EXPLODING MYTHS ABOUT MULTI-PURPOSE HALL DESIGN

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1 INTRODUCTION

Beginning in the late 1950s, many cities in North America built performing arts centres as reflections of their commitment to high culture and as expressions of civic pride. In major metropolitan cities such as New York City and Washington, these centres featured multiple halls, each tailored to a particular art form such as symphonic music, opera or drama. Smaller scale cities could not afford to build centres on the scale of New York's Lincoln Center for the Performing Arts. In addition, the performing ensembles in such communities were, with rare exceptions, not adequately developed artistically or institutionally to assume the operating challenges associated with purpose-built concert halls, opera houses and drama theatres.

These unique circumstances led many such communities to commission the design and construction of multi-purpose halls. Soon such halls were under construction in Los Angeles (the Dorothy Chandler Pavilion), Milwaukee (Uihlein Hall), Houston (Jesse Jones Hall), Montreal (Salle Wilfrid-Pelletier) and many other cities in Canada and the United States. Despite the best of intentions, most of these efforts fell short of meeting the expectations of performing artists and the public, particularly with respect to acoustics. By the late 1970's, the limitations of such structures were becoming painfully clear, causing many in the performing arts world to conclude that the idea of a multi-purpose hall was inherently flawed and that it was not possible to build such a hall with acoustical qualities equal to those found in single purpose halls.

More recent experiences suggest that this thinking was misguided. The authors will review two of these recent examples and view them in relation to the historical context surrounding the development of such halls.

2 MULTI-PURPOSE HALLS – A DEFINITION

When we use the term "multi-purpose hall," we are referring to a building that has been purpose-built to accommodate a diverse range of performance activities. At a minimum, such buildings are proscenium theatres with fully rigged stage houses and some means of adjusting their acoustics and stage accommodations to suit different performance types. Such buildings are distinct from auditoria that are conceived primarily to serve one art form such as an opera house or concert hall.

3 A BRIEF HISTORICAL PERSPECTIVE

3.1 An Early Forerunner of the Contemporary Multi-Purpose Hall

One of the earliest multi-purpose halls is the 4,000-seat Auditorium Theatre, designed by the famous architect Louis Sullivan and his talented engineer partner Dankmar Adler. The theatre was built in Chicago between 1887 and 1889. As originally designed, the Auditorium Theatre was intended to serve as concert hall, opera house, drama theatre, convention centre and banquet hall.

Even at this early date, the architect and engineer recognized that the various performance types proposed for the Auditorium Theatre would not all be well served by such a mammoth facility. Comments from Sullivan clearly indicate that he understood that drama required greater visual and acoustical intimacy than did opera or orchestral and choral music. The theatre therefore features an ingenious system of hinged ceiling panels and curtains that allow the upper balconies to be closed off from the main volume of the house thereby reducing the seat count from its maximum of over 4,000 to around 1,700.

