Sound intensity and directivity measurements for a loudspeaker canopy in a restrictive noise environment

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About us

MD Acoustics, LLC, provides acoustical consulting services for noise and vibration control. Located in Phoenix, Arizona, and Los Angeles, California our clients range from the aerospace industry to municipalities and private land developers. MD has completed numerous noise studies and noise evaluations across the nation. In addition to noise and vibration engineering services, MD also offers audio engineering services, air quality, and greenhouse gas impact studies.
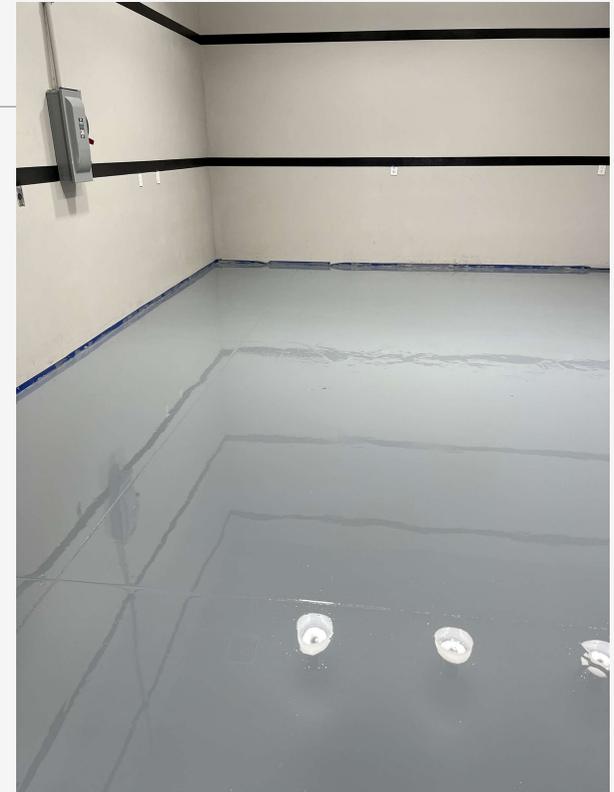
Our Team

Testing facilities
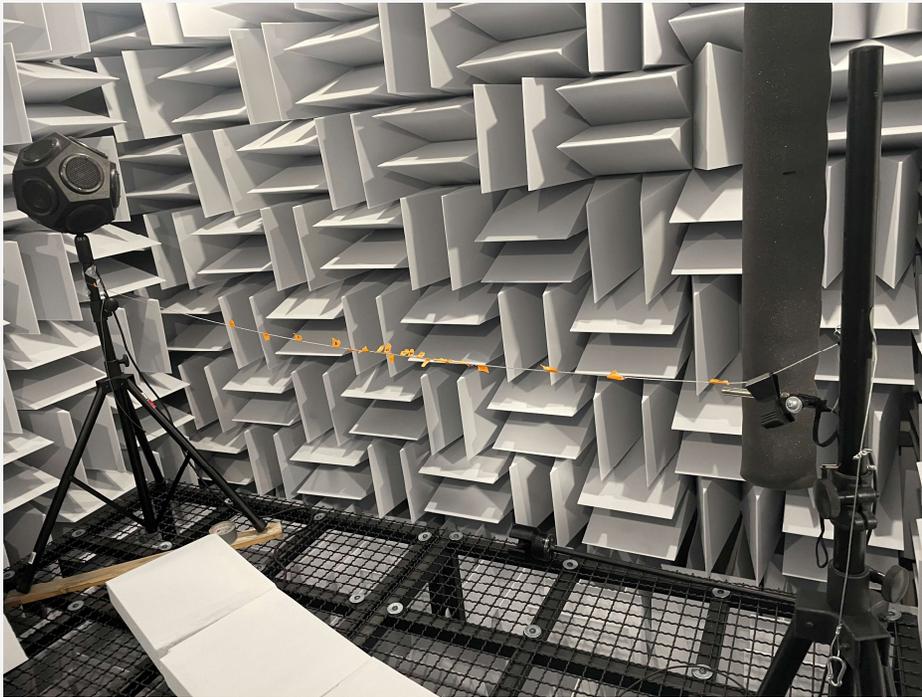
Anechoic Chamber

Reverberation Chamber

Canopy Array

JBN Sound ceiling speaker system

This directional speaker system focuses the Sound Pressure Level on specific areas. When installed on the ceiling of a dance floor or room, the main beam points downward and a 15 dB drop is observed from the shadow zone to the outer areas.

https://www.jbnsoundceilings.com/jbn-sound-ceiling-sound-system-australia/

Theory

Acoustic Intensity

Defined as the product of the particle velocity & sound pressure

$$I = \frac{1}{2} Re\{p\boldsymbol{u}^*\}$$

Is the energy density over a unit of area (sound power over the area). The energy-Based method is used for sound power and source characterization.

