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# Building a Mobile Worldizing Chamber

Audio engineers are often times limited to hardware or software reverbs, or even giant rooms that are pre-constructed for a specific room sound. Our mobile worldizing chamber was originally conceived with the idea that it would be able to be used as a portable version of an echo chamber that can be used in multiple applications. The inspiration for this project was based on the concept of worldizing, or the manipulation of a sound to seem as if it existed in a real space. This is typically done by injecting a sound sample into a listening chamber through a set of speakers, often times simply using consumer-grade speakers. Comparing this to the design of a reverb chamber used in audio engineering, worldizing is designed to create the image of placement in a natural space, rather than the effect caused by the consistent decay and flat response speakers and microphones of a reverb chamber.

Because of the space required to create a natural sounding reverberation and decay, any reasonably mobile worldizing chamber would have a unique tonality, completely different from the sound of any normal listening chamber. As it was deemed impossible to recreate the natural listening experience in a mobile, budget-friendly project, more emphasis was placed on creating and emphasizing the unique sound of the mobile worldizing chamber. However, as a nod to flexibility, the project did seek to reduce or eliminate any large natural modes from the chamber, creating a slightly more consistent frequency spectrum.

As this project was operated on a fairly strict budget, the basic materials chosen were a carbon steel fifty-five gallon drum with a resealable lid to act as the basic structure, and corrugated tin siding for internal structuring and sound manipulation. All attachment and bonding was done with a combination of construction adhesive and cotton-fiber tape. Although unmeasured, initial rough tests were done to judge the acoustic properties of the unmodified drum. It was determined that the tonal characteristics were characterized by an abundance of high frequencies, as well as a number of resonant modes. This agreed with the results of earlier modeling calculations, which took into account the resonant modes created by the vertical and horizontal surfaces of the drum, which were located at 380Hz and 580Hz respectively. It was quickly determined that internal structure of the drum should be changed to reduce the focusing effect of the drums concave shape, as well as to reduce the total surface areas of the drum that were parallel to each other.