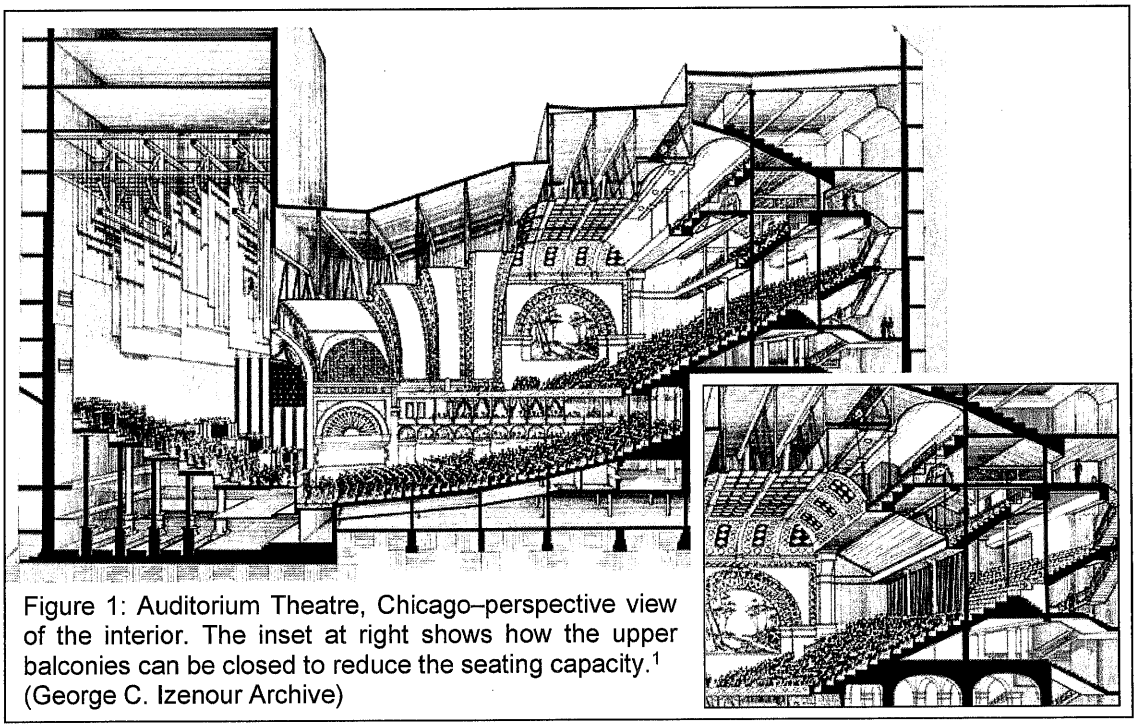

Figure 1: Auditorium Theatre, Chicago–perspective view of the interior. The inset at right shows how the upper balconies can be closed to reduce the seating capacity.[1] (George C. Izenour Archive)

The Auditorium Theatre was a revolutionary building but in the early 20th Century, as the limitations of this landmark structure became apparent, the various performing ensembles and companies once housed in the Theatre gradually moved to purpose-built theatres or concert halls that were more closely attuned to their theatrical and acoustical needs.[2] One might reasonably conclude that the problems of the Auditorium Theatre presaged the failures in later multi-purpose auditoria.

3.2 The Design Context of the 1950s and 1960s

The United States witnessed a boom in the construction of performing arts facilities in the post-World War II period. This boom was propelled by urban renewal philosophies that saw little of value in the architecture of the past. [3] New performing arts centres were seen as valuable tools to remake the urban environment.[4] At the same time that urban renewal was reshaping cities, new currents in architecture and theatre design were redefining the form that these new theatres would take. Broadly speaking, these currents can be summarized as follows:

- Corporations and institutions embraced the modernist style of architecture pioneered by the Bauhaus School in 1920s Germany and transplanted to America by Walter Gropius, Mies van der Rohe and their American-born disciples Philip Johnson and Gordon Bunshaft.[5]

- Some prominent theatre planning consultants rejected the traditional architectural forms that had served as models for the design of theatres for over 300 years. This movement is most clearly seen in the work of George Izenour.[6] In many ways, this rejection of the past paralleled modern architecture's rejection of historical styles and forms.

The impact of these movements on the design of performing arts spaces was profound. The complexities inherent in horseshoe-shaped opera houses or West-End lyric theatres were abandoned in favour of simple fan-shaped or cinematic style auditoria. The rich architectural detailing that was a central feature of Western Architecture for millennia gave way to surfaces stripped of virtually all form of differentiation and ornament.

Unfortunately, the very qualities that were central to these movements also planted the seeds of disaster particularly with respect to acoustical quality. While it is not the purpose of this paper to provide an exhaustive analysis of past failures, it is helpful to grasp some of the more problematic aspects of these designs. These included:

