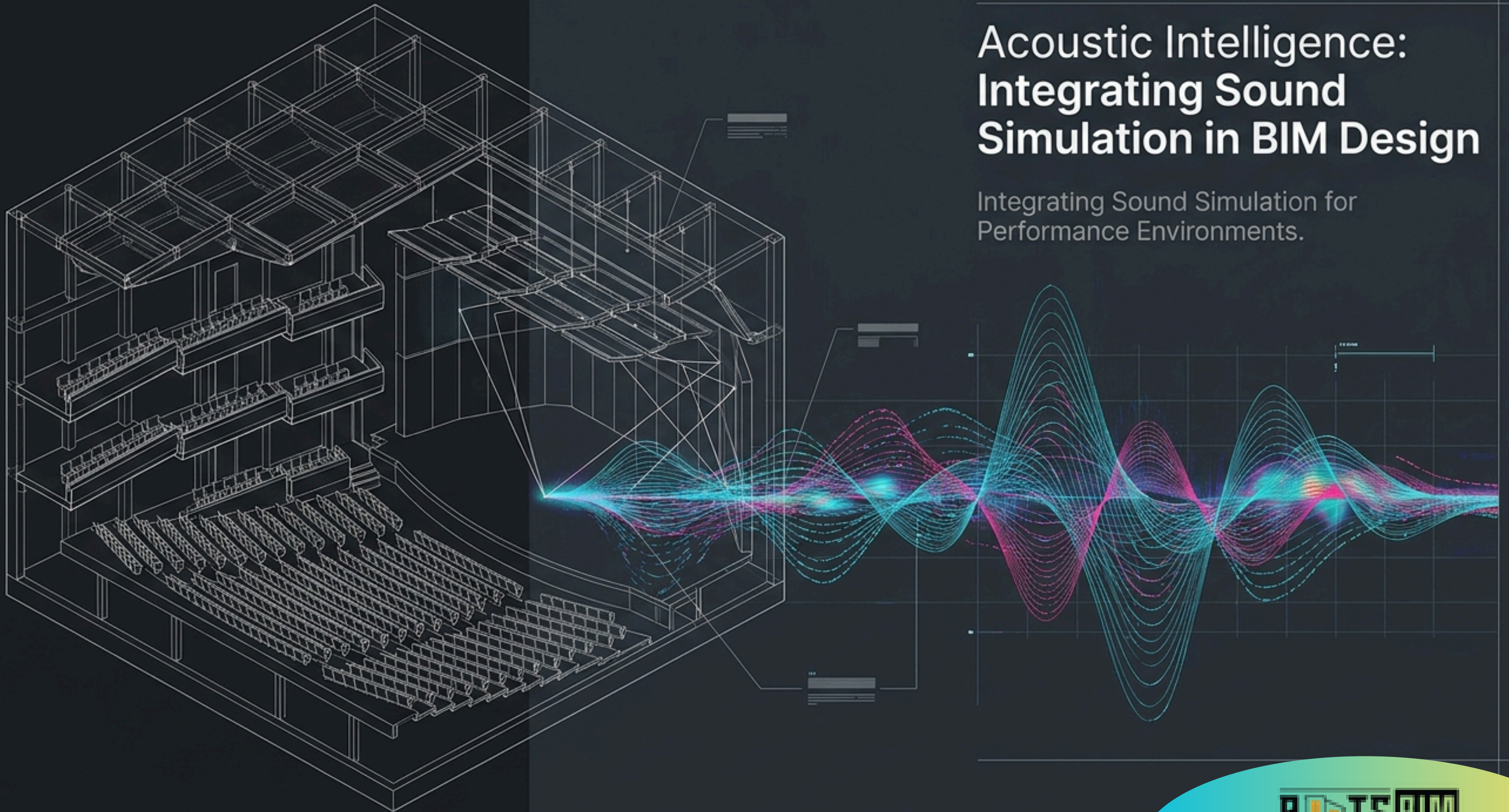


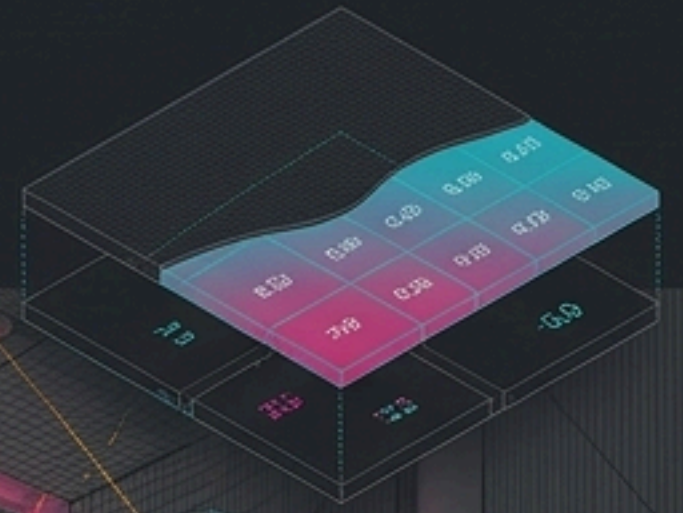
Acoustic Intelligence: Integrating Sound Simulation in BIM Design

Integrating Sound Simulation for
Performance Environments.



In performance environments, sound is architecture

Visual beauty is void if the acoustics fail.
Geometry, materials, and reverberation
must be digitally analyzed before
physical construction begins.



