A MINI SYMPOSIUM ON AUDITORIUM DESIGN

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The panel:
Mark Mayfield, moderator
John F Allen, panel's organizer
Ioan Allen
Mike Cummings

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Mark Mayfield, Director of Global Cinema Marketing, QSC
Moderator

John F Allen, Founder and President
High Performance Stereo
Historical Background and
Panel Organizer

Ioan Allen, Senior Vice President
Dolby Laboratories
The Impact of Theatre Shape
on Sound and Picture

Mike Cummings, Senior Principal
TK Architects International
Modern Design Considerations
and Guidelines

April 30, 2020

Mark Mayfield, *Director of Global Cinema Marketing* at *QSC* introduced an expert panel, which included **John Allen**, *founder and President of High Performance Stereo* (the panel's organizer), **Ioan Allen**, *Senior VP at Dolby Laboratories* and **Mike Cummings**, *Senior Principal* with *TK Architects International*. The panel was assembled to speak to various aspects of auditorium design, relevant to – as the company names suggest – mainly the audio experience.

Each of the panelists began with an opening topic, and for John Allen, it was waxing eloquent on the history of acoustic design, stretching back to the ancient Greek's open-air theatres (both in the round and stadia), continuing through Elizabethan playhouses, the first concert-cum-orchestral halls and then motion-picture theatres. "Going back a few hundred years, you didn't have sound systems to speak to large groups of people so they could actually hear 'us'. So if you look at these slides of amphitheatres, you'll see they are not very large and the audiences were kept as close as possible to the stage to be heard. The structure's shape was designed to concentrate and contain sound."

As music evolved and played a greater role in our popular culture, larger rooms, exemplified by the Palais Lobkowitz in Vienna, Austria – where Beethoven gave his first performance of the Eroica Symphony – began to predominate. "The Eroica was a revolution, being twice as big and twice as long as any symphony before it," said Allen. "Nothing has been the same since." The room is rectangular, not circular, and was chosen because the sound produced was the way that Beethoven, and then the audience, liked it. This exemplifies a "shoebox" pattern for rooms designed for music that continues to this day. Mind you, the sound of Beethoven's symphony in that relatively small room must have been very loud, but that's where it was played."

Allen then displayed a dozen slides of famous concert halls across the world in that style, including the Lincoln Center in NYC and Boston Symphony Hall. Music is actually written to take advantage of those rectangular spaces. Switching from concert halls to opera-house designs, Allen noted that the latter needs to accommodate speech as well as music, so the shoebox format became more amphitheatre-like, with tiers of seats and private boxes bringing the audience closer to the stage.

Concert halls are designed for longer reverberation times, typically around two seconds. Opera halls

are best with significantly shorter reverberation times and movie theatres shorter still. But the rectangular or shoebox shape has survived and is always preferred.

Not all rooms, including rectangular ones, work for sound. The Kennedy Center in Washington, D.C. is unfortunately a prime example, with Allen musing that he wouldn't go back once he had heard a performance there. "The musicians hate it and so do I, yet when you look at it, you would think that it ought to work!" There is an art to acoustic design.

But what about movie theatres? "They started off as vaudeville palaces. But since the films didn't have sound as we know it today, we didn't have to worry about that. Silent films were accompanied with an organ or a live orchestra. When sound arrived, speakers were placed behind perforated screens. Allen mentioned how the orchestra pits were sometimes a problem. When you 'shot' sound from the speakers across them, the sound was often "colored," much the same way we get sound when we blow across the top of a Coke bottle. The other things that these theatres had were enormous balconies. Some of these had large domes in the ceiling that directed the sound down to the audience.

Today's movie theatres generally retain the classic rectangular shape. They not only sound the best, but, coincidentally, are the cheapest to build as well."

Following John Allen, Ioan Allen took the stage and showed off a slide of the first theatre, in 450 BCE, which he jokingly said appeared to lack a projection room. But waxing serious, Ioan said it was a familiar shape and has appeared in modern incarnations like the Boston Symphony Hall. And then Allen brought up acoustic issues that, surprisingly, were the result of screen sizes and the angles at which they are positioned in the room.
Why? "Well, one of the major challenges for the design of any performance room is to avoid pronounced room resonances; there are particular frequencies which 'ring,' said Allen. The effect can best be imagined by a scale played on the low-frequency notes of a church organ—for in a badly designed space, certain notes will sound much louder than others.

"The best way to avoid these effects is to avoid repetition of a single dimension, or a multiple of a single dimension. For example, a sphere is a very bad shape, having a single dimension repeating. A cube is a bad shape, with the same length, breadth, and height dimension. A square room with a height half of the length would also be bad, as again, a certain note would be emphasized" said Allen.

"Now, acousticians analyzing the best-sounding concert halls find that there are some standard ratios that minimize the number of standing waves or resonances," said Allen. The best ratio of length to breadth is about 1.55 to 1, and a height-to-width ratio of about 0.67. "It is interesting that both these numbers (1.55 and 1/0.67) are close to (1.55)/2, 1.62, which is known as the Golden Ratio," he observed.

As a room shape deviates further and further from these ratios, certain room resonances will begin to dominate. "Going back to the hypothetical picture idea of a 45-degree subtended screen angle, two-thirds of the way back in the auditorium is best. If the screen is 85 percent of the width of the auditorium, allowing for some black masking, the new length of the room will be 1.54 times the width, or almost the acoustic ideal of 1.55:1." Paying homage to The Golden Ratio again, Allen said it's no

wonder that this ratio has been a fundamental principle of architecture and design for thousands of years." Allen also pointed out that too large a theatres' screen to depth ratio can lead to excessive image distortion in many seats, and a reduction in contrast.

