UNIVERSITY OF MIAMI

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ECE 502/602 - Engineering Acoustics

Project No. 2

Measurement of the reverberation time (ISO 3382)

The reverberant properties of a room have strong influence on the sound pressure level from noise sources, the intelligibility of speech, the perception of privacy and the quality of musical performance, and it can be used to determine the correction for room absorption and insulation. Reverberation time is defined as the time it takes the space-averaged sound energy density to decrease by 60 dB after source activity has stopped. The goal is to measure the reverberation time of an unoccupied room at the University of Miami. The method will follow the ISO 3382-2 (2008) standard provided in the course notes on Bb. The volume of the selected room must be at least 300 m^3 (large room.) Work in pairs, but analysis and reporting must be an individual effort.

Equipment

1. Sound source: Burst noise from an exploding plastic balloon
2. Receiver: Omnidirectional or supercardioid microphone
3. Recording equipment: High quality digital recorder

Procedure

1. Room excitation: Select 12 source-microphone combinations, with located source at least 1 m from any surface and microphone at least 3 m from source on a tripod. Avoid symmetric positions. In otherwise quiet conditions, explode balloon and record response monophonically with at least 16 bit precision and sampling rate of 44.1 kHz.
2. Averaging procedure: Superimpose amplitude normalized and time synchronized traces of the squared sound pressure recording and compute the average sound energy decay waveform.
3. Overall reverberation time: Use linear regression to model the decay curve and determine T20 and T30 of the averaged sound decay waveform. Calculate T60.
4. Octave bands reverberation time: Simulate the standard octave bands with center frequencies from 125 Hz to 8 kHz using Fourier analysis (FFT). Compute the average sound energy decay waveform for each octave band. Use linear regression to model the decay curve and determine T20 and T30 and calculate T60 for each octave band.

ECE 502 - Project 2

Mikaela Shannon

Room Identification

The impulses responses generated for this project were taken in the Live Room of the Weeks Recording Studio. This studio has been recently renovated, however the Live Room only received new wood floors and a fresh coat of paint so the room dimensions do not differ from past years.

Description of Room Condition

Since the room was recently renovated, the room has remained free of excessive clutter. We moved the baffles and piano into different rooms, so the room was completely empty when we took these measurements. The Live Room is asymmetrical and diffusers cover the walls without doors or windows. The ceiling also has diffusers and follows a zig-zag shape. Photographs of the room are included below, along with a sketch of the room dimensions.

Room Measurements

At the time we took our room measurements, the room temperature was 70℉ and the relative humidity was 64%. We estimate that the volume of the room is 413.6 m^3. The measurements used for this estimate can be found in the room sketch below. We recorded these impulse responses on November 14, 2016.