RT60		STI	
4.00	1.20	0.30	
1.90	1.50	1.50	
0.60	1.00	3.30	1.20
0.00	0.30	1.20	3.30
STI	0.20	0.20	0.20

Moving from post-design reaction to pre-construction computation

Traditional Workflow

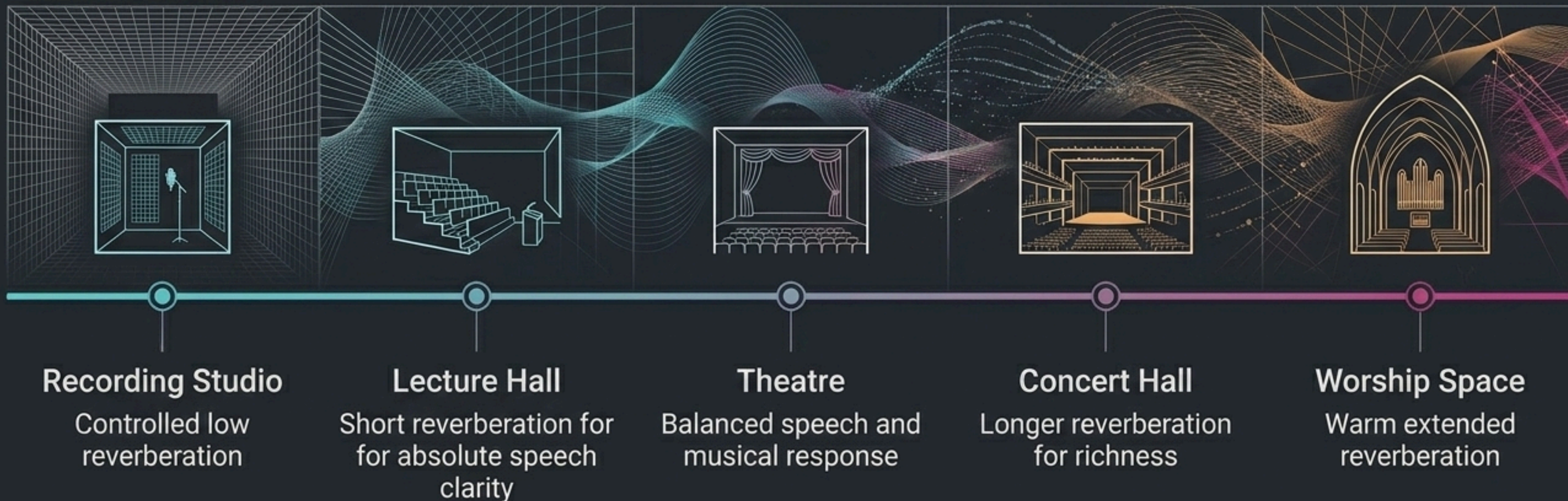
- Expensive post-design redesigns
- Reactive post-occupancy material replacement
- Unidentified acoustic dead zones
- Unpredictable flutter echoes and standing waves

BIM-Integrated Workflow

- Embedded acoustic performance data
- Computationally optimized ceiling geometries
- Perfectly calibrated seating densities
- Precise speech intelligibility from day one