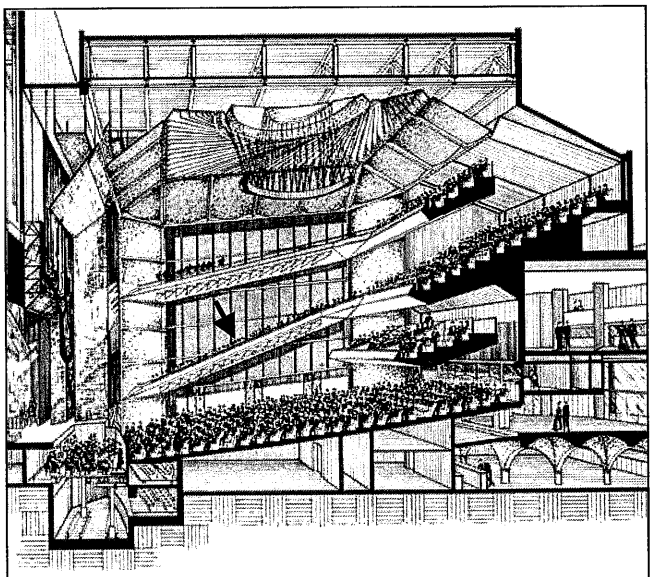

Figure 2: Uihlein Hall, Milwaukee–perspective view of the house. The side loge (indicated by the arrow) is so steeply sloped that it fails to provide early reflections to the stalls.[7] (George C. Izenour Archive)

- Designers began to place more emphasis on sightlines and minimizing the number of seats with partial views of the stage. In many examples from this period, side boxes or tiers were eliminated or featured designs that were radically different from those in traditional halls. This reduced the strength of early reflections in the stalls with a concomitant reduction in acoustic intimacy, presence, articulation and envelopment.

- Another consequence of this obsession with uniform sightlines was the adoption of the fan-shape in many of these halls. As we now know, this shape tends to direct sound energy to the rear of the room, where the audience in the balcony more readily absorbs it. This, in turn, reduces the strength and duration of reverberant energy in a space.

- The reduction and outright elimination of the rich architectural ornamentation associated with older architectural styles often deprived such rooms of the small-scale and medium-scale diffusion that is so important to promoting uniformity in the reverberant field and reducing the harshness of high frequency sound.

- Such halls frequently accommodated far in excess of 2,500 people and some prominent examples featured more than 3,000 seats. The vast scale of these halls cut the sonic impact of natural acoustic music, reducing the excitement that makes attending live performances special.

Figure 3: Comparison of Seating Capacities *

Dorothy Chandler Pavilion (Los Angeles)	3,197
Salle Wilfrid-Pelletier (Montreal)	2,982
Jesse Jones Hall (Houston)	2,745
Uihlein Hall (Milwaukee)	2,305

* Figures are from the website of each venue

It was in this context that architects, theatre consultants and acousticians began to reconsider the fundamental design concepts behind multi-purpose auditoria. The experience of the 1950s and 1960s was found wanting. New directions were needed.

4 IMPLEMENTING LESSONS FROM THE PAST

Just as architects eventually began to question the wisdom of modernist architecture's near total rejection of traditional architectural styles and forms, theatre planning consultants and acousticians began to re-examine the great concert halls and theatres of the past to understand how the various features of these buildings contributed to the experience of viewing and hearing a performance.

Through these studies, designers gained increased appreciation for the important role that form plays in creating an engaging performance space. Theatre planning consultants began to recognize that the multiple tiers of boxes in a traditional horseshoe-shaped opera house bring a theatre to life and give the audience chamber a sense of excitement and drama. Such designs acknowledge that there is a social aspect to attending a performance that goes beyond simply viewing the action on stage or sharing a glass of wine at the interval. Designers learned that many audience members will gladly give up a "perfect" view of the entire stage in exchange for a "special" seat, one where they can "see and be seen."

In a similar vein, acousticians discovered how the form and dimensions of the great spaces of the past contributed to their acoustical quality. They also came to a much better understanding of how to manipulate these factors to meet the challenges of modern expectations about seating comfort, regulations concerning accessibility by the disabled, and the myriad building code issues that prevent us from slavishly duplicating the buildings of the past.

