MUE 606 Acoustical Report

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Overview

The following short report details the process of acoustically simulating, measuring, analyzing, and making treatment recommendations for a home production/mixing studio. The studio was located in the living room of a 1 bedroom/1 bathroom apartment located on the 2nd floor of small-sized apartment complex in a relatively quiet residential area of South Miami. As the room, apartment, and building were designed primarily to be living spaces, there were various limitations and confounding factors to acoustical measurement and analysis, including parallel walls, usage of non-absorptive construction materials, acoustically coupled spaces, and other considerations that will be mentioned in latter sections of this report.

1 Acoustical Simulation

Prior to taking acoustic measurement, key attributes/characteristics of the acoustic space were mathematically modeled in MATLAB. The real life acoustical space was not fully enclosed, with openings leading to both the kitchen area and the bedroom potentially creating acoustically coupled spaces (Figure 9). However for modeling purposes the room was sufficiently rectangular to utilize the shoebox approximation and treat the room as an enclosed, $11' \times 15' \times 8'$ space. As seen in figure 1, these dimensions fall within the Bolt area recommendations.

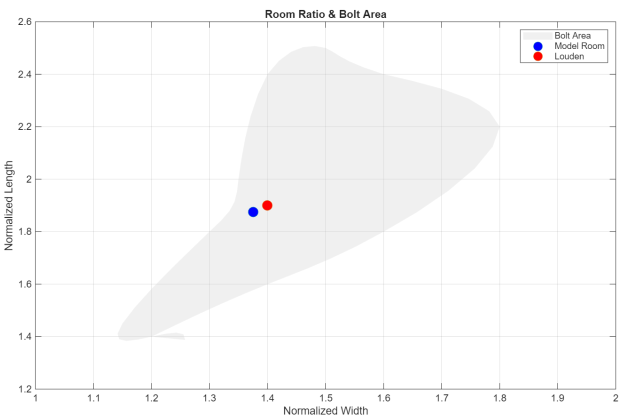

Figure 1: *A plot of the measured room ratio (blue), the nearest recommended Louden room ratio (red), and the overall Bolt area (shaded gray)*

Figure 2 shows models of both the axial mode spacing below Schroeder frequency (253.71 Hz) and the modal density in $\frac{1}{3}$-octave bands from 20 Hz through 800 Hz. The simulations predict irregular modal spacing around 70 and 150 Hz (common for small rooms) but show overall convergence to the Bonnello criterion. However, the existence of acoustically coupled spaces could potentially disrupt the modal spacing and cause the actual measurements to diverge from this prediction.

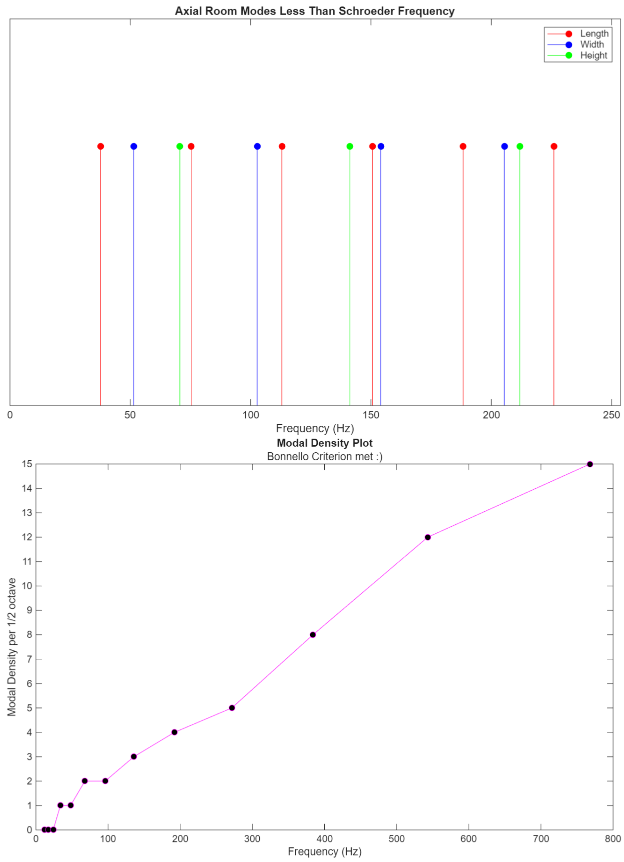

Figure 2: *Top- Predicted distribution of axial room modes below Schroeder frequency*
Bottom- Predicted modal density chart, measured in $\frac{1}{3}$*-octave bands*

The total absorption of the room in sabins was estimated, with the main materials involved in the calculation being hardwood floors, plaster walls, painted concrete ceilings and draped tapestry. Figure 3 then shows the estimated RT60 times for various frequencies, although the values are expected to be overestimates (especially at 1 kHz) due to the tapestry being minimally draped to $> \frac{7}{8}$ length and mounted less than 1" away from the wall.