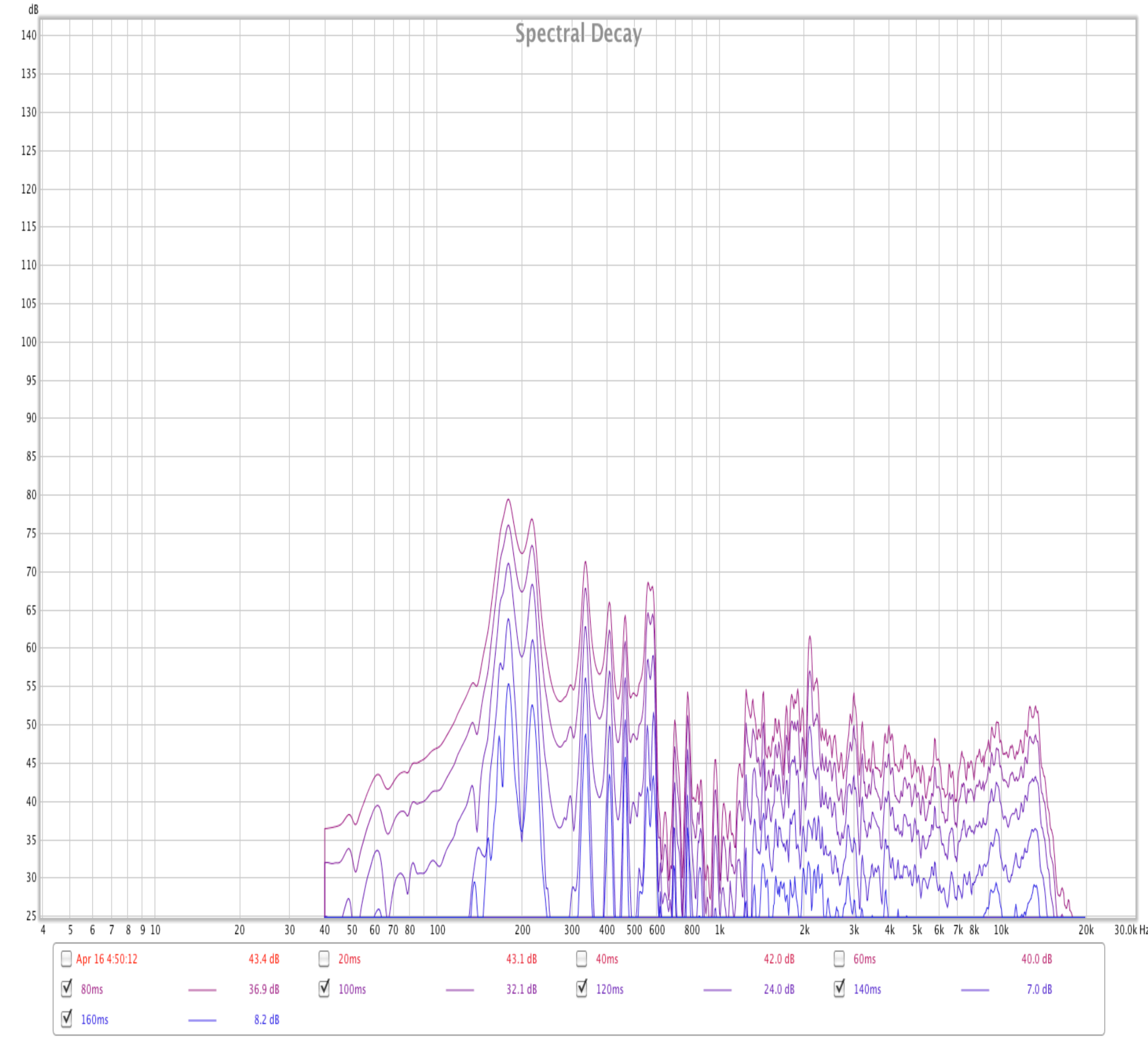
Construction was done by cutting the tin into a set of panels, which were used to cover the bottom of the drum, as well as suspended at vertical angles from the bottom to the top of the drum. The vertical panels were placed in the focal points created by the concave drum siding, and the corrugation further contributed by acting as a diffuser for higher frequencies. For microphone and speaker placement, a shock mount and a platform of wood shims were attached to the lid of the drum on either side of the topmost vertical panel. This design was chosen in an effort to isolate the drum lid from resonances and magnetic fields created by the speaker, and to isolate the microphone from any similar resonances. Placing the microphone and speaker on opposite sides of the vertical panel prevented any direct sound from reaching the microphone, creating better conditions for a more resonant output signal.

The microphone chosen used in the initial tests was an AKG C 414 B-ULS placed in bidirectional mode, although this was later switched to omnidirectional mode due to the cancellation of bad modes that omnidirectional offered. However, theoretically, any flat-response microphone could be used here. As to the speakers, several options were tried, including speakers from audio monitors and other media devices. However, each of these failed to provide the volume necessary for this application without their initial housing, which were all decided to be too cumbersome and oversized for use in this situation. The speakers used during testing were a pair of powered Logitech computer speakers still in their factory enclosures. This follows the trend of using consumer grade speakers in worldizing applications. However, if further improvements were made to the chamber construction, this would be one of the earliest modifications.

Testing the chamber used a combination of samples, software, and interfacing. A MOTU Ultralite mk3 was used to connect the inputs and outputs of the drum to a computer, which had REAPER digital audio workstation installed on it. Initial listening comparison and rough frequency analysis were done using snare drum and pink noise injected into the chamber. These tests suggested there were still a few resonant modes, which needed to be resolved. In particular the 380Hz mode, which corresponded to the vertical height of the drum, as well as its multiples, were still very present. This was one of the primary reasons that led us to switch the microphone from bi-directional to omni-directional mode. Initial solutions to the modes involved dedicated equalization to reduce the problem frequencies of the chamber, as well as boost the frequency ranges below 125Hz, as these could not reverberate due to the size of the drum. Though unused after the microphone was switched to omni-directional, this approach is still viable, and could easily be used to correct any other problems present with the tonal characteristics of the chamber. In addition to changing microphone patterns, further diffusion material and absorptive tape were also added in an attempt to reduce these problem modes.