Engineering the perfect reverberation decay

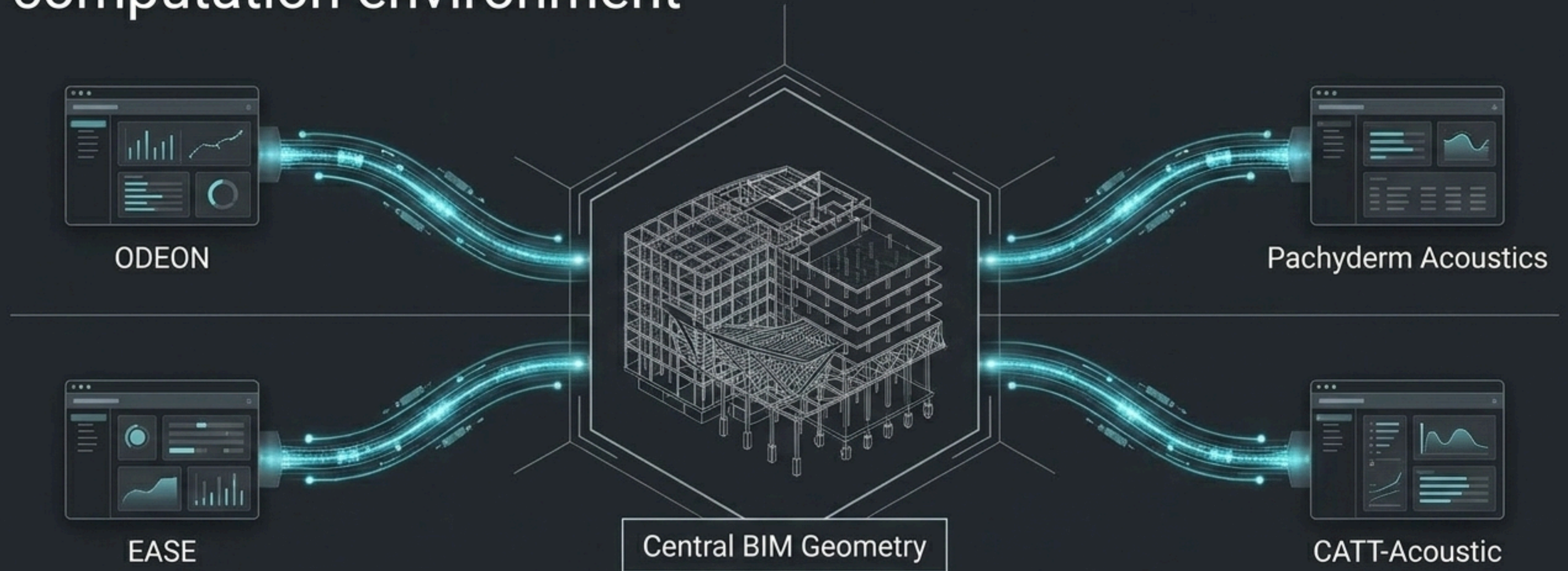
RT60 Spectrum



Short / Clarity

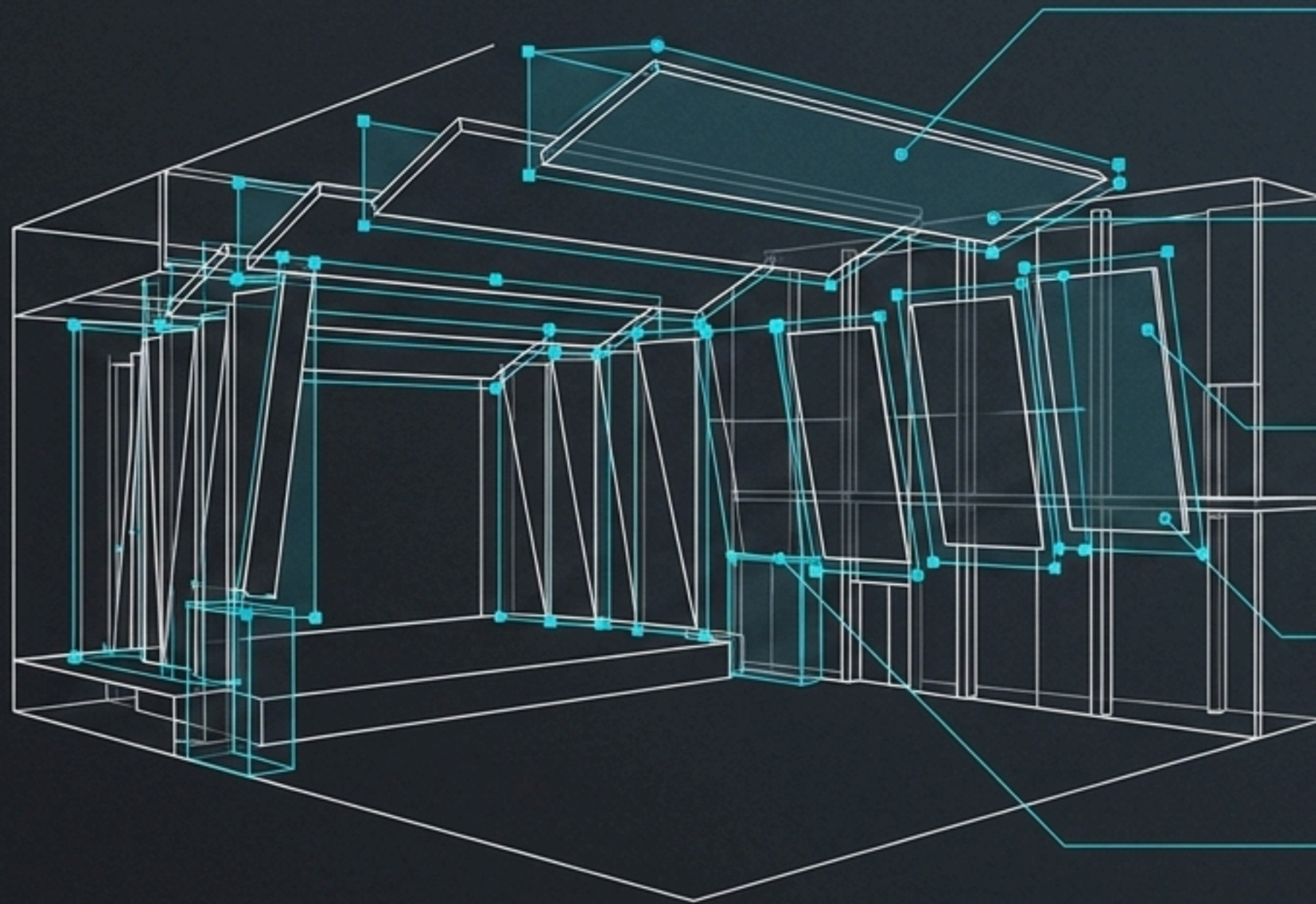
Long / Warmth

The BIM model as an acoustic computation environment



By linking core BIM models with physics-based simulation engines, we evaluate exactly how sound behaves inside a proposed geometry long before ground is broken.