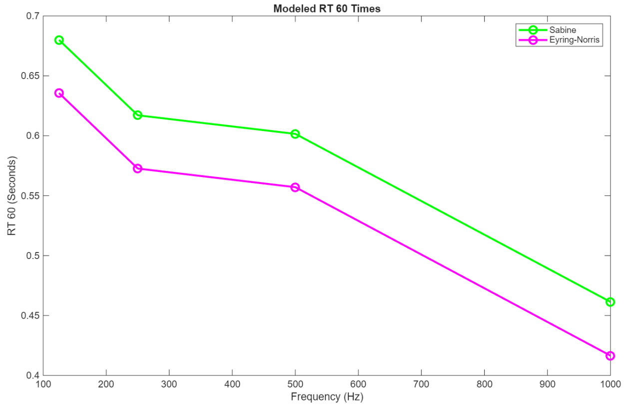

Figure 3: *Modeled RT 60 times at select frequencies, derived from both the Sabine & Eyring-Norris equations*

Finally, an analysis of first-reflections was done, considering possible reflection paths from the ceiling, floor, and the wall behind the source. Figure 4 shows the both the expected comb spacing frequencies and the relative levels of the peaks/nulls.

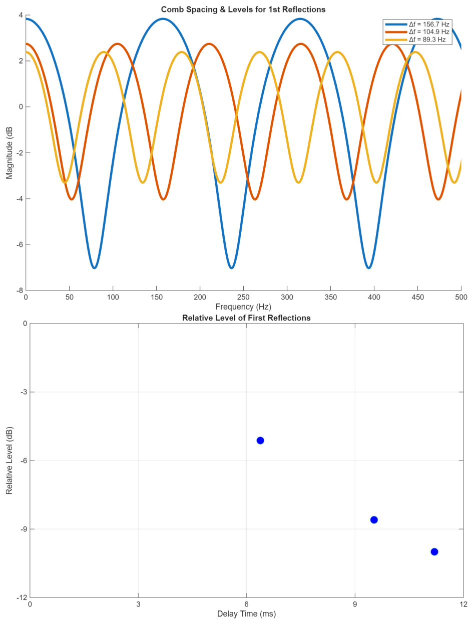

Figure 4: *Comb spacing levels for 1st reflections (top) and the predicted relative levels of first reflections (bottom)*

2 Measurement & Analysis

Acoustical measurements were taken with the aid of Room EQ Wizard (REW) acoustic software. The measurement source was an ADAM Audio T7V studio monitor, and the receiver was a miniDSP U-MIK 1 omnidirectional microphone. The source was placed 1 foot away from the front wall, and a total of 9 measurements were taken at equally-spaced intervals in a 3×3 square grid, as shown in figure 5. This was done to increase the chance of measuring low-frequency modal interactions, which are more sensitive to listening position.

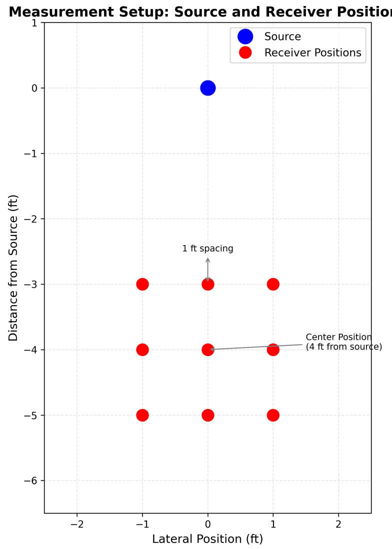

Figure 5: *Diagram of source and receiver positions for the acoustic measurements*

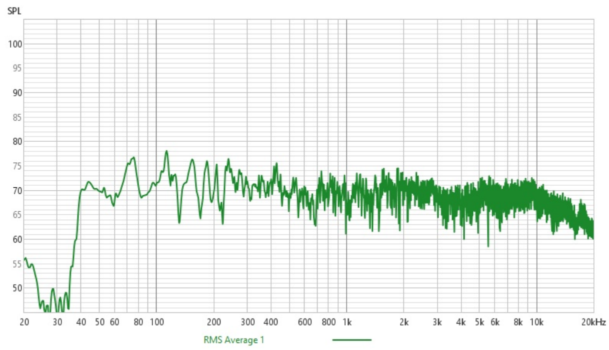

Figure 6: *RMS-average of the SPL readings for the 9 measurements*

An RMS average of the SPL readings was taken, and can be seen in figure 6. As predicted by the simulations, the SPL readings show significant fluctuations in the lower frequencies (specifically around 70 and 150 Hz), due to the modal resonances of the small room and coupled spaces. The low SPL response below 40 Hz can be attributed to limitations in the studio monitor itself, confirmed by consulting the technical manual for the product.