In closing his remarks, Allen was strident that "good theatres have black-matte seats and black-matte walls…and the bottom line is that you can't have too much of a good thing, and not to turn this into a commercial, but 1.4 to 1 is as far as we have got to perfect screen ratio – in terms of the length and breadth of the cinema. And Dolby Cinema installations are 1.4 to 1, with total black-matte within," noted Allen.

Concluding the presentations was Michael Cummings, Senior Principal at TK Architects, who noted that the two experts before him had the science of sound down pat, so his contribution would be on the room environments, emphasizing that control and isolation of sound must be achievable within real-world parameters. First off, is to secure the perimeters, beginning with conditions from auditorium to auditorium, which connect to hallways as well, and have potentially 'noisy' elements – such as projection booths or halls – as access to lounges, toilets and concession areas. "And then there are non-noisy spaces, such as offices and storage spaces, to also consider in the mix," noted Cummings.

Most wall structures are drywall and Cummings laid out various specs, including STC 70+/NIC 60 for aud-to-aud standards; STC 55/NIC 50 for auds-to-noisy rooms and STC 50 for aud-to-non noisy rooms. Turning to floor structures, Cummings said "…that if you're on-grade, it's a fairly easy thing to separate floors, not share the slabs and eliminate vibrations." However, if you have space below your aud and therefore need a raised floor, "then you have a whole different challenge below you, so the most common solution implemented is a floating floor (multi-storied structure) with distinct isolation materials as well as a concrete floor above those." Again, you're aiming for a STC rating of 70 or better.

Turning to roof structures, separation of multi-storeys, if you can, is optimal but Cummings acknowledged that it's not always possible to achieve, but should be an objective. "You're still trying to get to STC 70+ (NIC 60+) and "if you have no room above, isolation is not normally used so to overcome noise concerns, one solution is to install a floating ceiling," aiming for STC 55/NIC 50. "It all comes down to minding the details, following through, and that carries on to stadium seating, which many exhibitors like."

Stadium seating should be totally isolated, from aud-to-aud, with their own support systems. "And then you know that we designers try to cram as much as we can in the space underneath those stadium seats as we can," which can inadvertently cause noise, such as washrooms. "No one wants to hear a toilet flush while watching a love story," observed Cummings. Again, shoot for non-noisy use spaces and not noisy ones.

Exhibitors need building services but good design ensures they aren't an undue noise factor in one's auditoriums. Routing services such as HVAC, sound, power, fire alarms and sprinkler systems, data (network) feeds and even roof drains should have their own routing, and not be fed between auditoriums. The background noise from HVAC systems is particularly challenging and the specs should be NC 25/380 feet-per-minute (fpm), positioning units in isolation, with noise-retardant 'lined' ductwork and air flow lining and diffusers, including return air flows. "Controlling the air flows is

typically an afterthought, but although it's very challenging and there's a cost, particularly in an existing building, there are workarounds, it can be done, and they merit the same level of attention as the actual room isolation."

Cummings spent little time on projection but noted that the traditional wall-and-port layout for lamp-based projectors required a major rethink for boothless setups, and certainly for laser-light projectors, which have hazard-distancing considerations similar to xenon projectors but also the added concern of separation for the restricted zone, which typically took out a few seats in the back row or two.

Zeroing in on room acoustics, sound absorption is an issue. Absorbing insulation (surface) treatments are important across ceilings, floors, behind the screen and of course rear and side walls.

Screen presentations obviously play a big role in auditorium designs and the primary goal is to have wall-to-wall and floor-to-ceiling screens, and Cummings displayed some preferred screen proportions. He spoke to the practicality of designing edge clearances – sides, top and bottom – and flat versus scope proportions. Throw distances must be a paramount consideration also when figuring out the impact on room proportions.

Speaking to lighting and light levels, Cummings noted that "the screen is the primary light source during presentations" and cleaning the screen pre-and-post feature presentation is important. Several necessary but distracting light sources need to be minimized while being still effective when needed, specifically related to safety levels for steps and entry/exits. In the aud photo displayed, Cummings said "There are seven exit signs in this room and sometimes they're green, sometimes red, but the keys are getting them as far from the screen, and angled-away from it, so there are less incidents of light reflected back to the screen." Exit-level lighting on steps is a necessity but sometimes you can design in lighting that goes off during the movie presentation and back on if there's an 'event'. Other distractions are not occurring in new builds; "We're seeing less and less of ceiling lights and sconce-lighting, thank goodness."

Situating seating is another important design element, and although old enough to remember the rocker-type seating of the past, the replacement in the form of reclining seats (recliners) are significantly bigger and take up more space when extended. "There remains a requirement for a minimum, 12-inch clearance, and don't forget that there's accessible-viewing positions to consider also," noted Cummings. "We work towards the requirement for a 40th percentile. And with 12 inches as the minimum, you can only cross seven seats. Now inner aisle locations are becoming rarer; side aisles give you proper egress clearance, but for where inner aisles exist, handrails are a requirement and these can also cause sightline problems."

Sightlines also loom large in design considerations and are very different between traditional seating and recliner-seating layouts, "...with the challenge being greater when going with recliners, as there are all sorts of row height, gap and protection considerations," said Cummings.

Concluding his presentation, designers are always eager to try something new and there's lots of fodder for creativity, given the next decade will see more spaces going for immersive sound systems – with their additional, second-level of speakers – over traditional, digital ones; laser projection over lamp projection and more recliner seating over traditional seating. "Those are the three most

prevalent trends that will impact how you think about auditorium shapes and layouts, pushing us to think about 3-dimensional 'volume' in an auditorium" said Cummings.