Step 1: Intelligent geometry extraction



IFC workflows

gbXML

DXF

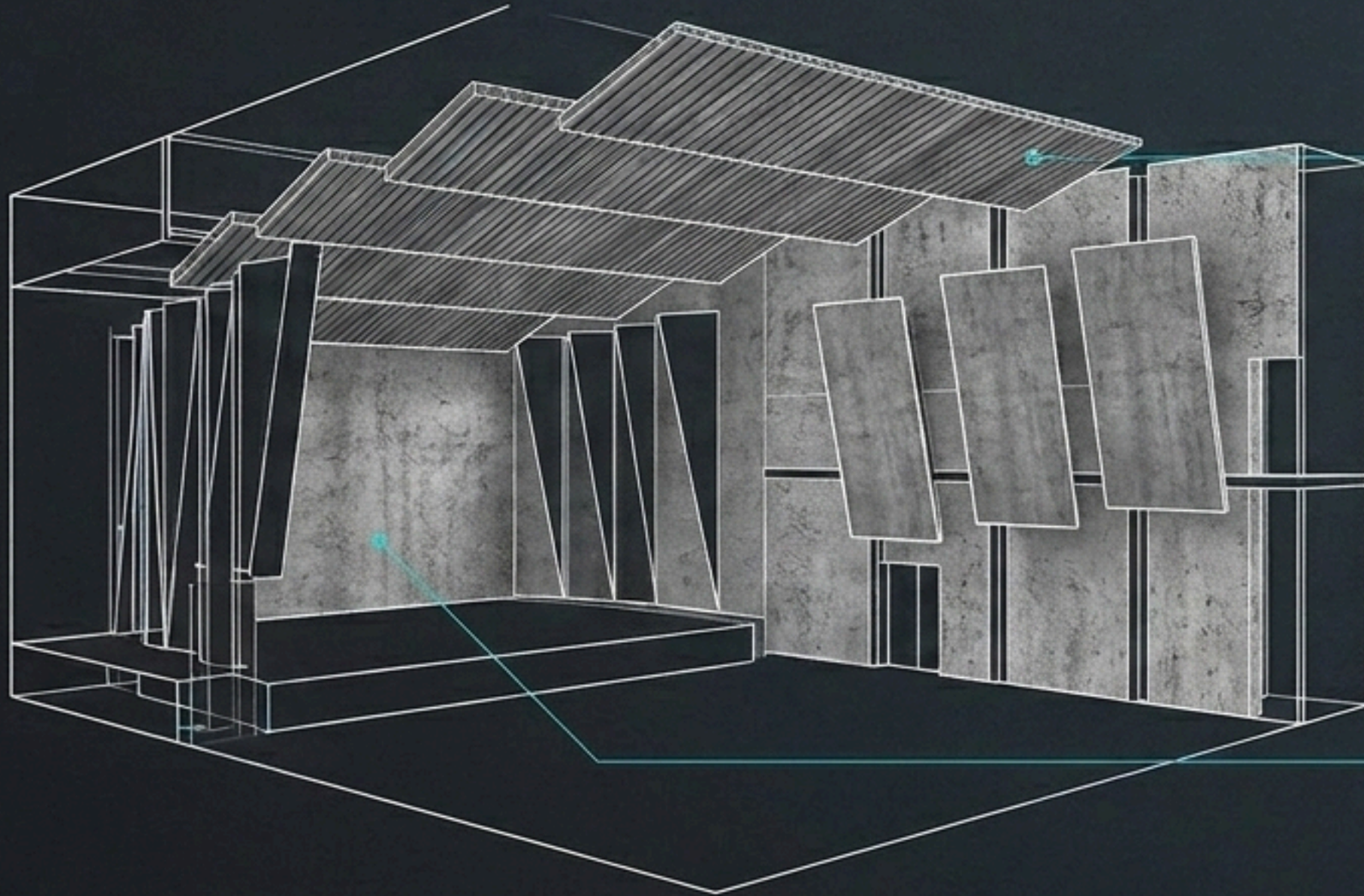
Rhino interoperability

Direct plugin integration

Translating architectural surfaces into
acoustically analyzable planes.

Step 2:

Material acoustic mapping



Timber / Acoustic Panels

Mid/High-frequency absorption, tailored diffusion.

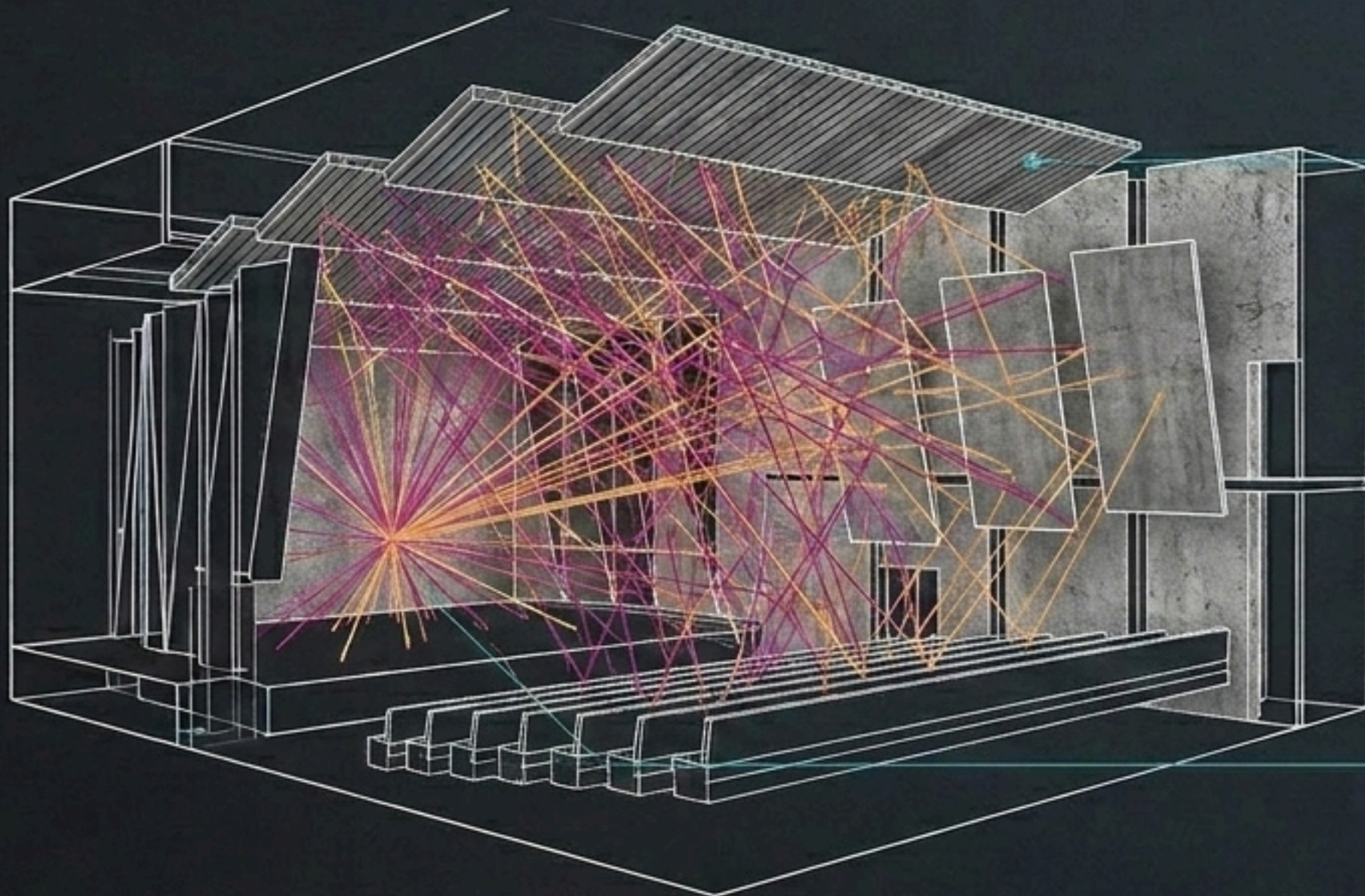
Concrete

High reflection, low absorption.
Assigned Absorption / Scattering /
Transmission Loss coefficients.