The RT60 measurements were exported and averaged as well (Figure 7). Due to a variety of factors, the background noise level of the environment was too high to allow 60 dB of dynamic range, thus RT60 times were estimated along 3 metrics: Early Decay

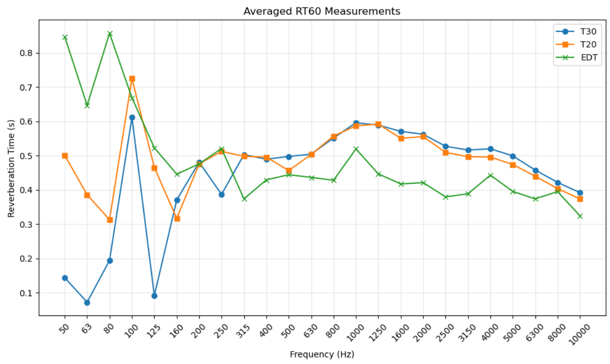

Figure 7: *Averaged EDT, T20, and T30 estimates of RT60 times*

Time (EDT), T20, and T30. Even using these estimations ran into some limitations- note the abnormal variation in T30 estimates at values of 125 Hz and below. However, the results were still robust enough to perform general analysis. The EDT and T20 averages agree on high decay times for low frequencies (< 125 Hz), and all 3 metrics also display an increase in decay times around 1 kHz. While the decay times for low-frequencies were consistent with predictions, the rise in mid-frequency decay times was unexpected. Possible reasons for this include late reflections from acoustically couple spaces and overestimation of absorption coefficients due to discrepancies in tapestry mounting and drape area.

3 Recommendations

The analysis of physical measurements showed general agreement with the simulated acoustics, with modal resonances and high decay times in the low frequencies and a rise in decay times around 1 kHz. Recommendations for acoustic treatment were limited in scope by a few factors, including economic and livability concerns. RT60 times at 1 kHz can be attenuated economically using two techniques:

- Properly mounting the existing tapestries and draping them more effectively to at least $\frac{3}{4}$ area
- Adding absorptive sheets to cover doorways/openings to the acoustically coupled spaces, minimizing late reflections. Audimute absorptive sheets (NRC = 0.85, $69) are a great candidate for this application.

Modal resonances at 70 and 150 Hz could be treated with a combination of panel absorbers and corner bass traps- however, the limited space available in the room combined with the monetary and labor cost of implementation makes using solely this approach unfeasible. Instead, a three-pronged approach is recommended:

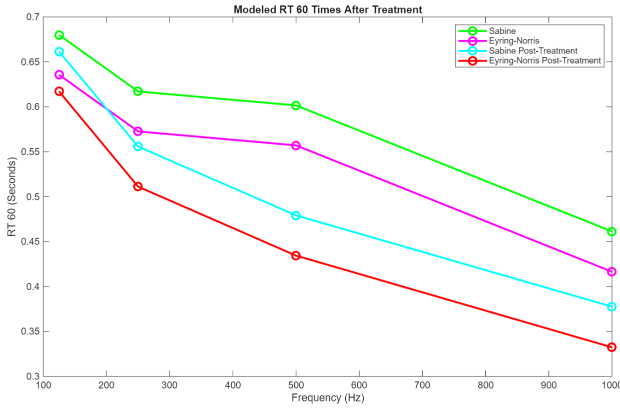

Figure 8: *Predicted RT60 times after recommended treatment. Improvement is shown across the frequency spectrum, particularly at the 500 Hz benchmark.*

- Intentional studio monitor placement, moving away from walls and corners to minimize modes
- Utilize REW measurements to select critical listening position with flattest response
- If economically plausible, implement 1 to 2 small bass trap panels with thickness of at least 4” to target modes below 100 Hz. GIK Acoustics $2' \times 2'$ classic panels are an ideal candidate for this at just $79

These recommendations should adequately address low- and mid-frequency modal buildup for the purposes of this home studio, and at a total cost of $148 remains budget-friendly. Figure 8 shows the predicted RT60 results post-treatment, with marked improvement across the frequency spectrum, especially at 500 Hz.

Figure 9: *A wide angle view of the home studio room. The acoustically coupled spaces can be seen on the left and right sides.*