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Acoustic Modeling with *Google Sketchup* and *JBL Ease*

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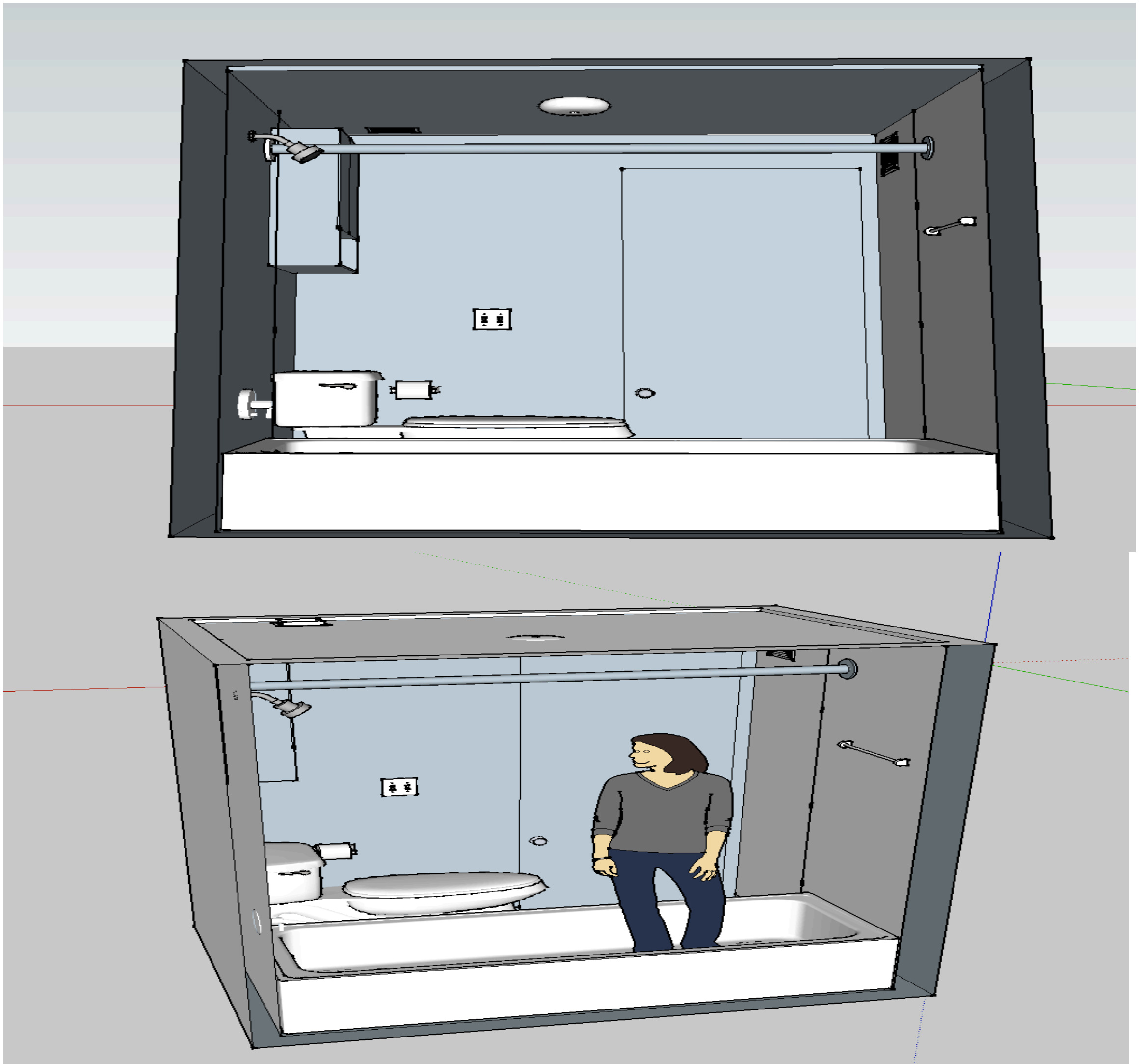
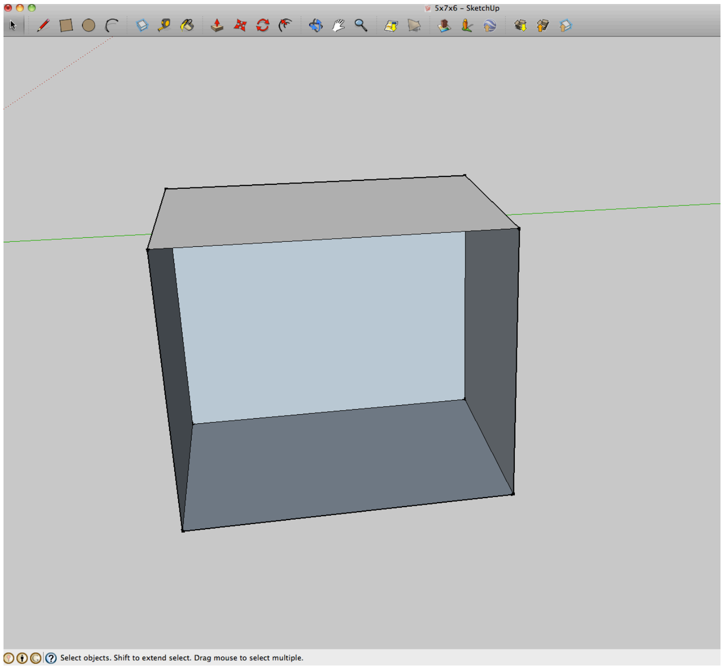
This project's goal is to compare two spaces, one physical and one modeled. The physical room is a bathroom in the University Village "Cane" type apartment, which is a four-bedroom, two-bathroom configuration. The space was modeled in *Google Sketchup*. I used *JBL EASE* to acoustically measure the simulated space. This is a great way to predict how a space will sound before you actually build it. It may be cheaper to simulate and fix preemptively as opposed to trying to fix it after it is already built. The value of learning how to do this in school before you encounter it in a real world job is incredible. However, while the project was an interesting way to apply what we learned all semester, more time was spent troubleshooting than getting results. I suppose this could also be how it might happen in real life too.