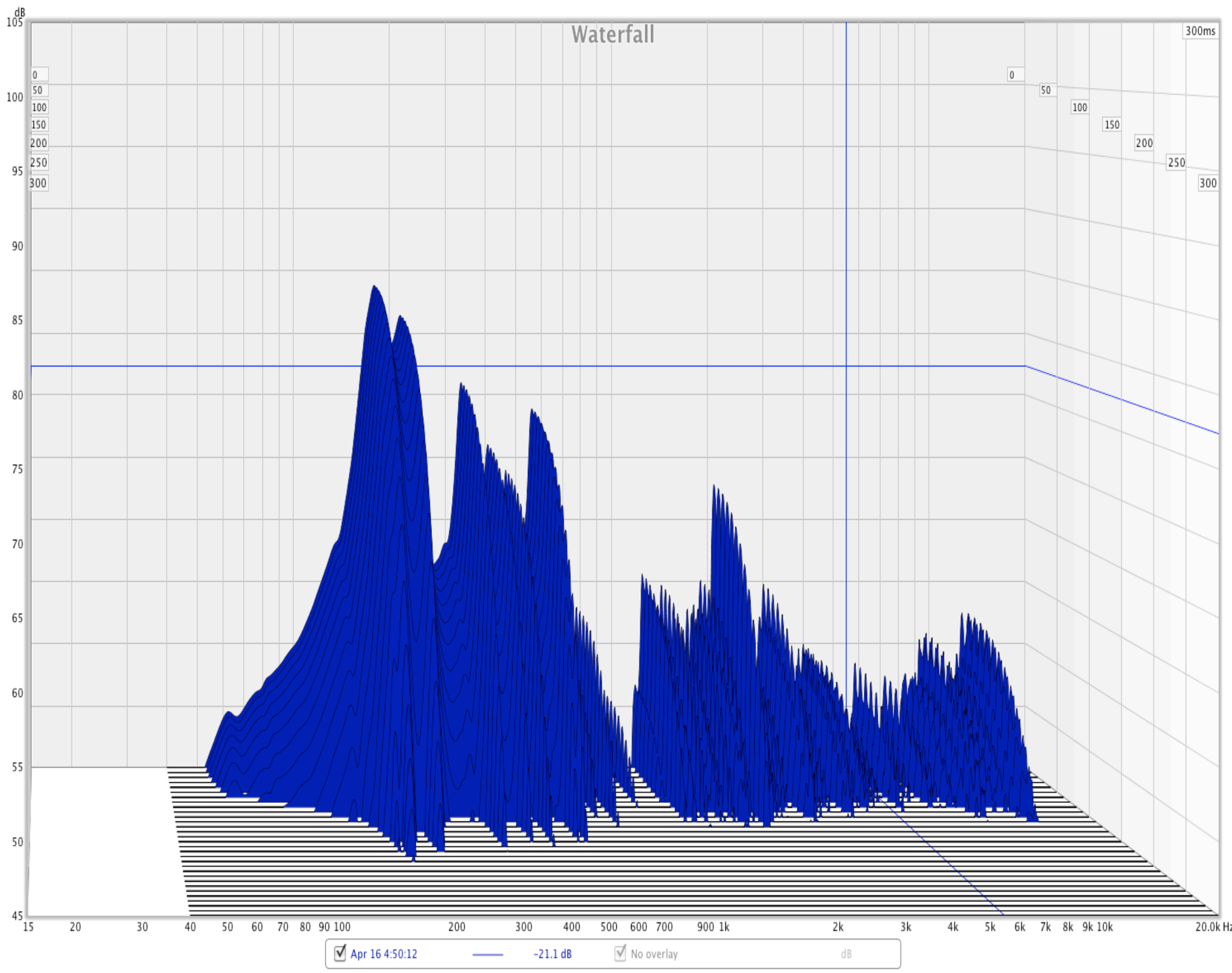
Once reasonable characteristics had been achieved in rough tests, rigorous examinations were done to determine the acoustical properties of the chamber. Comparison tests were done using pink noise, snare drum, acoustic and electric guitars, and male vocals. These tests demonstrated a tonal characteristic which can be characterized as “industrial,” although the acoustic guitar was an exception in that it accentuated the character of the metal strings without dramatically changing the properties of the guitar itself. After comparison tests, the audio testing software Room EQ Wizard was used to create a mapping of the decay times for individual frequencies.