Appreciation for these concepts developed in the late 1970s, grew throughout the 1980s and began to be reflected in built form in facilities that were completed in the 1980s such as the Atwood Concert Hall at the Alaska Centre for the Performing Arts in Anchorage,[8] the Belk Theatre at the Blumenthal Performing Arts Centre in Charlotte, North Carolina and the Carol Morsani Hall at the Tampa Bay Performing Arts Centre in Florida. All of these halls represented significant improvements over earlier multi-use designs, although few today judge them to be the acoustical equals to single-purpose halls.

5 ACOUSTICAL GOALS IN OKLAHOMA CITY AND DAYTON

In order to assess the success–or failure–of a particular multi-purpose hall design, it is essential to have an understanding of the criteria upon which the design is founded. Such criteria must necessarily begin with a definition of the programme uses of the facility.

5.1 Programme Definition

The programme of uses for our two case study examples is fairly typical of multi-purpose halls throughout North America. These uses include:

- Touring musical theatre productions (i.e., Broadway or West End style musicals)
- Amplified music concerts (what are typically referred to as "Middle of the Road" entertainers)
- Lectures and films
- Opera (both light and grand)
- Dance (ballet, modern dance and other forms)
- Orchestral concerts (including those with chorus)

The balance among these various programme activities will certainly vary from facility to facility, and even from year to year in any one facility, but the range of performance types tends to remain fairly constant over time.

5.2 Acoustic Goals

The goals used to guide the development of the two projects included the following:

- A reverberation time (RT_{60}) that could be varied between a high value of 1.9-2.0 seconds at mid-frequencies (for orchestral/choral music) and a low value not more than 1.4 seconds (for amplified programmes)
- A strong early decay time for orchestra/choral music
- Excellent acoustical intimacy, presence and articulation for orchestral, choral and opera uses
- Excellent articulation for amplified uses (articulation in music and intelligibility in speech)
- A dramatic impact of natural acoustic sources such as an orchestra
- A good sense of immersion or envelopment for natural acoustic sources
- A background noise criteria below NC-15

6 OKLAHOMA CITY CIVIC CENTRE MUSIC HALL

6.1 Background

The Oklahoma City Civic Centre Music Hall opened in 1937 as the Municipal Auditorium. As originally constructed, the Auditorium had a maximum seating capacity of 6,200 and featured a flexible main floor that could be raked for good views of the proscenium stage or flattened so that the space could become an arena for sporting events.

In 1967, the Municipal Auditorium was renamed the Civic Centre Music Hall when the space underwent renovations that transformed the hall into a 3,200-seat fan-shaped auditorium with a low ceiling and single balcony. The results of the 1967 renovation were architecturally undistinguished and acoustically appalling.

6.2 Genesis of the 2001 Renovation

The 2001 renovation came about as a result of a 1991 acoustic survey of the Music Hall commissioned by the Oklahoma City Philharmonic and undertaken by Paul Scarbrough (then of Jaffe Holden Scarbrough Acoustics), the principal author of this paper. This survey recommended that the City abandon plans to restore the interior of the Civic Centre Music Hall to its original 1937 dimensions and appearance. The report instead argued that creating a wholly new hall inside the envelope of the old building would create a much better hall acoustically, theatrically and architecturally. The City ultimately embraced the core ideas in this report and made the renovation of the Civic Centre Music Hall one of seven major civic projects approved by the voters of the City in a referendum in 1994.

6.3 Key Features of the New Civic Centre Music Hall

To create a multi-purpose hall with top calibre acoustics required a total makeover of the original interior of the building. The building was totally gutted save for a handful of 1937 spaces that retained their original art deco interiors such as the Little Theatre (a 390-seat theatre at the northeast corner of the building), the main entrance lobby and the Hall of Mirrors (a ballroom on the second floor above the main entrance lobby).

6.3.1 Seating Capacity

One of the difficult early discussions regarding the new hall revolved around its seating capacity. The local presenter of touring Broadway productions argued in favour of retaining most or all of the then 3,200-seat capacity. At the same time, the Oklahoma City Philharmonic, the most prominent performing ensemble in the City and one of the most vocal supporter of the renovation, insisted that the requirements for excellent symphonic acoustics drive the decision about seating capacity. After detailed study, the various constituents agreed upon a capacity of 2,500-seats. This was felt to be the maximum seating capacity consistent with providing top calibre acoustics for the Philharmonic.