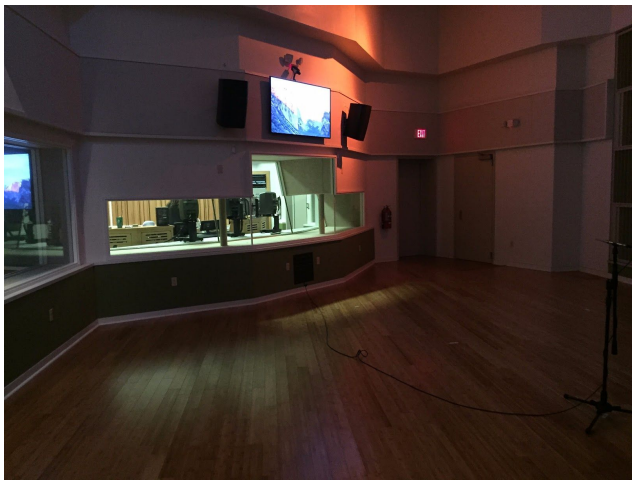
Description of Sound Source

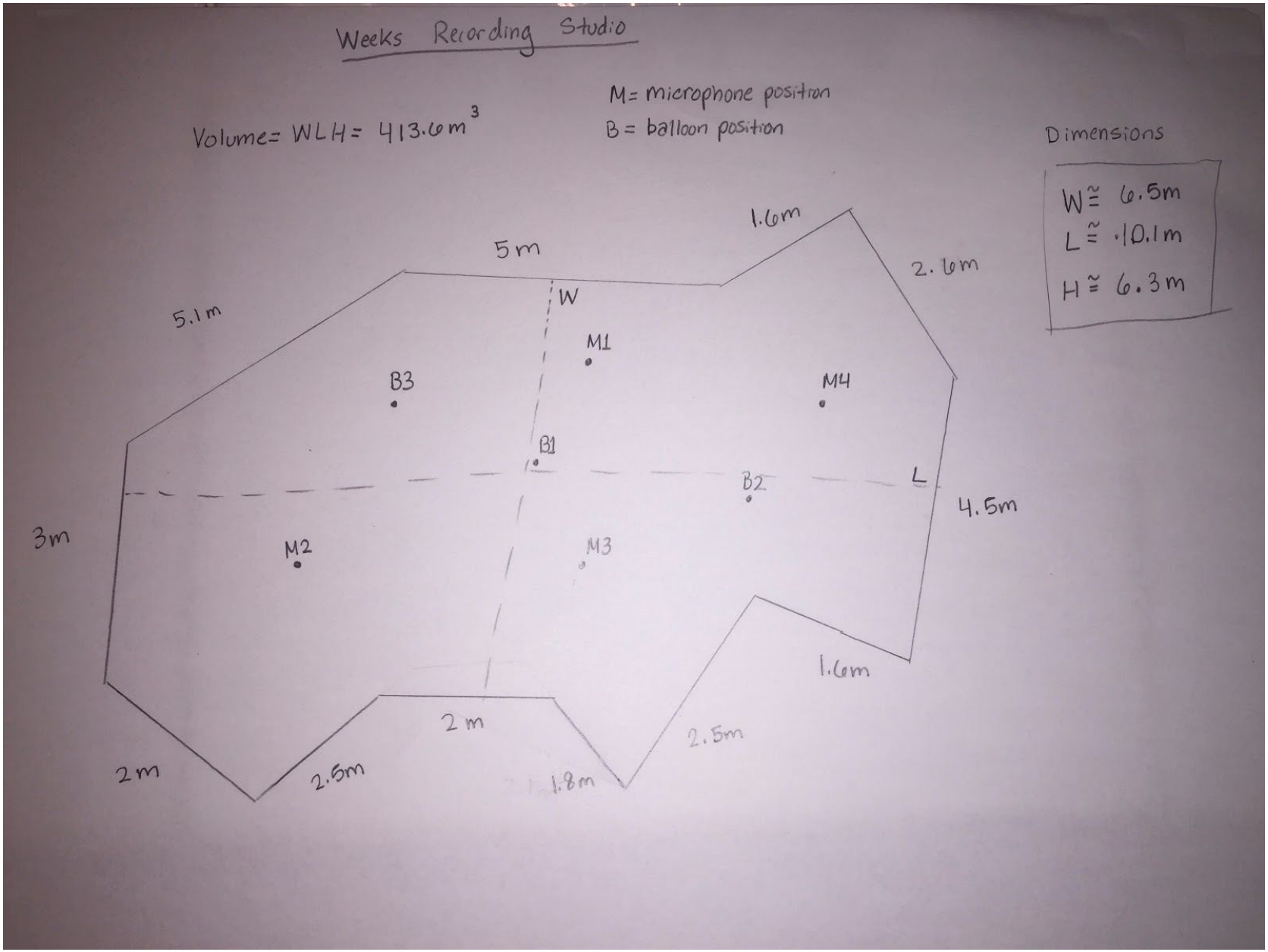
Impulses were generated by Inflated balloons roughly 8 inches in diameter which we popped with a sharp pencil. The balloons were popped 1.7 m above the ground, towards the microphone, and away from the student's body in order to reduce interference of the body during measurements.

Details of the Source and Microphone positions

We semi-randomly selected 4 different microphone placements and 3 different balloon placements throughout the room, totaling in 12 different resulting impulse responses. We made sure to place the microphones and balloons at least 1 meter from any wall. We also selected balloon locations that were at least 3 meters from each microphone location.