The project requirements stated that "[i]t is important that the virtual space be as accurate as possible". However, I found this to be untrue. I spent the better part of two whole days meticulously measuring the physical space and making sure the *Sketchup* model was correct. I downloaded 3D models from the online database of things like the toilet and showerhead. I found my initial drawing to be very accurate and visually pleasing. Figure 1 shows a cutaway of the bathroom. The actual drawing is fully enclosed. It was very frustrating when, after spending an afternoon learning how to import a *Sketchup* file into *EASE*, it refused to simulate the space because of errors that sent me through loops back and forth between menus. I finally realized that the simpler the model, the easier it was to simulate the space. It was instantly clear that while *EASE* may be a powerful tool, it is extremely not user-friendly or intuitive. It is absolutely unbelievable that a program that costs such an absurd amount of money could be so backwards and difficult to use. The user guide provided by a third party was more helpful than any help files included with the software. I must have created and scrapped close to fifteen different projects until I finally was able to get it to do what it was intended to do- model the acoustics of a simulated space.

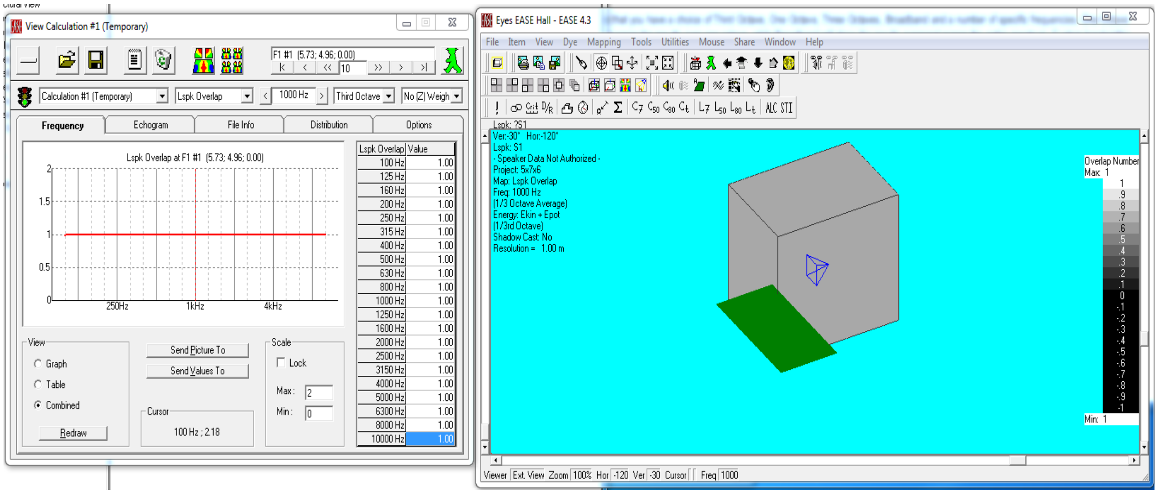


After realizing what a complete mess *EASE* was, I was forced to go back to *Google Sketchup* to create a simpler model. The thing that made it so complicated was that using curved surfaces (like on my downloaded doorknob or light fixture) caused vertices to intersect and give errors. While I never found an exact answer to this problem, it was apparent that I needed to make a simpler model