6.3.2 Form of the Hall

Because the hall would be at the upper limit of size with respect to achieving high quality symphonic acoustics, a conscious decision was made to shape the interior of the hall on the shoebox concert hall model rather than an opera house. In doing so, the room would gain the fundamental acoustical advantages of that form. In addition, the acoustical qualities of the room would be reinforced by the visual image of the space. The audience would feel like it was in a concert hall before the first note sounded from the stage.

Of course, grafting a concert hall onto a proscenium stage was not without its challenges particularly given the seating capacity. In addition, the new hall had to be built within the envelope of the old building, including the truss system that bridged across the 250-foot width of the structure. Fortunately, the structure offered opportunities as well as challenges. The stage and stalls were originally on the second floor, more than 3 meters above grade. Dropping the stage one full floor level created the opportunity to craft a taller narrower house, improve loading access to the stage and make entry into the hall more convenient for patrons in the stalls.

To accommodate the specified 2,500-seats and keep balcony overhangs to a minimum, required an audience chamber with a stalls level and three balconies. To develop the specific form and dimensions of the house, design features from three halls were combined:

- Boston Symphony Hall contributed the concept of two side tiers reaching all of the way to the proscenium. The lower of these two tiers forms a parterre that intersects the stalls at a rear cross aisle.
- Carnegie Hall, a hall with two box tiers and two balconies, showed how the upper balconies could step back from the proscenium to minimize sound absorbing seating on the upper side walls of the hall.
- Vienna's Musikvereinssaal, supplied the dimension of the hall at its lowest level, close to the stage. The distance between parterre walls at the front of the Civic Centre Music Hall was modelled on comparable distances in the Musikverein.

Figure 4: Interior view of the house of the Civic Centre Music Hall. Note the side tiers and how the first two engage the proscenium. The next level steps back one bay from the proscenium while the top level is set back two bays from the proscenium.

Even with the decision to drop the auditorium one floor, the structure of the roof trusses would not provide sufficient cubic volume within the audience chamber were the narrow walls at the stalls level carried straight up. To

compensate for this, the dimension between the sidewalls increases at each level as one goes up from the stalls. Likewise, the narrow dimension established at the front of the room, if carried all the way to the rear, would have prevented the room from achieving the capacity target of 2,500 seats. Hence it was decided to allow the side walls to step away from centreline in plan from the stage end of the room to the rear wall. The steps were arranged to coincide with the side entry doors of the hall. Large-scale diffusive elements on the sidewalls help defeat any shadowing of early reflection coverage in the stalls.

6.3.3 Orchestra Shell

The orchestra shell design was based upon a concept developed for Hall B at the Tokyo International Forum and Bass Performing Arts Hall in Fort Worth, Texas. Basically a large mechanized ceiling seals off the lower half of the stage house volume from the upper half (where all of the sound absorptive scenery and drapery are stored). This effectively turns the lower portion of the stage house into a reverberation chamber. Within this reverberation chamber, traditional rolling orchestra shell towers form the side and rear wall of the shell and an adjustable acoustical canopy deploys from the structure of the mechanized stage house ceiling. The orchestra also plays forward of the proscenium arch on a lift. An adjustable forestage acoustic canopy can be lowered to enhance hearing onstage for the performers and clarity in the stalls.

6.3.4 Other Design Features

The vertical stepping of the sidewalls was defined as part of the project definition prepared by the acoustician. Early in the design process, the architects asked if the side walls could be angled or sloped instead of stepped. This change was accepted with the proviso that the undersides of the side tier ceilings were also angled to maintain a 90-degree angle between the wall and ceiling surfaces. Acoustic studies were undertaken to confirm that this would not unduly reduce lateral energy in the stalls. To further enhance lateral energy in the stalls, the fascias of the side tiers were designed to be larger and were shaped to direct a significant portion of their reflected energy down to the stalls.

