context-aware noise selection, choosing different noise profiles based on the environment. For example, a bustling city street might use a different noise profile than a quiet library, ensuring that the noise blends naturally and effectively masks the desired audio message.

# DNEA in Action: Practical Applications Across Diverse Scenarios



## Museums & Exhibits

Imagine personalized audio descriptions in museums without headphones, minimizing sound pollution and allowing visitors to enjoy the exhibits without interruption. DNEA could provide audio information only to the visitor standing near a specific exhibit, creating an immersive experience without disturbing others.



## Retail & Digital Signage

DNEA could revolutionize retail experiences. Targeted promotions could be delivered directly to shoppers at specific displays, engaging them with personalized offers and information without overwhelming them with general announcements. This personalized and contextual approach can enhance engagement and drive sales.



## Quiet Offices & Co-working

In quiet office environments, DNEA could provide discreet notifications and private messages without disrupting colleagues. This allows for focused work without the need for headphones, creating a more collaborative and productive environment.

# Technology Building Blocks: Real-World Systems Inspiring DNEA

## Parametric Speakers

Commercially available directional audio systems like Parametric Speakers are already used in museums and retail settings, demonstrating the feasibility of delivering targeted sound. These systems employ principles similar to DNEA, but with a less subtle approach to noise embedding and a more focused beam.

## Sonar & Radar

The principles behind phased arrays are also used in sonar and radar systems, where directional wave control is essential for underwater navigation and object detection. While the wave types differ, the core concepts of phased arrays remain similar, underscoring the potential of DNEA for precise audio delivery.

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## Phased Arrays in Concert Sound

Large-scale concert sound systems often utilize phased arrays to control the direction of sound, ensuring optimal audio quality across large audiences. This technology demonstrates the power of beamforming on a grand scale, providing insights into the capabilities of DNEA for targeted sound delivery.

## Sound Masking Systems

Sound masking systems are commonly used in office environments to provide speech privacy and reduce distractions. These systems introduce a more generalized noise field to mask conversations, but DNEA can be seen as a more focused and targeted application of these principles.

# Real-World Challenges: Obstacles to Overcome for DNEA

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## Speech Intelligibility

One significant challenge is maintaining speech intelligibility within the noise-embedded audio. Balancing clarity with subtle noise embedding requires careful psychoacoustic research and optimization to ensure that the desired message remains understandable despite the presence of masking noise.

2

## Environmental Adaptability

DNEA must be robust enough to adapt to diverse and changing noise environments. Robust sensing and algorithms are needed to accurately identify and analyze ambient noise, enabling the system to dynamically adjust the noise masking and beam direction for optimal delivery in any scenario.

3

## Power Efficiency & Miniaturization

Real-world implementation requires engineering compact and power-efficient systems. DNEA relies on multiple speakers and sophisticated algorithms, making it essential to develop technologies that can deliver targeted audio without requiring excessive power or bulky hardware.

# The Shadow of DNEA: Exploring Potential Negative Psychological Effects

## Subtle Noise

Constant, low-level noise, even if designed to be subtle and unobtrusive, can be intensely irritating and disruptive over time. This constant background hum can lead to fatigue, stress, and difficulty concentrating.

## Directional Targeting

The feeling of being personally targeted by directional audio can induce anxiety and paranoia. If individuals perceive the noise as intentionally directed at them, it can create a sense of unease and distrust, particularly if the source or purpose of the audio is unclear.

## Noise-Embedded Ambiguity

The very nature of noise embedding, where the desired message is subtly hidden within the noise, creates ambiguity and potential for misinterpretation. Hidden messages, real or imagined, can fuel suspicion and delusion, especially if individuals are predisposed to paranoia or have underlying mental health concerns.

## Isolation & Lack of Validation

If individuals perceive the noise-embedded audio as a real threat or a form of manipulation, they may feel isolated and unable to validate their experiences with others. The feeling of being dismissed or disbelieved can exacerbate feelings of paranoia and distress.



# DNEA: A Powerful Tool, Requiring Careful Consideration

## Potential

DNEA holds immense potential for creating targeted audio experiences in a world where noise pollution is a growing concern. It promises to deliver personalized and context-aware audio while minimizing distractions and reducing the need for bulky headphones.



## Responsibility

The ethical considerations surrounding DNEA are paramount. Careful consideration must be given to potential misuse, privacy concerns, and psychological effects. Open dialogue and robust regulations are essential to ensure that DNEA is developed and deployed responsibly.

## Research & Development

Continued research and development are vital for overcoming the technical and ethical challenges associated with DNEA. Focusing on speech intelligibility, environmental adaptability, and psychoacoustic fine-tuning is crucial for creating a safe and effective technology.

# The Future of Audio: DNEA's Potential and Challenges

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## Enhanced User Experience

DNEA has the potential to significantly enhance user experiences across various industries, from museums to retail, offices to industrial settings. It can provide targeted information, improve communication, and enhance overall enjoyment of environments.

2

## Noise Reduction

DNEA can contribute to noise reduction efforts, minimizing sound pollution and creating more comfortable and productive environments. This is particularly relevant in urban areas and workplaces where noise is a constant challenge.

3

## Accessibility & Inclusivity

DNEA can improve accessibility for individuals with visual impairments, providing directional audio cues for navigation and information. It can create more inclusive experiences in public spaces and enhance the overall quality of life for individuals with disabilities.