to get *EASE* to work. This model was a five feet wide by seven feet long by six feet tall box. This model made it easy to assign wall materials to the “faces” of the model. It seemed there was no way to select multiple “faces” in *EASE*, so going from my original 2500 faces to only six was a very welcome change of pace. If I had realized this earlier on in the project, I may have been able to create a compromise between 2500 and six faces, creating a somewhat believable space as opposed to such a simple one. Unfortunately, much like in the real world, I was running close to my deadline and had to cut my losses. Figure 2 shows this new model.

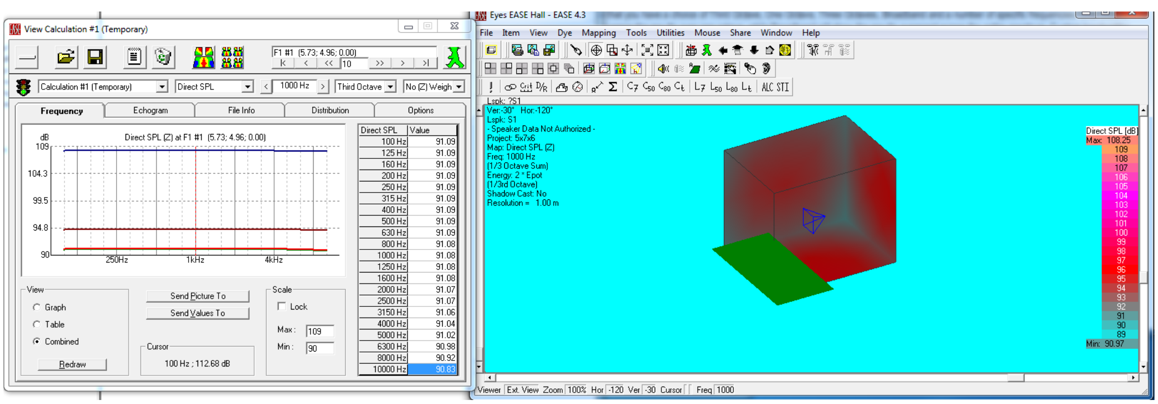


That was, until I realized that by default, the only wall material in the *EASE* database was an absorptive paneling. Again, it was back to the third party tutorial to learn that you have to import other materials through hidden directories that were placed in hilariously long file paths. Once I had assigned materials to the six surfaces, it was time to place the speaker. I used the default speaker, since they did not have the speaker I used in my physical test. Of course, importing the speaker library is done in the same way as adding wall materials. In order to simulate, you need to also place an audience area. I placed them directly in front of the speaker since the room is so small. Figure 2 shows the *EASE* model of the simpler design.

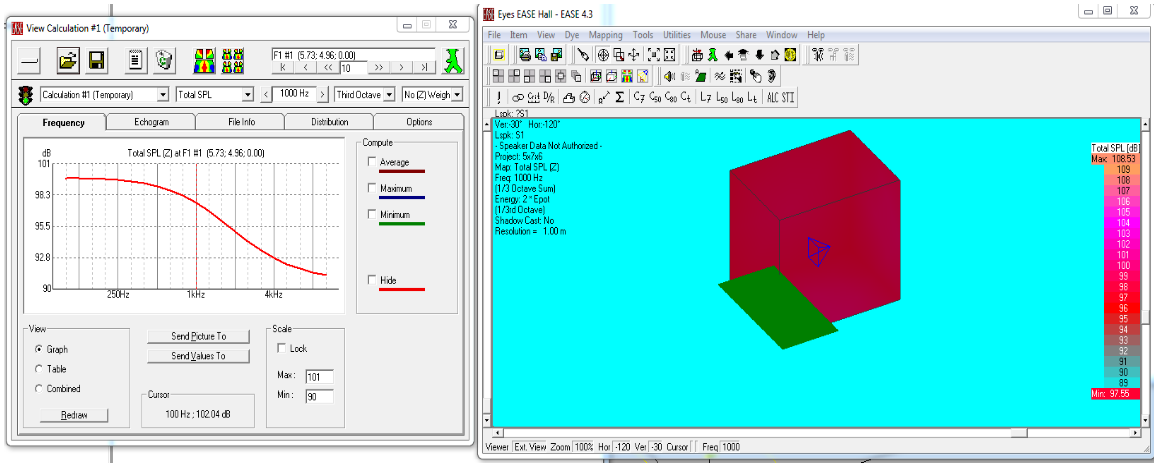
After spending so long getting my project ready to be simulated, I finally was able to calculate some acoustic properties of my space. This is where *EASE* really shines. It is able to relatively quickly compute simulations of acoustic traits of the room. First is the energy level of the room, Figure 3.