6.3.5 Variable Acoustic System

The acoustics of the audience chamber can be adjusted using a system of acoustical draperies distributed around the hall. These draperies are hidden in pockets in the side walls of the hall and in the upper volume of hall interspersed around the lighting catwalks and other technical facilities in the ceiling area of the hall. The draperies are heavy velour with a mass of 0.8 kg/m^2 and are typically suspended about 24 to 30 cm from the wall. The fabric is sewn with 100% fullness.

6.3.6 Sound System Concept

A full complement of sound reinforcement and production communications systems was planned for the venue. These included:

- Sound reinforcement system with winch-mounted centre cluster and side speaker arrays, distributed speaker systems to cover under-balcony and over-balcony zones, sub-woofers, and the associated equalisation and amplification.
- Front-of-house mix console along with its associated processing gear and microphones.
- Backstage show relay, performer paging and production intercom systems along with front-of-house show relay and audience paging systems.

7 SCHUSTER PERFORMING ARTS CENTRE

7.1 Background

The Schuster Performing Arts Centre resulted from a broad based community effort to replace the Memorial Hall. Memorial Hall, built in 1909, is a very wide auditorium with a deep balcony overhanging the stalls and acoustics wholly unsuited to anything other than amplified entertainment. The centrepiece of the Schuster Centre is the Mead Theatre, a multi-purpose hall designed to serve the Dayton Philharmonic, the Dayton Opera, the Victoria Theatre Association (the local presenter of touring Broadway productions) and other local performing ensembles, companies and presenters.

7.2 Key Features of the Mead

7.2.1 Seating Capacity

The capacity of the hall was set at 2,300-seats.

7.2.2 Form of the Hall

Unlike the Civic Centre Music Hall, where the volume of the existing structure allowed for the creation of a hall based upon shoe-box concert hall models, the form of the Mead Theatre is based upon the horseshoe shaped European opera house. This was dictated by the building site, which was constrained in the longitudinal dimension. The site was not deep enough to contain a shoebox footprint of the appropriate scale for a 2,300-seat house. The final concept for the room provides a stalls level plus three balcony levels. The design also includes four side tiers, three of which are used for audience seating and the highest of which serves as a technical ledge for theatrical lighting.

Figure 5: A view of the interior of the Mead Theatre. Note how the balconies and side tiers wrap around the room in the classic style of the Italian horseshoe shaped opera house. The sienna coloured wall elements are the pre-cast concrete diffusion panels. When the tracked acoustical panels are deployed, they cover these diffusion panels. The edge of the acoustical canopy is visible in the upper right corner.

7.2.3 Orchestra Shell

The concept for symphonic acoustics involved placing the orchestra deep into the audience chamber. In this scenario, over half and nearly two-thirds of the orchestra is set downstage of the proscenium arch. This allowed for a very simple and comparatively lightweight orchestra shell. The acoustic canopy comprises two parts: one is suspended from the stage house rigging and the balance flies in from a storage location just downstage of the proscenium. Budget constraints ultimately resulted in the use of standard Wenger panels for the shell towers and the onstage portion of the canopy. The surface articulation of these elements is simpler than might be considered ideal and some improvement in cross stage hearing could be achieved with more articulated surfaces.

7.2.4 Other Design Features

The width of the stalls is nominally 26m. The four side tiers are carefully arranged to enhance lateral energy in the stalls. Pre-cast concrete panels with stepped profiles provide medium scale diffusion on the side walls. A sound transparent ceiling comprised of perforated and expanded metal panels conceals a much higher hard ceiling while preserving a strong sense of visual intimacy.

7.2.5 Variable Acoustic Systems

The variable acoustic system is similar to that provided in the Civic Centre Music Hall with one exception. The side wall absorption in the Mead Theatre is provided via a system of mechanized acoustical panels rather than draperies. The panels are constructed of 5 cm thick semi-rigid glass fibre with a fabric covering. The track system is designed to hold the panels an average of 24 cm from the wall. This approach was selected because the panels would provide a more uniform broadband absorption character than the equivalent area of drapery.