Every BIM element is assigned frequency-dependent acoustic behavior. A visual model is converted into a physics-informed dataset.

Step 3:

Ray tracing and spatial simulation



Algorithms in Action:

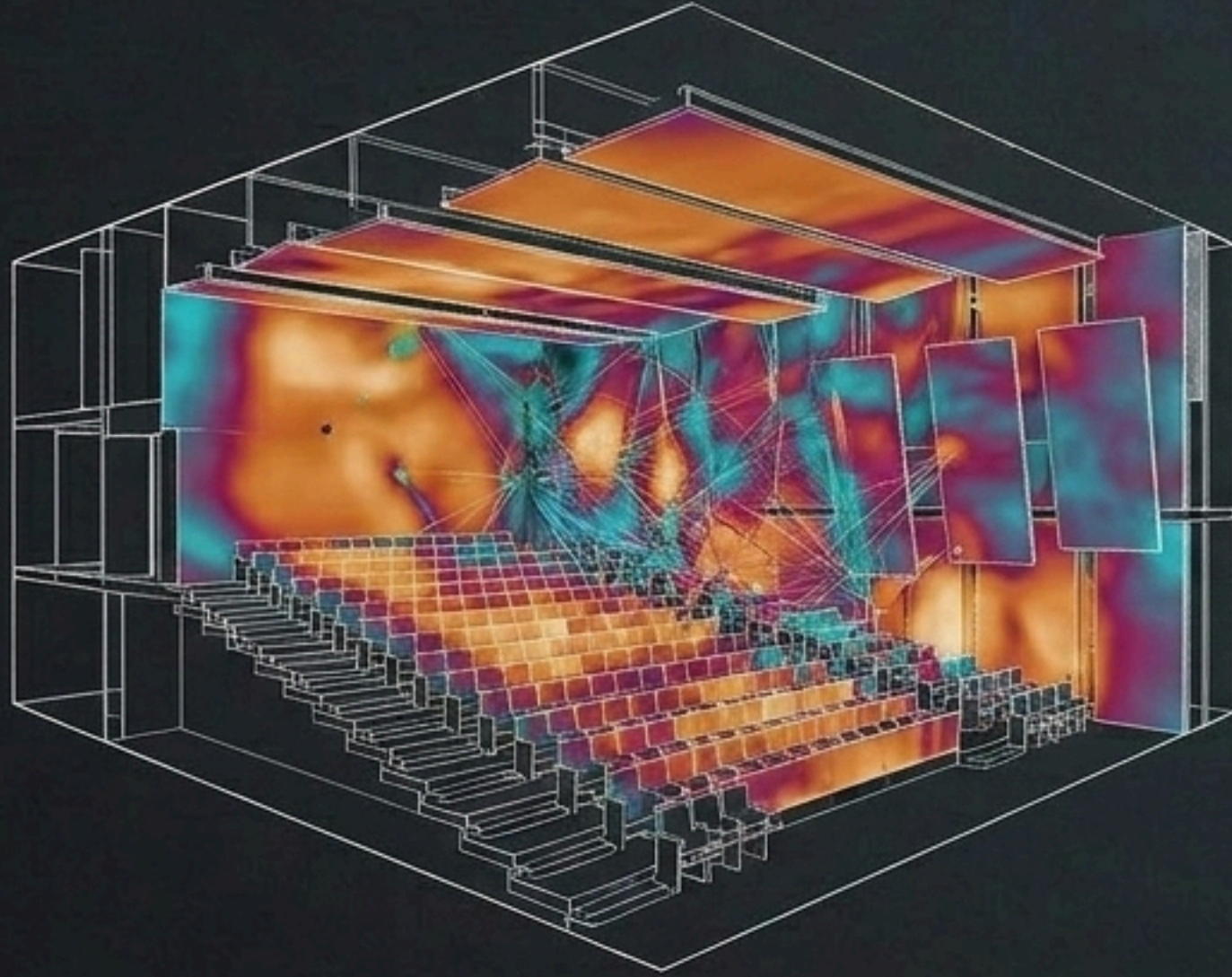
Utilizing Hybrid Ray Tracing, Image Source Modeling, and Particle Reflection Analysis.

Simulation Outputs:

Mapping first reflections, late reflections, spatial decay, and sound pressure distribution.