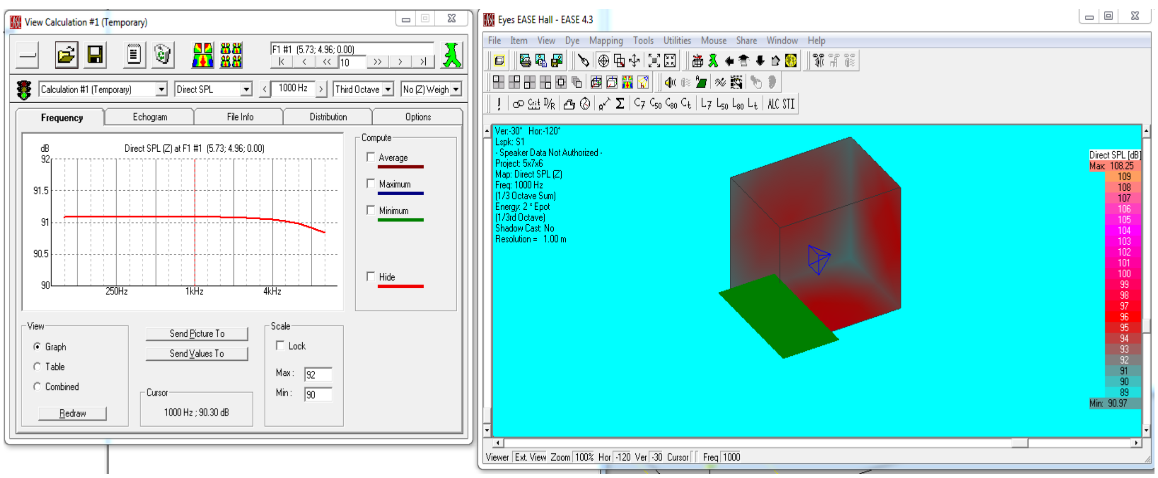
Next is ALcons, or Articulation Loss. This is the percentage of consonats that are lost within the space. Lower ALcon percentage means that a listener can understand a higher percentage of syllables. Most of this falls around 90%, which means the room is highly unintelligible. While this may be true, the designers probably never took into account more than one person being in this space at a time since it is only for toilet use and showering. Also, you will realistically have absorptive materials like a shower curtain, rug, or towels in the room. See Figure 4.