Particle velocity can be estimated from the gradient of the pressure (Euler's Eq.)

$$\rho_o \frac{\partial u}{\partial t} = -\nabla p$$
$$(Euler's\ Equation)$$

Theory

Outdoor sound propagation (ISO9613-2)

Sound pressure depends on source strength directivity and attenuation.

Source variables: Source geometry and type, meteorological conditions, atmospheric absorption, terrain type and contour, obstructions

Spherical spread assumption

Inverse square law: 6 dB reduction per doubling the distance

$$L_p = L_w + D_c - \text{A}$$

$$\text{A} = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}$$

Theory

Source Directivity for out of phase arrays

Given frequency with wavenumber k, directivity factor H for two out of phase sources: located d apart, theta defined relative to the line bisecting the source axis, far field r>>d:

$$H(\theta) = \sin\left(\frac{kd}{2} * \sin\theta\right)$$

Measurement Experiment

7 by 3.5 by 3 meters canopy array (frame+sound panels)

40 panels with of 80 subwoofer and 240 mid-high loudspeaker.

The designed main lobe direction is 0 degrees (down)

Measurements were made at horizontal, transversal, and vertical faces axis with a two-microphone intensity probe (1" spacing)

Crystal Instruments Coco 80X Dynamic signal analyzer

2 PCB free field ½" 377B02 mic.

63 (30ft)

90   87

82   77

90

89   90

80

All levels in dBA

Birdseye view

X axis

Z axis

Y axis

Measurement Experiment

Intensity was measured in three axes using a line array probe and orienting the probe to each axis.