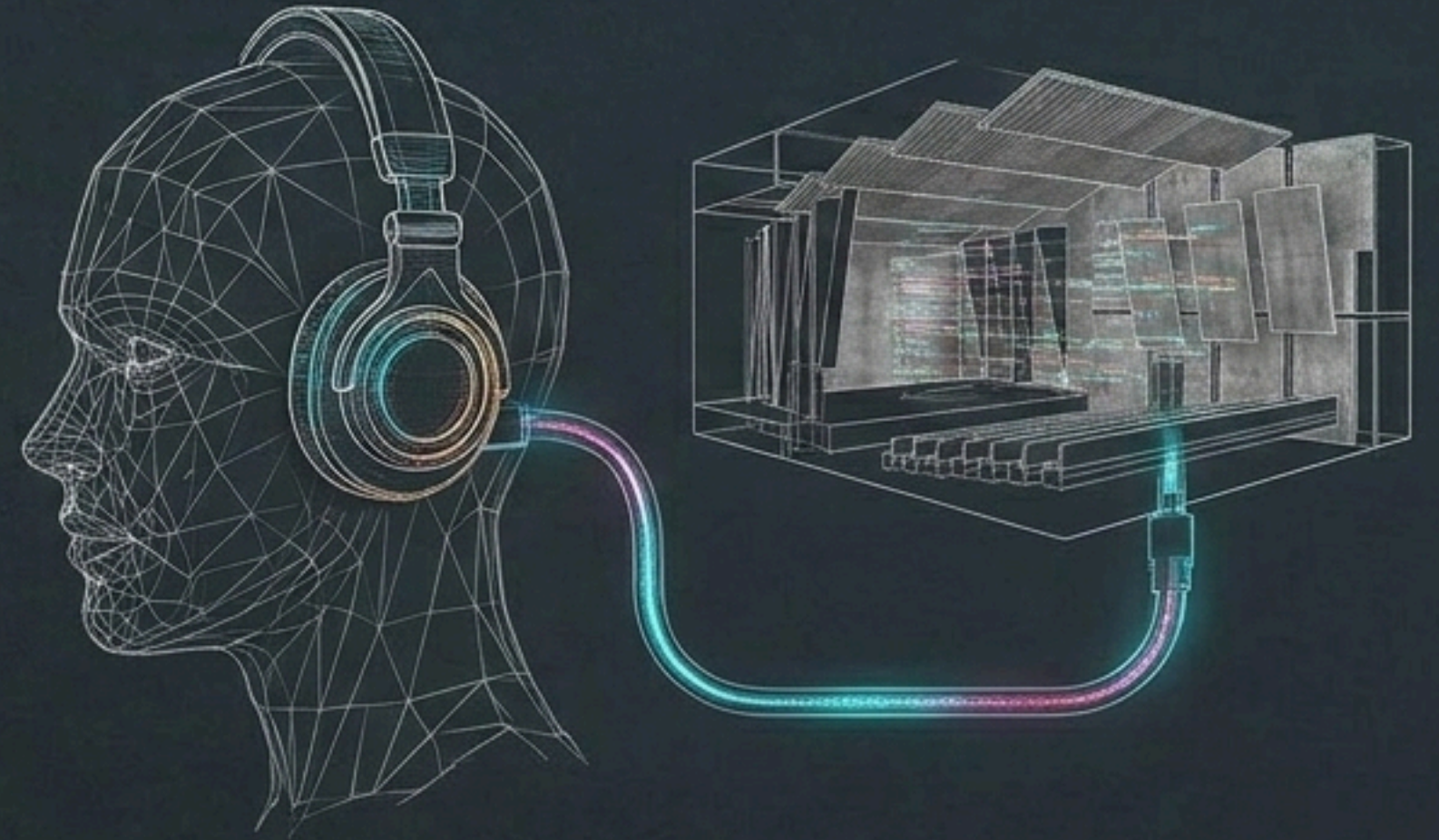
The building is officially "heard" before it is built.

Experiencing the virtual acoustic prototype



Visualization

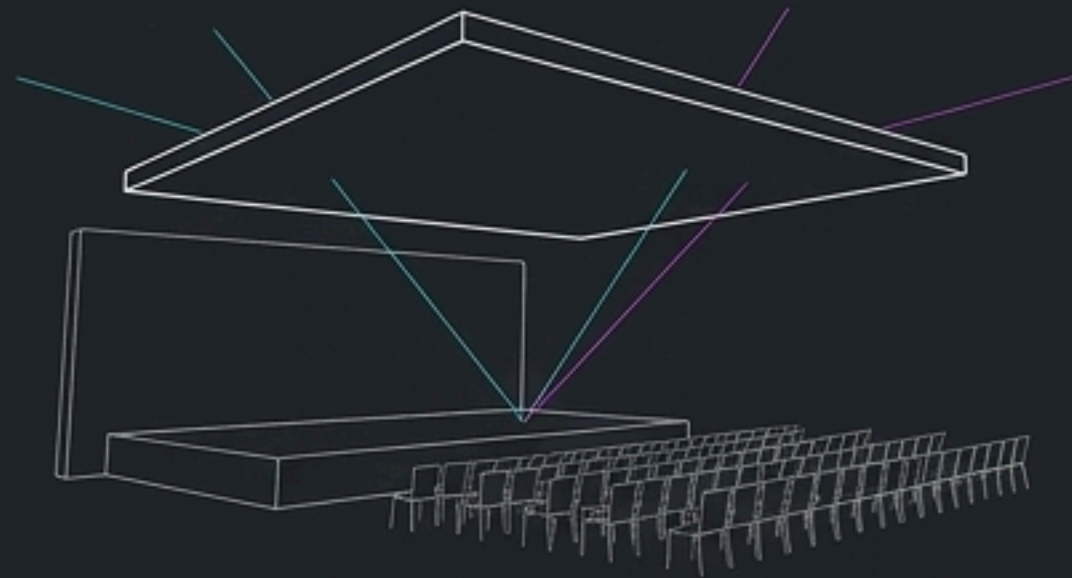
Identifying reflection paths and eliminating trial-and-error during construction.