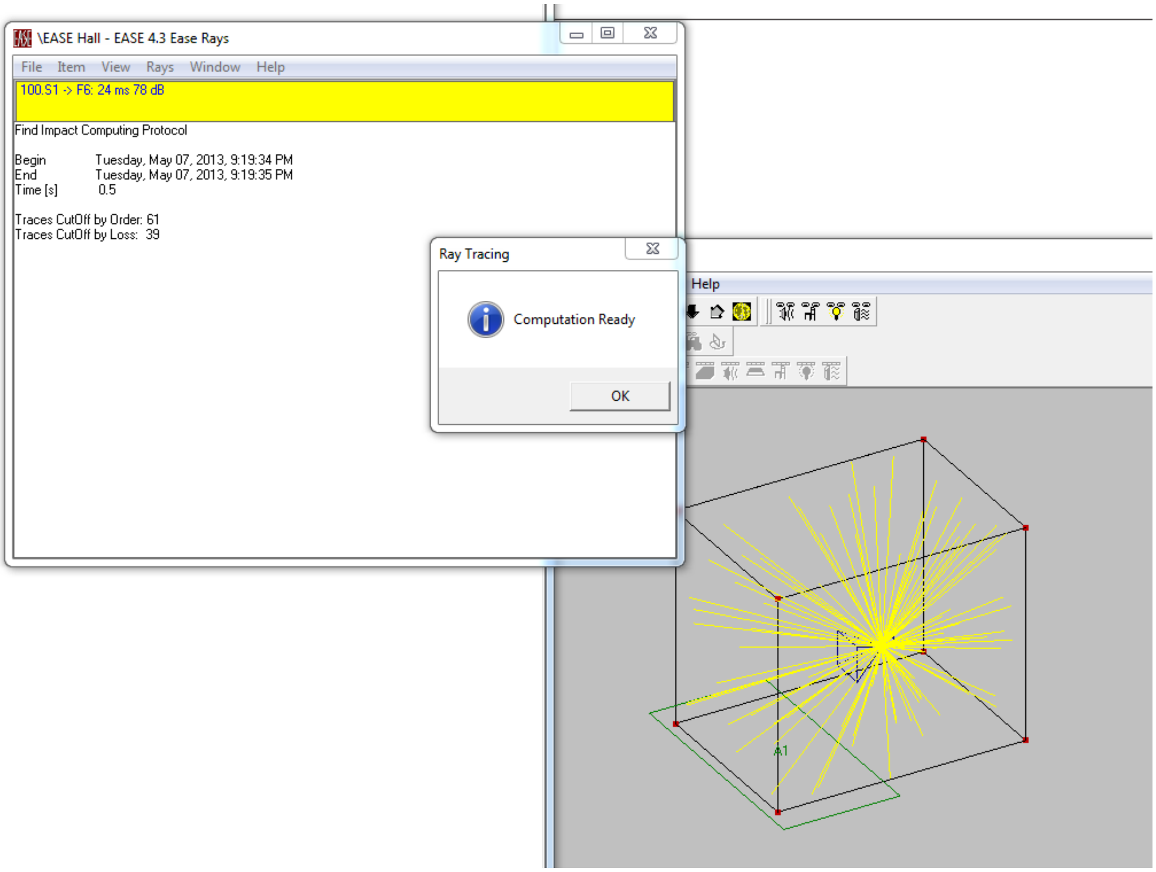
Total SPL is the total maximum loudness produced by the speaker. It is the sum of direct sound and reflected sound. See Figure 5.



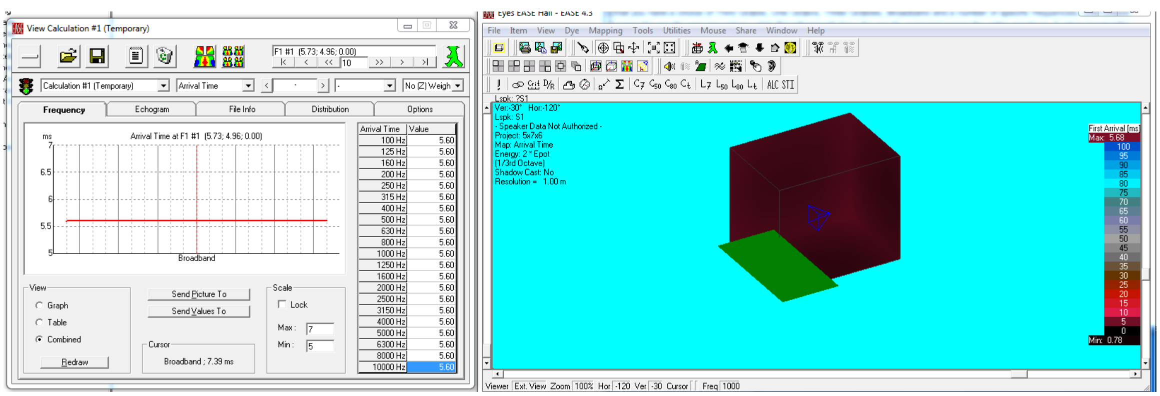
Direct SPL is measured only by the loudness of direct sound. Since there are no dips in the frequency response, it appears that there are no room modes present. There also appears to be no harmonics. While this is a small room, it seems unlikely that this would actually happen in real life. See Figure 6.