Several sweeps were performed, ranging from 20Hz to 20kHz and 40Hz to 20kHz. These sweeps revealed several interesting properties of the chamber. Easily noticeable were the presences of several resonant modes that structural changes had failed to eliminate. Also present, and much less expected, as a large dip if the frequency band between 600Hz and 1.2kHz. Although not unwelcome, as this is normally a frequency band which is cut after worldizing or reverberation is applied, its large size in amplitude and bandwidth was the cause for some concern.




Further testing demonstrated that the speakers were not to blame, and the reason lie solely with the construction of the chamber. We took the lid off of the oil drum, and blasted the speakers into open air in the room we were in, taking tests of it with the same microphone configuration in the same spot on the lid. The graph was wildly different and it had lots of midrange content between 600 and 1.2kHz. Although unconfirmed, it is possible this band corresponds to the resonant frequencies of the outer drum itself, which may account for the large dip in the region. The drum had been wrapped in a foam padding to reduce its resonance, and if this is the drum's band of resonance, then the drum would have acted as a large absorber for all sound in the chamber, obviously resulting in the strange gap. Other possibilities include a quarter-mode cancelation in that band, although measurements do not suggest any easily determinable modes which would cancel in those frequencies. We were led to believe the problem is a bit above our current level of knowledge, or that it would require calculations that were outside the scope of what we originally intended the project to be.

After full testing of the chamber, the data from the tests was recompiled. The chamber had a reverb time of approximately .1 to .2 seconds, and had several modes, which prevented a steady decay. The waterfall graph below, which contains our final testing results, shows the extreme drop-off between 600 and 1.2kHz.



Because the goal of the project was focused on the creation of a mobile chamber which presented a unique tonal effect, rather than a high quality reverberation product, it was determined that these were all characteristics of the sound of the drum, and changes to them would be outside the initial scope of the project. However, these do bring up a variety of possibilities. which could be used in further research in this topic. Also, in our original mockups, we had hoped to try different materials in order to create a different sound in the drum for different applications. Our budget and time constraints prevented us from purchasing an assortment of other materials to test out in the drum, but we also realized that it was unnecessary to even bother with this. The size of the oil drum did not allow enough space to have inserts after the tin divider was put into place. In conjunction with this thought process, it would have been a hindrance to the decay time of the drum to add anymore materials inside of it, especially those which could and would absorb the bulk of the frequencies which gave the drum its sound (highs mostly).

To continue work on this particular chamber, the cause of the 600Hz to 1.2kHz drop is probably the most glaring topic of research and would need to be remedied or understood fully to be able to produce a better reverb sound and smoother decay across the full range of frequencies that the drum is capable of sustaining. This priority is followed directly by ways of reducing the remaining modes present in the chamber. Once an optimal placement of internal panel structuring has been achieved, a more permanent means of attachment for the panels can be employed. Further projects would also benefit from improved speakers in the chamber, as the current ones are limited in volume, and their small size only compounds the problem of the drum to work poorly in the lower frequency ranges. Besides changes to the test drum used in this project, it is also possible to create other similar reverb tanks using different materials, drum sizes, and internal coatings. Each of these should present acoustical properties different than the ones achieved in the testing of the worldizing chamber created for this project. Overall, we are very happy with our finished product and we believe we accomplished our goals for the project and answered many questions that we originally had before beginning it.

Works Cited

*AKG*. AKG. Web. 15 Apr. 2012. <http://www.akg.com/site/products/powerslave,id,214,pid,214,nodeid,2,_language,EN,view,diagram.html>.

Berg, Richard E., and David G. Stork. *The Physics of Sound*. Englewood Cliffs, NJ: Prentice-Hall, 1982. Print.

Everest, Alton F., and Ken C. Pohlmann. *Master Handbook of Acoustics*. New York: McGraw-Hill, 2009. Print.

"Open and Tight Head Carbon Steel Drums." *Skolnik*. Skolnik. Web. 15 Apr. 2012. <http://www.skolnik.com/carbon.shtml>.

"REWRoom EQ Wizard." *REW*. Web. 15 Apr. 2012. <http://www.hometheatershack.com/roomeq/>.