Photos of Room

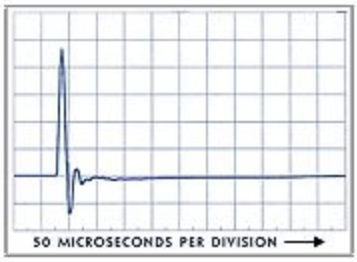



Weeks Recording Studio
M= microphone position
B= balloon position
Volume= WLH= 413.6m 3
Dimensions
W≅ 6.5m
L≅ 10.1m
H≅ 6.3m
1.6m
5m
2.6m
W
5.1m
M1
B3
M4
B1
B2
L
4.5m
3m
M2
M3
1.6m
2m
2.5m
2m
2.5m
1.8m

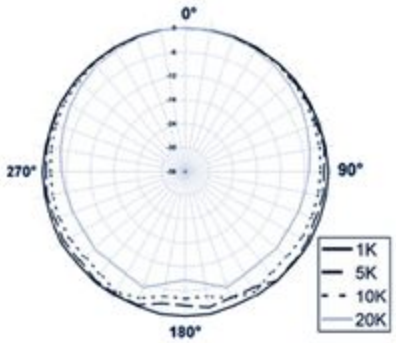
Room Sketch

Description of Measuring Apparatus and Microphones

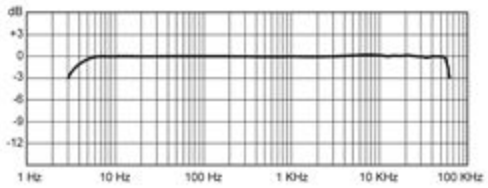
Measurements were taken using one Earthworks QTC50 omnidirectional microphone because they have excellent transient response and a flat frequency response curve so it serves well as a reference microphone, as shown by the graphs below. The microphone was secured onto a regular boom stand, approximately 1.5 m high, and aimed at the sound source.