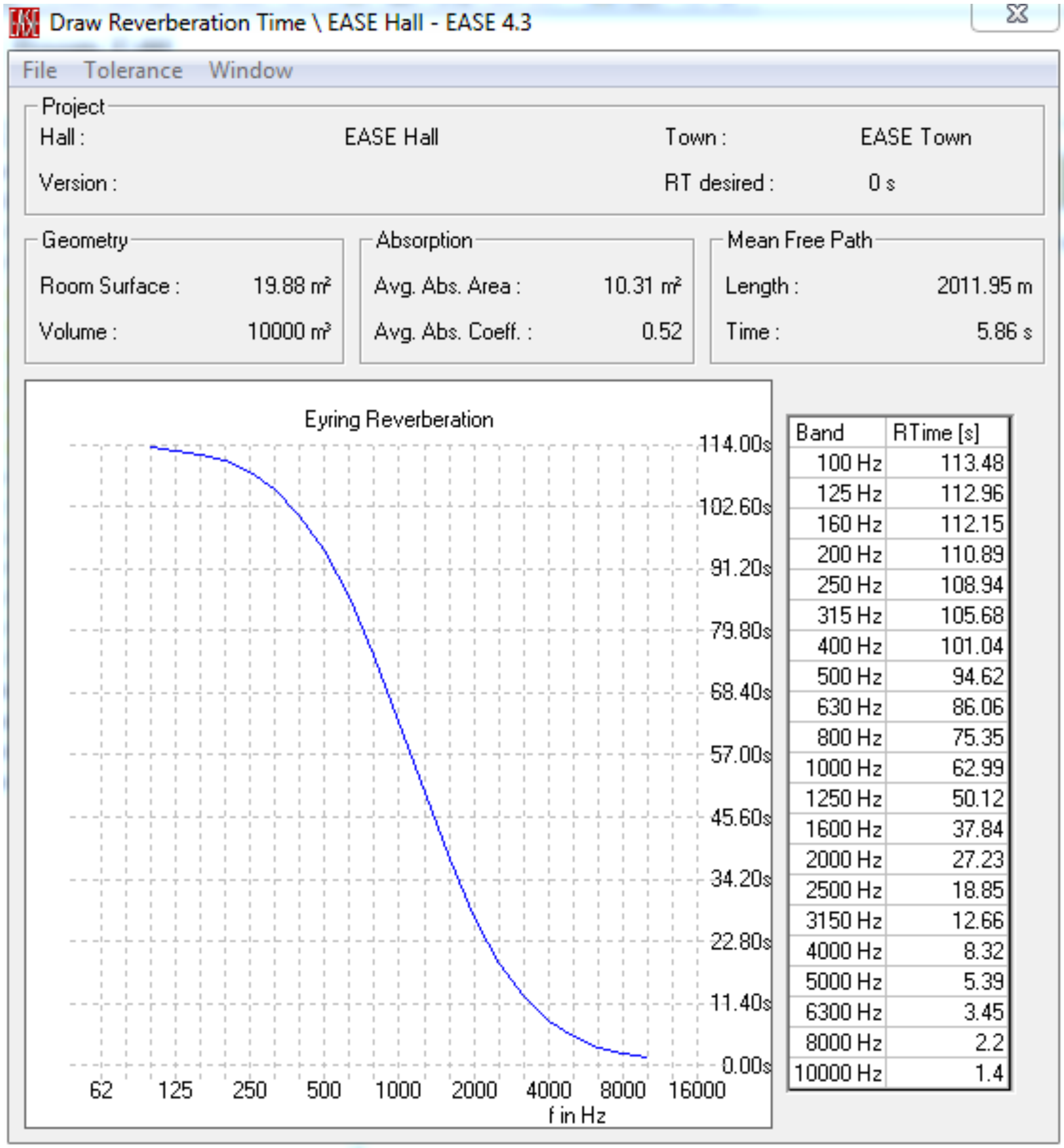
Ray tracing is when you draw the direct sound along with its first reflection in a space. Since the simple model has nothing that would block rays, it appears that at any point in the room you would be able to hear the speaker. My standing in the room and moving around during a sine sweep verified this. I was able to hear the speaker at all parts of the room. See Figure 7.



The First Delay arrival time was only about 5.5ms, which seems accurate since the room is so small. See Figure 8.