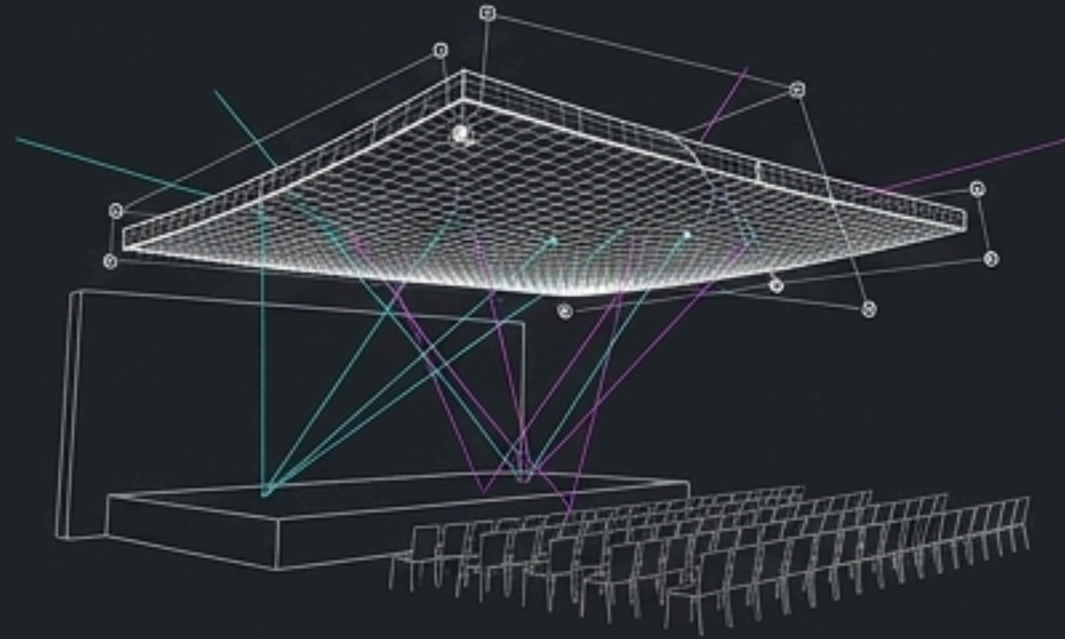
Auralization

Allowing stakeholders to literally listen to the future acoustic behavior. Musicians evaluate stage acoustics, theatre designers assess clarity, and owners compare design alternatives via digital audio playback.

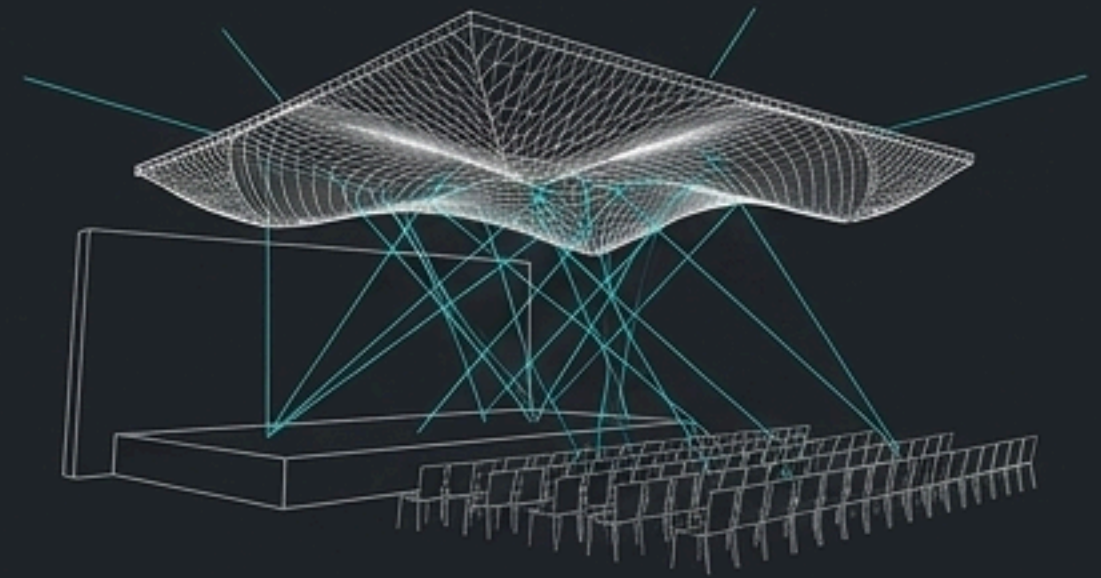
Parametric optimization through computational design



RT Target: Deviation High



RT Target: Iterating



RT Target: Optimized

The Engine

Integrating BIM with Rhino, Grasshopper, and Dynamo.