QTC50 Impulse Chart

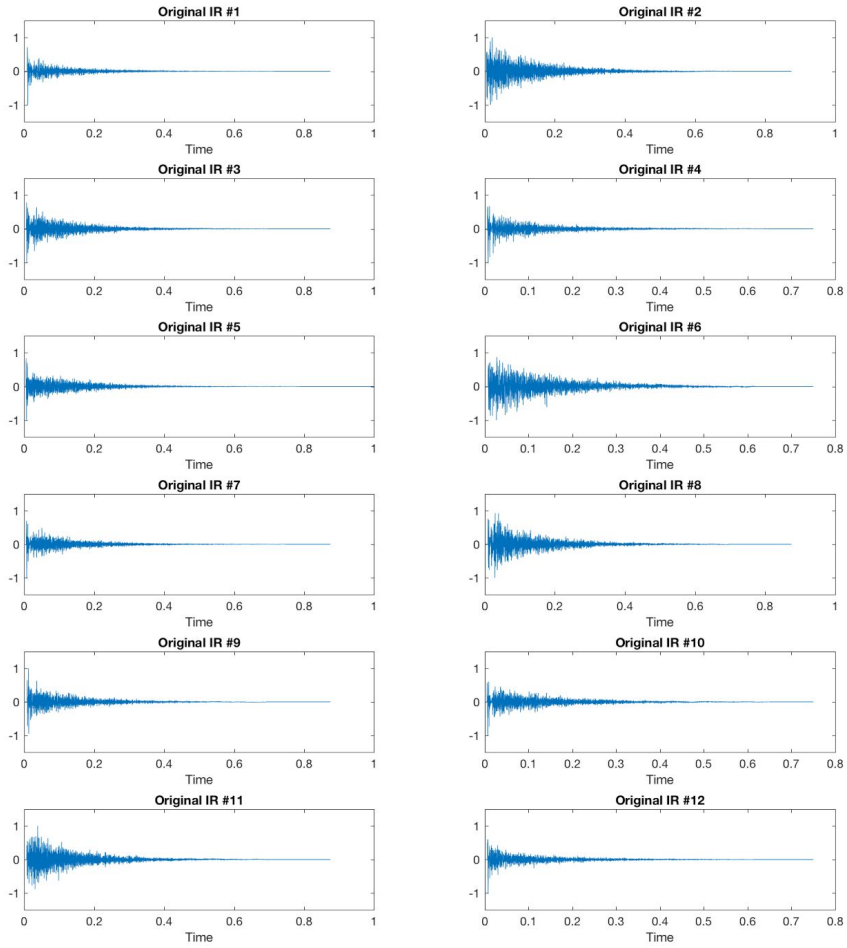


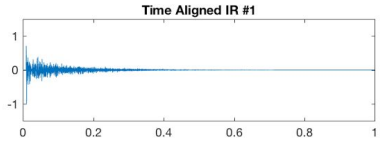
Polar Pattern

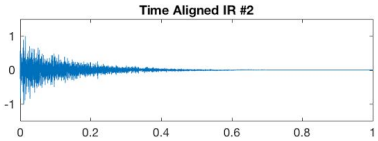


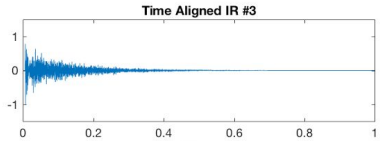
QTC50 Frequency Response Chart

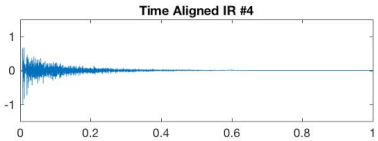
Plots of Recorded Impulses

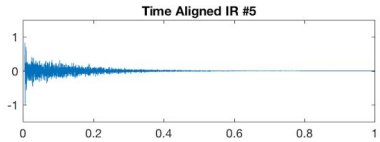


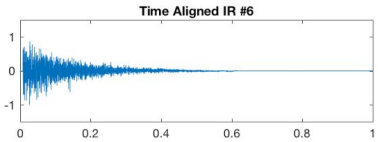

Time Aligned IR #1
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

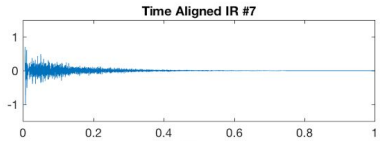

Time Aligned IR #2
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

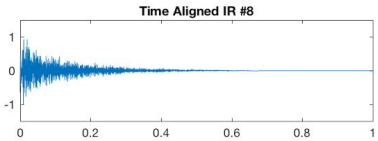

Time Aligned IR #3
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

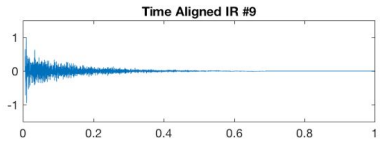

Time Aligned IR #4
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