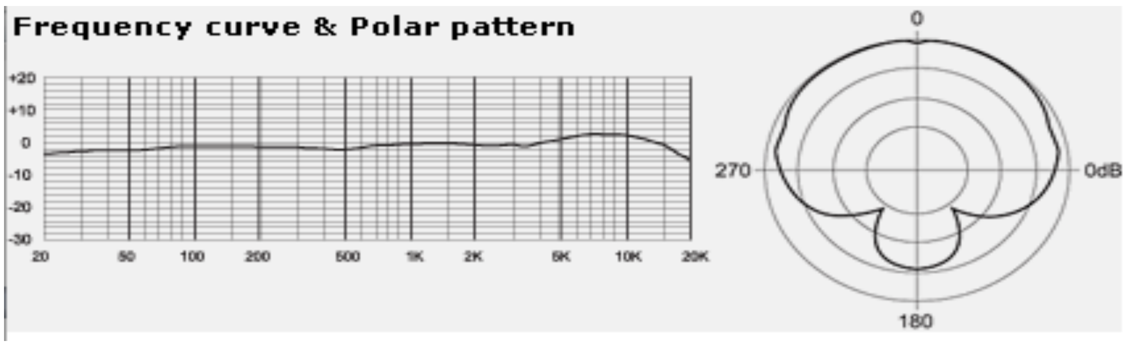


Also included is the ability to predict the RT60 of the room. See Figure 9.

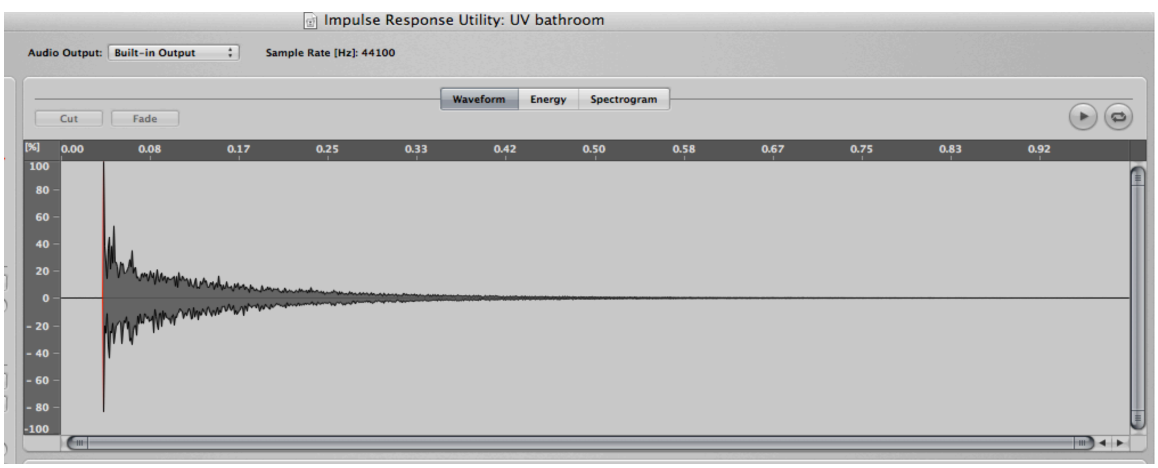


Band	RTime [s]
100 Hz	113.48
125 Hz	112.96
160 Hz	112.15
200 Hz	110.89
250 Hz	108.94
315 Hz	105.68
400 Hz	101.04
500 Hz	94.62
630 Hz	86.06
800 Hz	75.35
1000 Hz	62.99
1250 Hz	50.12
1600 Hz	37.84
2000 Hz	27.23
2500 Hz	18.85
3150 Hz	12.66
4000 Hz	8.32
5000 Hz	5.39
6300 Hz	3.45
8000 Hz	2.2
10000 Hz	1.4

