Some Recent Experiences with the Acoustical Design of Orchestra Pits

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Abstract: A number of recent projects, including work for the San Francisco and Houston Operas, have included acoustical designs for new and/or renovated orchestra pits. This paper will review some of these projects, their criteria, design, measurements and evaluation.

GENERAL BACKGROUND

An increasing number of orchestra pit renovations are taking place, often being initiated by the musicians’ dissatisfaction with the pit environment as a location for music performance. There are a number of key elements to their displeasure: the increased awareness of the threat to hearing loss that continued exposure to loud sound pressure levels may provide, the frustration over the lack of inter-player communication as compromised by the typical pit architecture, and the generally cramped pit conditions that exacerbate the loudness and the communication problems.

During the renovation of the San Francisco War Memorial Opera House necessitated by the 1989 Loma Prieta earthquake, the Opera maintained performances by utilizing other venues within the city. One of these was the 2500 seat Orpheum Theatre, where the Orpheum’s existing orchestra pit had to be enlarged from its 25 musician capacity to the 65 musician minimum needed in order to meet the requirements of the Opera. The configuration of the pit was less than optimum in other respects as well, including an extremely shallow depth limited by structure. Detailed recommendations were made to the Opera for acoustical treatments to the pit as part of the renovation/enlargement.

The Brown Theatre at the Wortham Center in Houston, TX is the home of the Houston Opera. Musician concerns with the layout and acoustics of the existing orchestra pit served as the catalyst for an expansion of the pit and options for the front portion of the stage overhang. Removable panels of either steel grating or wooden construction were provided to allow choices between open or closed stage overhang conditions. The architect’s drawings of the proposed pit renovation served as the basis for recommendations for shaping, interior finishes, and acoustical elements.

ACOUSTICAL CONSIDERATIONS/CHALLENGES

Due to a complex interplay of people and physics, one is unlikely to establish an optimum configuration for an orchestra pit. Acoustically they are difficult environments, which ideally, would provide ensemble conditions similar to those onstage. Instead, physical conditions in the understage pit (low height, relatively long width, etc.) versus the “open-air” portion make “cross-stage” inter-player communications difficult. The close proximity of the players to one another almost assures situations where louder instruments will be adjacent to quieter ones, creating potential hearing loss problems and problems in hearing one another. Loudness levels will exceed 100 dB on crescendos. Blanket reduction of the sound energy in the pit has repercussions on the communication between the pit and the singers, and the balance of vocal and orchestral energy in the house. The configuration of the musicians is often dictated either by space limitations in fitting them into the pit, or conductor/musician sight lines, rather than by acoustical or musical criteria.

HUMAN CONSIDERATIONS/CHALLENGES

It is difficult (perhaps impossible) to obtain a clear consensus from the musicians on what are the desired/preferred acoustical conditions in the pit. The critique from a musician under the stage overhang towards the rear of the pit can be the antithesis of one who is on a riser in the “open-air” area at the front of the pit. These location dependent conditions are typically greater than those encountered on an open stage. Due to union and player/orchestra agreements, it is difficult to have access to the musicians in order to establish preferences for alternate acoustical choices (ie, adjustment of variable acoustical elements in real time). Similarly, conductors may be “out-of-the-loop” with regards to musicians’ discussions with management regarding the pit, and are frequently reticent to get involved with “acousto-political” issues. Consequently one is often left with the necessity to make design decisions based upon experience/common sense, realizing that the coordination and cooperation required to provide a “fine-tuning” of all of these elements is unlikely to occur in time to meet the typically restrictive construction schedules.
**DESIGN GOALS/PROCEDURES**

Within the relatively rigid constraints of the orchestra pit environment, the stated goals for both of these projects were to improve the communication between musicians while also providing reduction of sound pressure levels with the pit. Ideally, the reduction in sound pressure level locally in the pit would have minimal impact on the total energy available to the house. This suggested the use of diffusing elements rather than simple absorption, although the differing configurations of musicians meant that variability in the acoustical elements would also be desirable.

The surface areas available were rather limited, consisting of the ceiling and rear wall areas, and portions of the pit front wall. Due to the restricted height, ceiling treatment was non-variable, and was provided as two-dimensional acoustic diffusers based upon number theory sequences. By their nature, two-dimensional diffusors will scatter energy in planes parallel to both their width and height. This allowed greater scattering than a one-dimensional diffuser or absorption would provide, hopefully improving the sense of ensemble for the musicians.

The rear wall areas were provided with moveable panels, which could be rotated to present either a one-dimensional diffusive surface, or an absorptive one. In this location the one-dimensional diffusers were installed vertically, to provide left-to-right scattering within the pit. In addition to rotation, the panels could also track upstage and downstage within the pit, allowing the understage area to be closed off, or to adjust the pit depth to the size of the ensemble.

**MEASUREMENT SYSTEMS**

The primary measurement instrumentation platform was the Techron TEF 20, using the MLS (Maximum Length Sequence), TDS (Time Delay Spectrometry), RTA (Real Time Analyzer), and PETC (Polar Energy Time Curve) software modules. Impulse (balloon burst) data was recorded to DAT, and analyzed using the MLS time module and the JBL-SMAART Pro analysis package.

**MEASUREMENT METHODOLOGY**

At the Orpheum, acoustic measurements of the half/pit were restricted by construction site logistics and rehearsal/performance considerations to a few maximum length sequence (MLS) “snapshots” within the original pit prior to renovation. The Brown Theatre, however, requested a comprehensive series of measurements to establish a baseline for the acoustical performance prior to the pit renovation, which could be used as a comparative benchmark to assess the acoustical environment post-construction. This was accomplished just prior to the onset of construction.

At the Brown Theatre, a test procedure was established utilizing a variety of listener/source positions and stimulus types. Sources were located in the orchestra pit at three positions: at the stage left and stage center on the front pit lift forward of the stage overhang, and a stage right rear location under the overhang. Source stimuli included balloon bursts, a loudspeaker array with 150° horizontal by 70° vertical coverage, and an Ilg fan standard sound source.

Receiver locations were established at 22 representative seating locations within the audience area, 3 locations within the pit, and 3 locations on the stage apron, forward of the proscenium arch and the closed fire curtain. As the theatre is symmetrical about the centerline, measurement locations were from centerline to house right only. The seating locations chosen were roughly equidistant from the front to rear of the seating area based upon distance and seating level. MLS data was gathered for all of the source/receiver locations, TDS and balloon-burst data was gathered for inter-pit source/receiver locations, and the RTA module was used to gather Ilg fan data from all of the source/receiver locations. PETC were collected from the central pit source location and selected receiver positions within the theatre.

At this juncture pit construction is not yet completed, and a return visit to obtain comparative data is pending. We are working with the Houston Opera in planning a combined musician survey/measurement approach to our analysis of the reconfigured pit acoustics.

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