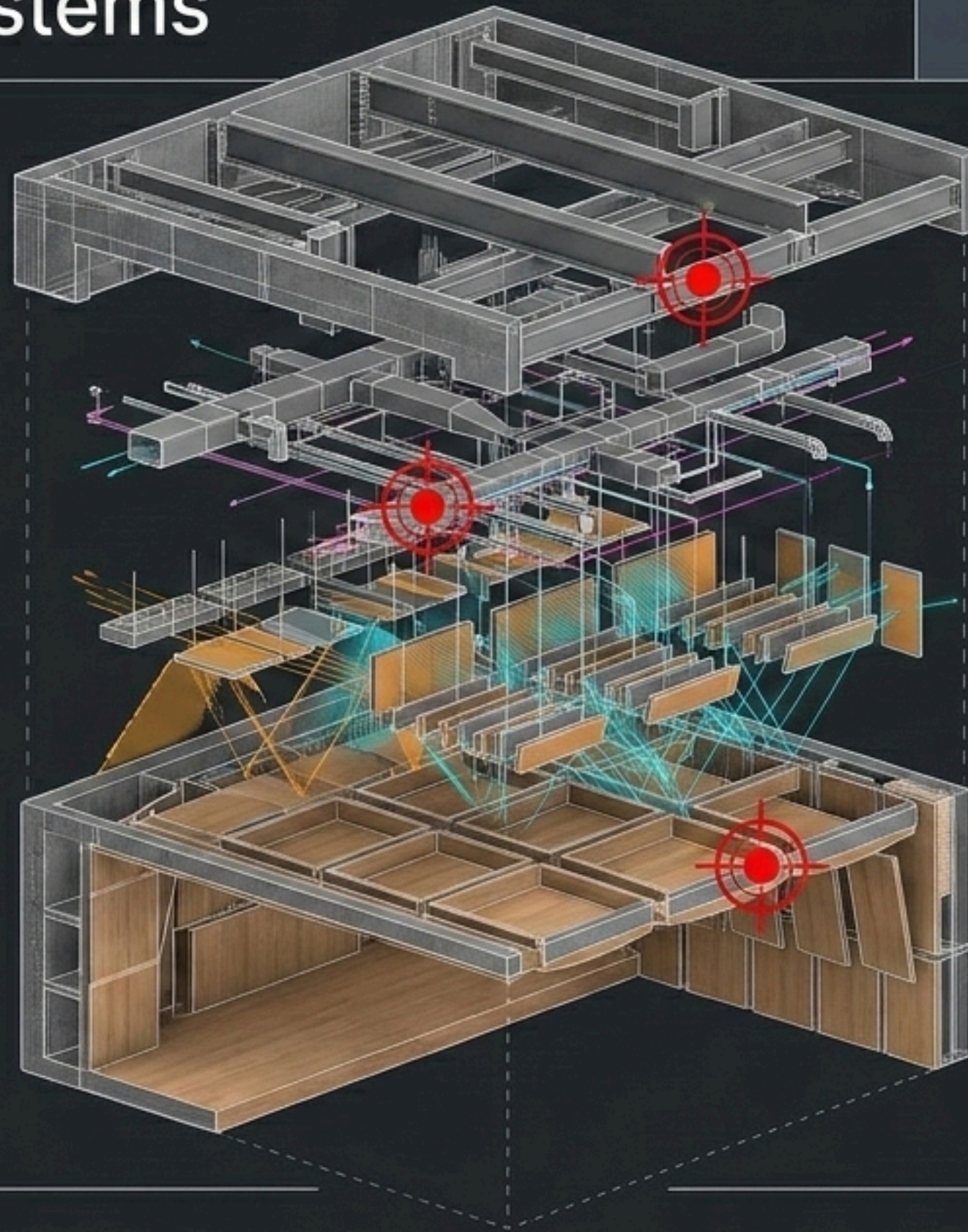
The Outcome

Ceiling curvature auto-adjusts for diffusion, wall angles optimize reflections, and seating layouts adapt acoustically. Optimization becomes algorithmic and iterative rather than manual.

Clash detection across multidisciplinary systems

The Network

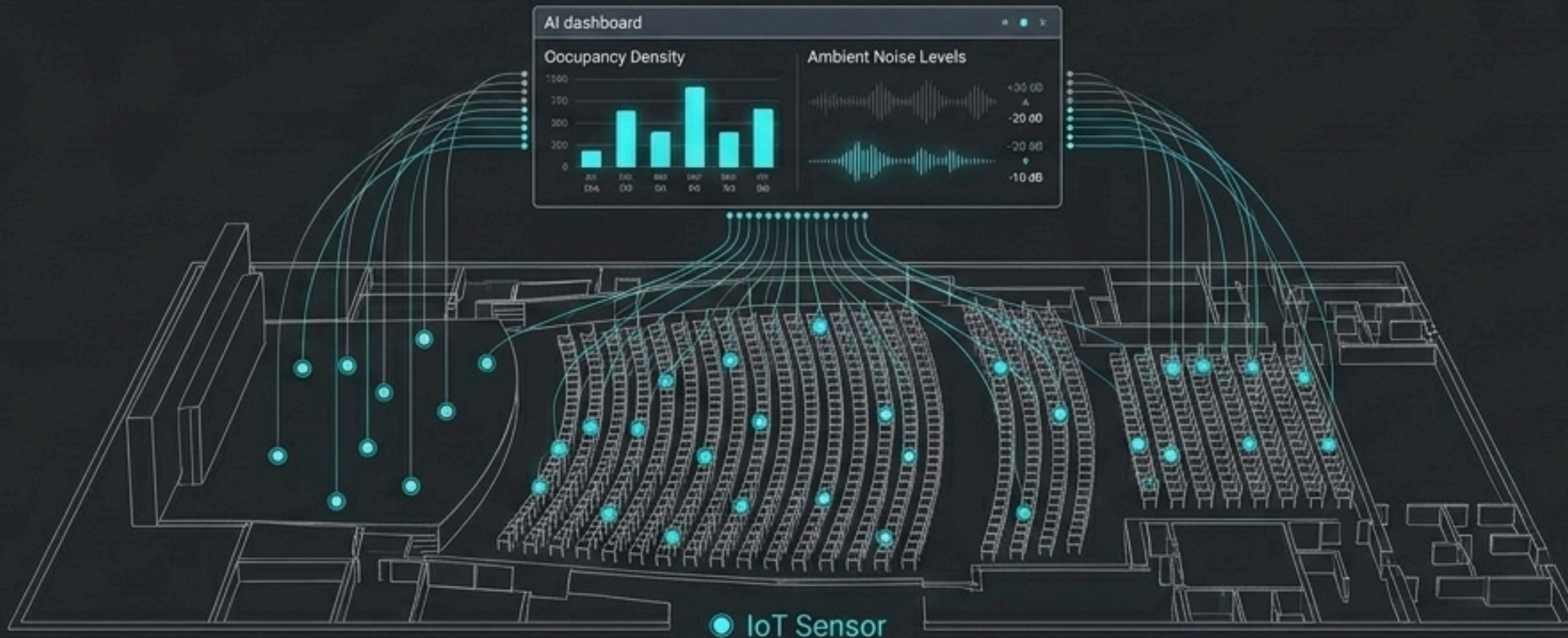
Acoustic systems must be coordinated against HVAC rigs, lighting, and fire protection.



The Catch

Identifying acoustic leakage paths, mechanical vibration conflicts, and duct-borne noise transmission in complex spaces like opera houses and performing arts complexes before installation.

Digital twins and post-occupancy intelligence



The Horizon

IoT sound sensors, real-time occupancy analytics, and AI-driven acoustic calibration.

The Application

Facility managers continuously optimize amplification systems, background noise, and speech clarity based on real-time audience density. The venue evolves into a responsive, living acoustic environment.

The building itself becomes an instrument

Synthesis

Performance architecture goes beyond what audiences see—it is what they hear, feel, and experience spatially.

The Roots BIM LLC Ecosystem

Architecture, engineering, environmental behavior, and acoustic physics converging into one integrated digital model. Predictable, Optimized, Coordinated, Immersive.

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