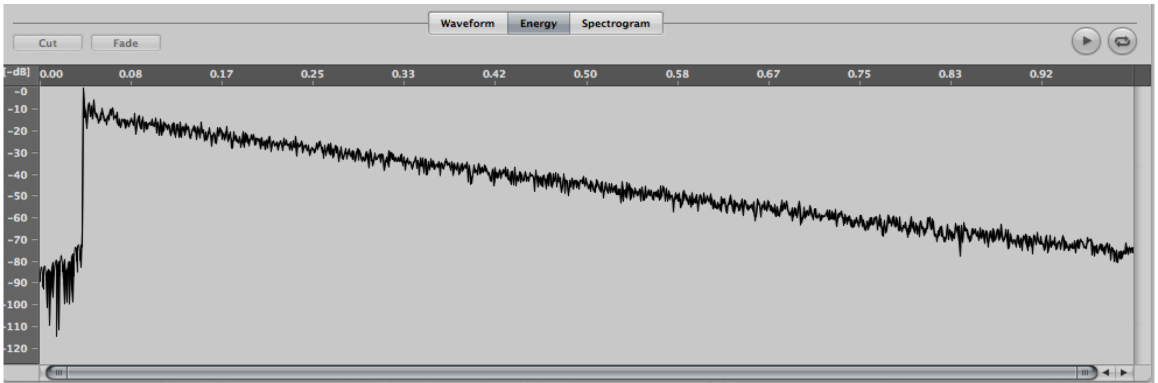
Now let us compare these simulated results with my measured results. For my setup, I prepared the space by removing all materials not bolted down to the room. This included objects like the shower curtain, rug, towels, soap bottles, and some other things. Next, since it is a bathroom, I made sure the to clear the air of any humidity from hot showers by running the fan and opening the door for a period of time before taking measurements. In addition to water damage to sensitive equipment, we learned that humidity and temperature of the air can change how sound propagates through the air. I then brought my equipment into the room. I placed my speaker on isolation pads on the floor angled up at approximately a 45-degree angle. The speaker is a powered mixing monitor, an M-Audio BX5 D2 5 inch, so it can be said that it has a relatively flat frequency response. A condenser microphone, MXL 990 was used since I had no way to access an official audio precision measurement microphone. This microphone does not have a completely flat polar pattern, so some of my data may be skewed because of this. See Figure 10 for the frequency curve and polar pattern.

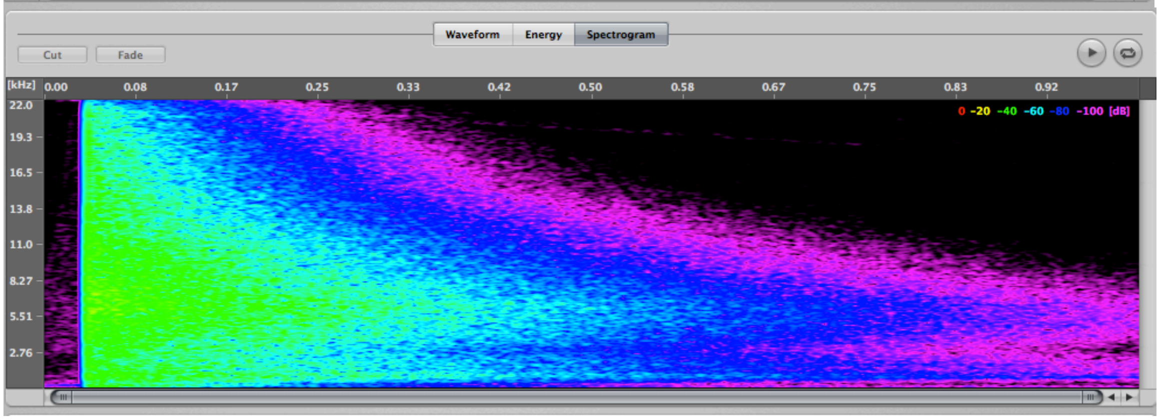


I ran the microphone through an M-Audio Firewire interface and the speaker through an M-Audio USB interface. Two devices were used since the USB device had an eighth-inch jack and I did not have an adapter that fit into the quarter-inch plug in the Firewire device. I did not plug the speakers directly into my laptop because it has a very noisy output jack, which is typical of laptops. I used Apple's Impulse Response utility to de-convolve a 50 second sine sweep. See Figure 11 for the Impulse Response.



I have also included the energy of the impulse response and the spectrogram in figures 12 and 13 respectively.





After importing it to Logic's Space Designer, it is remarkable how accurately the setting sounded like the bathroom. I would first listen on headphones, then go into the actual room and it sounded eerily close. Some things that might have thrown it off is that I played the sine sweep loud enough to resonate the tub and shower curtain rod at their resonant frequencies. I verified this by standing in the room for one test and could audibly hear this happen.

Overall, despite it's shortcomings, *EASE* is a very powerful tool to know how to use. There is really nothing else quite like it out there. That does not excuse it though from the frustration it causes. It can definitely be useful in a situation where you cannot build a space without taking its acoustics into considerations, such as a concert hall. It was interesting to see how all of the things we learned in class could be actually applied to real world projects.

References:

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