7.2.6 Sound System Concept

The sound reinforcement and production communications systems were quite similar in scope to those installed in the Civic Centre Music Hall. These included:

- Sound reinforcement system with winch-mounted centre cluster and side speaker arrays, distributed speaker systems to cover under-balcony and over-balcony zones, sub-woofers, and the associated equalisation and amplification.
- Front-of-house mix console along with its associated processing gear and microphones.
- Backstage show relay, performer paging and production intercom systems along with front-of-house show relay and audience paging systems.

8 RESULTS

8.1 Subjective Impressions

8.1.1 Oklahoma Civic Centre Music Hall

The Civic Centre Music Hall is an extremely successful multipurpose hall. For orchestral and choral music, the sound quality is warm and rich. There is an excellent sense of acoustical intimacy, presence and articulation in the hall. The hall has a surprisingly good sense of impact for such a large-scale venue and there is excellent envelopment in the stalls.

Oklahoma City Philharmonic Music Director Joel Levine has reported very positive reactions from performers to the new hall. Onstage hearing is generally considered quite good. Soloists report that the hall gives strong feedback to the stage. Vocal and string soloists report that the hall has an effortless quality that allows them considerable latitude to use dynamics to shape their performance.

If the hall has one area of slight disappointment, it concerns the degree to which the variable acoustic systems control the reverberation characteristics of the room. As can be seen in the objective results below, the completed does not quite meet our target with respect to the low end of the reverberation range. The result is that the room is somewhat less forgiving to high-level amplification than would be ideal. Sensitive sound mix engineers carefully manage sound levels to keep from over-driving the space. If the mix engineer allows levels to creep too high, music articulation and speech intelligibility both suffer.

8.1.2 Schuster Performing Arts Centre

The Schuster Centre is similarly successful when judged from a subjective point of view. The smaller scale of the house and the opera house geometry combine to create an extraordinarily intimate visual and aural experience. The position of the orchestra far out into the house contributes to a sense of heightened impact and strengthens the connection between performer and audience. Neal Gittleman, music director of the Dayton Philharmonic, has reported great satisfaction with the acoustics for orchestral music, choral music and opera. He has also begun to work with the variable acoustic systems to gain a better understanding of how these systems can be used to fine tune the character of the hall for different events or to create a more accommodating rehearsal environment.

The Schuster Centre is also far more successful as an amplified venue. The larger area of sound absorptive drapery in the ceiling, combined with the side wall panel system offers a fuller range of control over the reverberation characteristics of the hall. Sound mix engineers report that it is very easy to achieve good results in the space.

8.2 Objective Measurements

As of this date, we have only had the opportunity to complete a detailed measurement exercise in the Oklahoma City Civic Centre Music Hall. We hope to complete a similar survey in the Schuster Centre to be able to correlate with the subjective impressions. Here is a summary of some key acoustical parameters from the Civic Centre measurement survey.

Reverberation Time (RT_{60})	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Variable Acoustics Stored	2.6	2.3	2.4	2.4	2.4	2.1	1.7
Variable Acoustics Deployed	2.4	2.2	2.0	2.0	1.9	1.7	1.4

Early Decay Time	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Variable Acoustics Stored	2.3	2.1	2.1	2.2	2.0	1.8	1.5
Variable Acoustics Deployed	2.4	1.9	1.8	1.8	1.6	1.5	1.3

Occupied Data (2 seats)	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Reverberation Time (RT_{60})	2.5	2.0	2.2	1.9	1.8	1.6	1.4

Occupied measurements were taken during a concert with the draperies in their stored positions.

9 CONCLUSIONS

The Oklahoma Civic Centre Music Hall and the Schuster Performing Arts Centre demonstrate that it is possible to craft multi-purpose halls that have excellent acoustical properties for a wide range of activity. Such spaces can provide worthwhile homes for local resident companies and allow such groups to grow artistically and institutionally until such time as dedicated facilities can be supported.

10 REFERENCES & NOTES

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8. Atwood Concert Hall uses an electronic enhancement system to vary its acoustics.