The shadow area was 10-15 dB louder than the side faces.
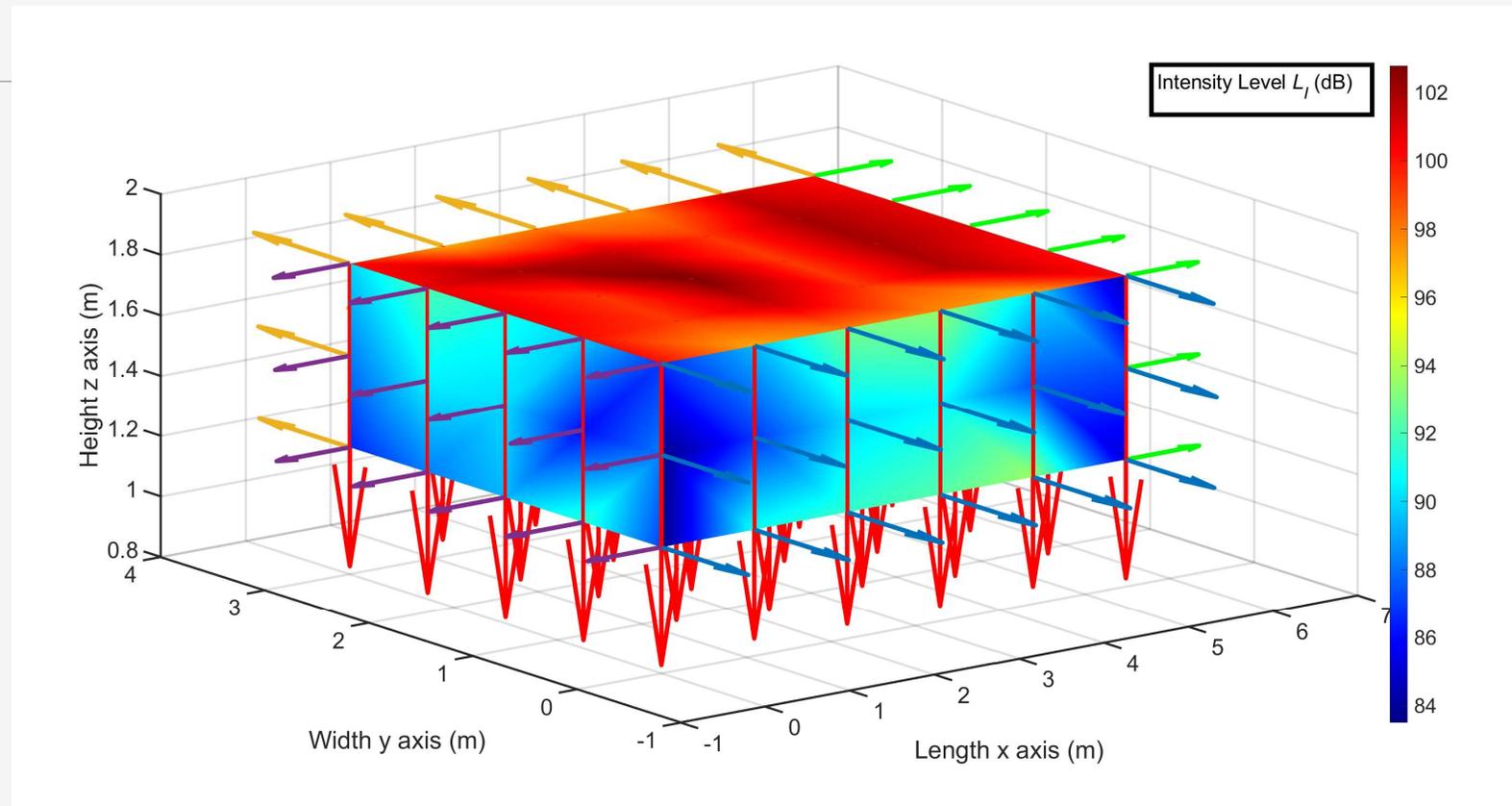
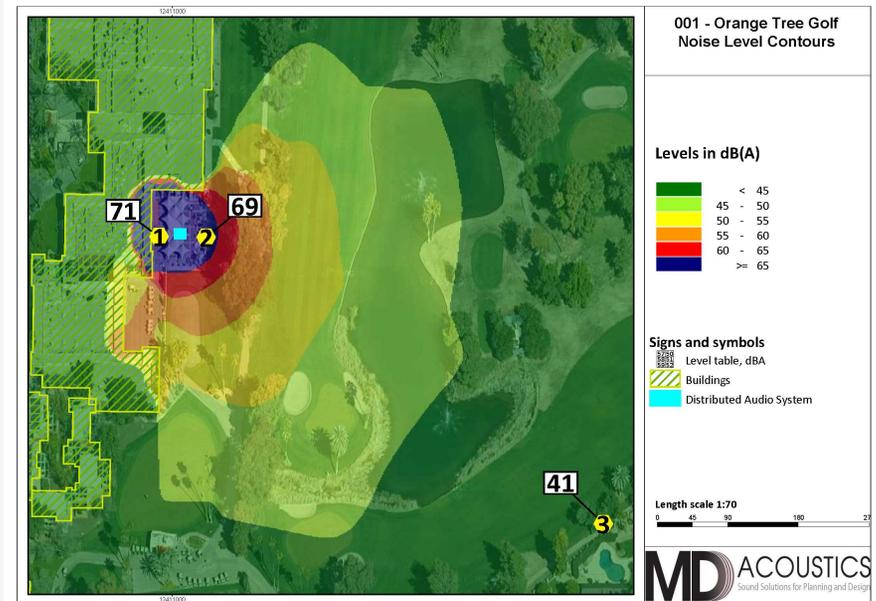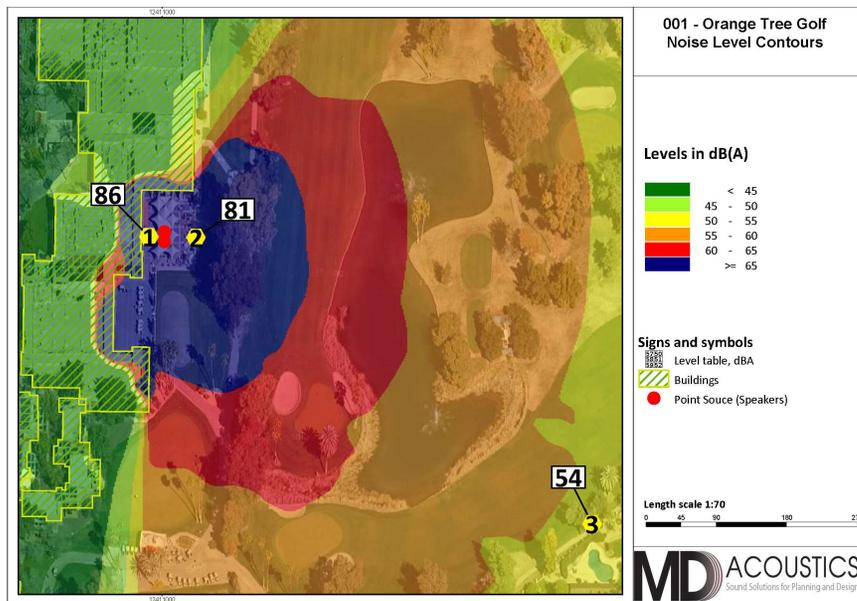Intensity Levels L_I JBN Sound System
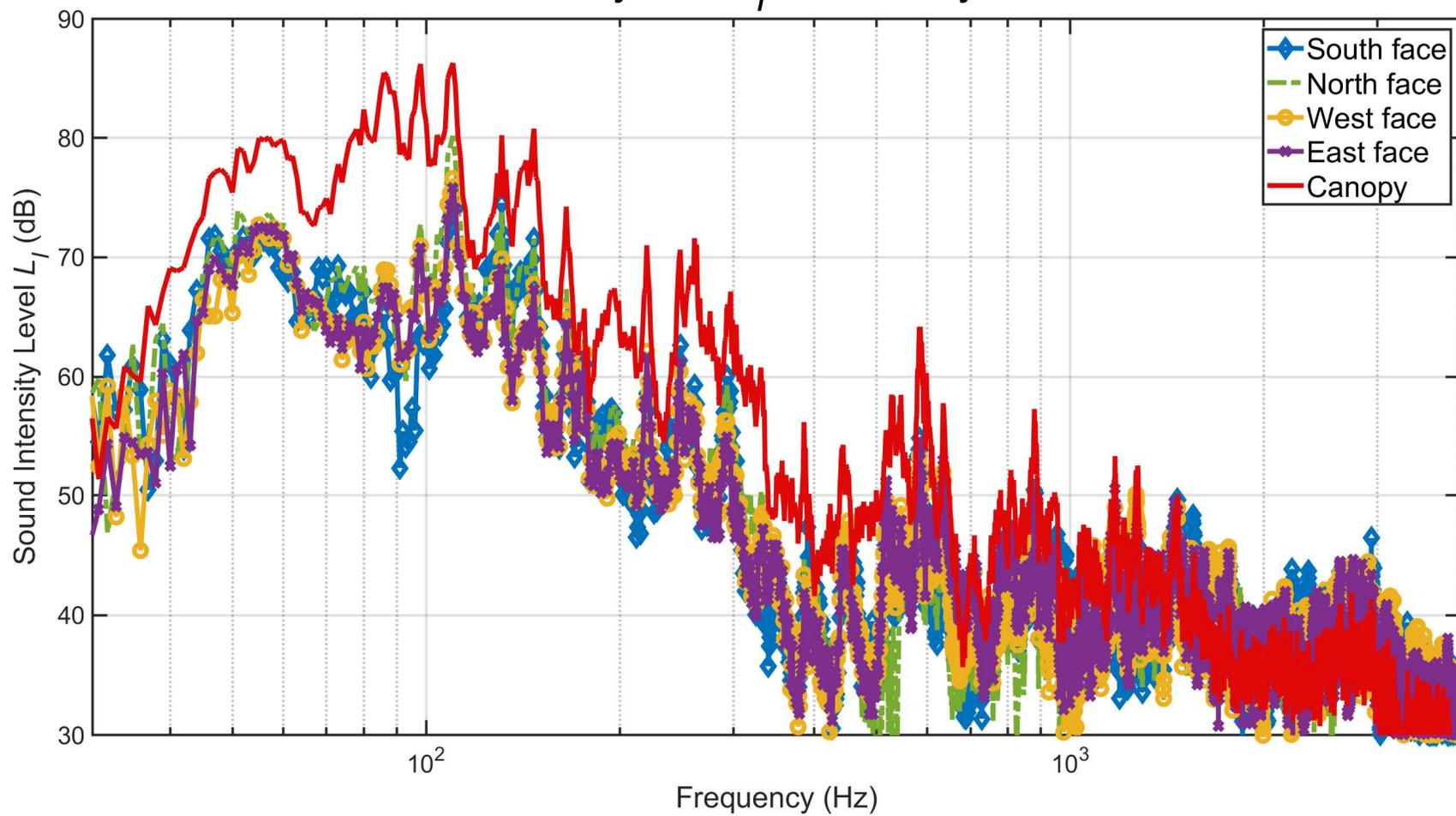
Application Project using SoundPlan
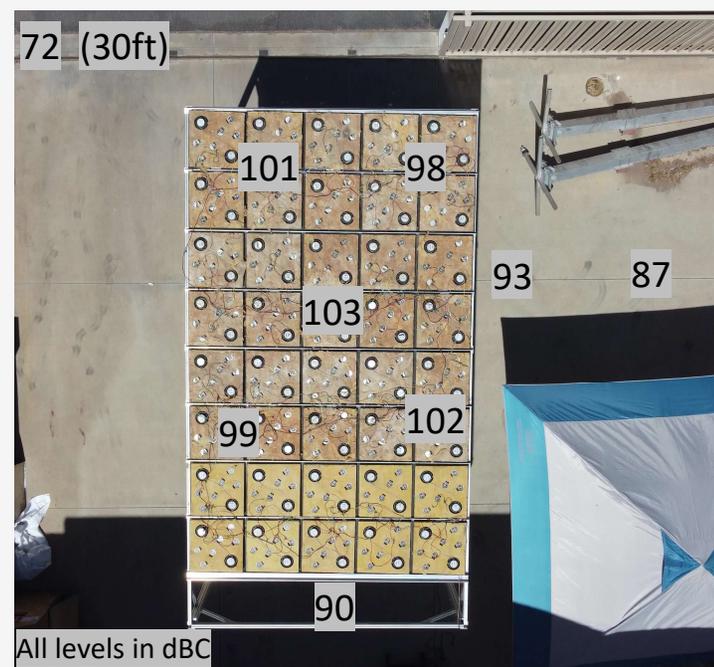
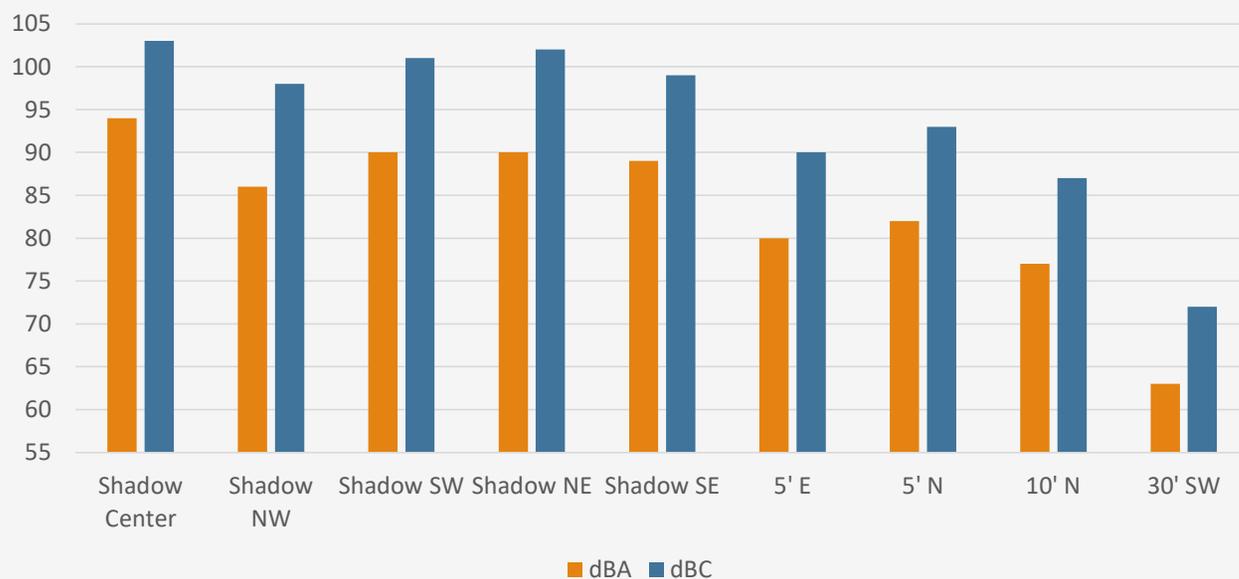Resort and event facilities in a quiet-type area

SoundPlan software model

Sound Pressure Level Contours

Sound Pressure C Scale Noise Evaluation

Canopy sound pressure level map

Conclusions

1. Highly Directional loudspeaker array, helps to reduce noise propagation in restrictive environment

2. Intensity levels on the "shadow direction" were maximums compared to side faces of the array.

3. Application of solutions based on directional amplification system attenuate the noise impact on communities with diverse land uses in reduced areas.

4. Remarks the necessity to address community noise problems with new technologies and the actualization on noise evaluation scales for live music (C-Scale)

Thank you for your attendance!

https://www.mdacoustics.com/