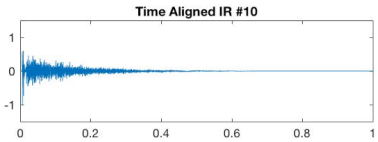

Time Aligned IR #5
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

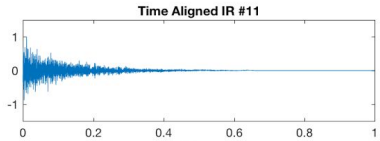

Time Aligned IR #6
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

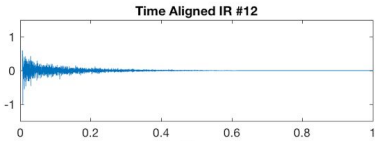

Time Aligned IR #7
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time


Time Aligned IR #8
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

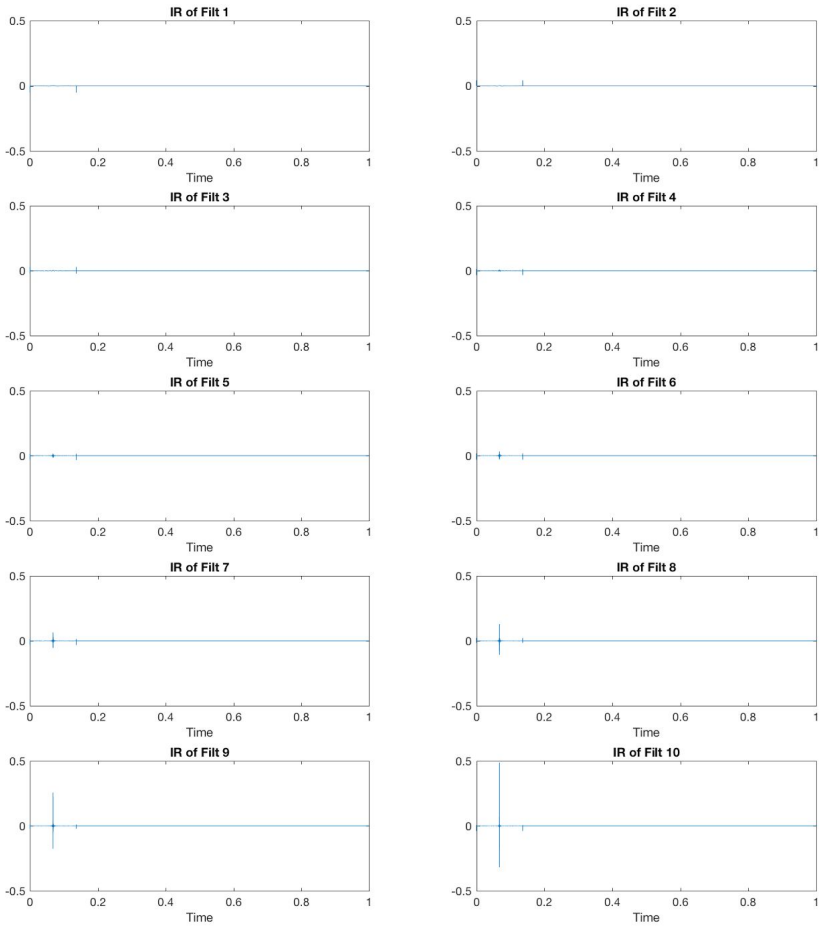

Time Aligned IR #9
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time


Time Aligned IR #10
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

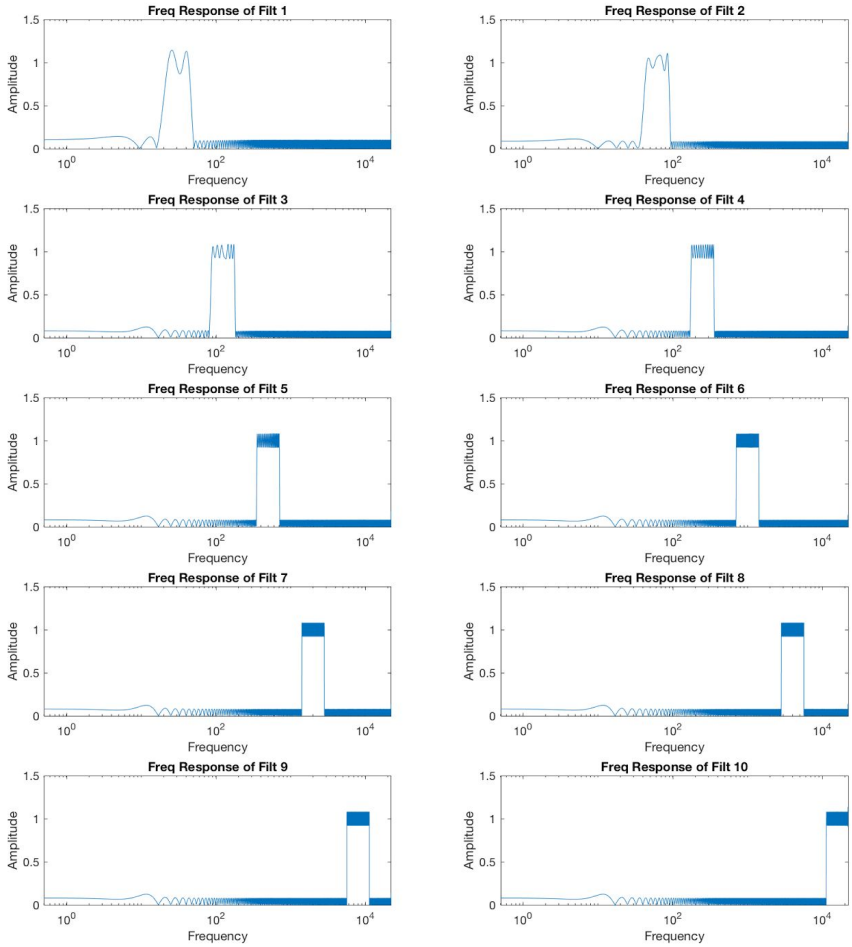

Time Aligned IR #11
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time


Time Aligned IR #12
1
0
-1
0
0.2
0.4
0.6
0.8
1
Time

Filtered Impulse Responses

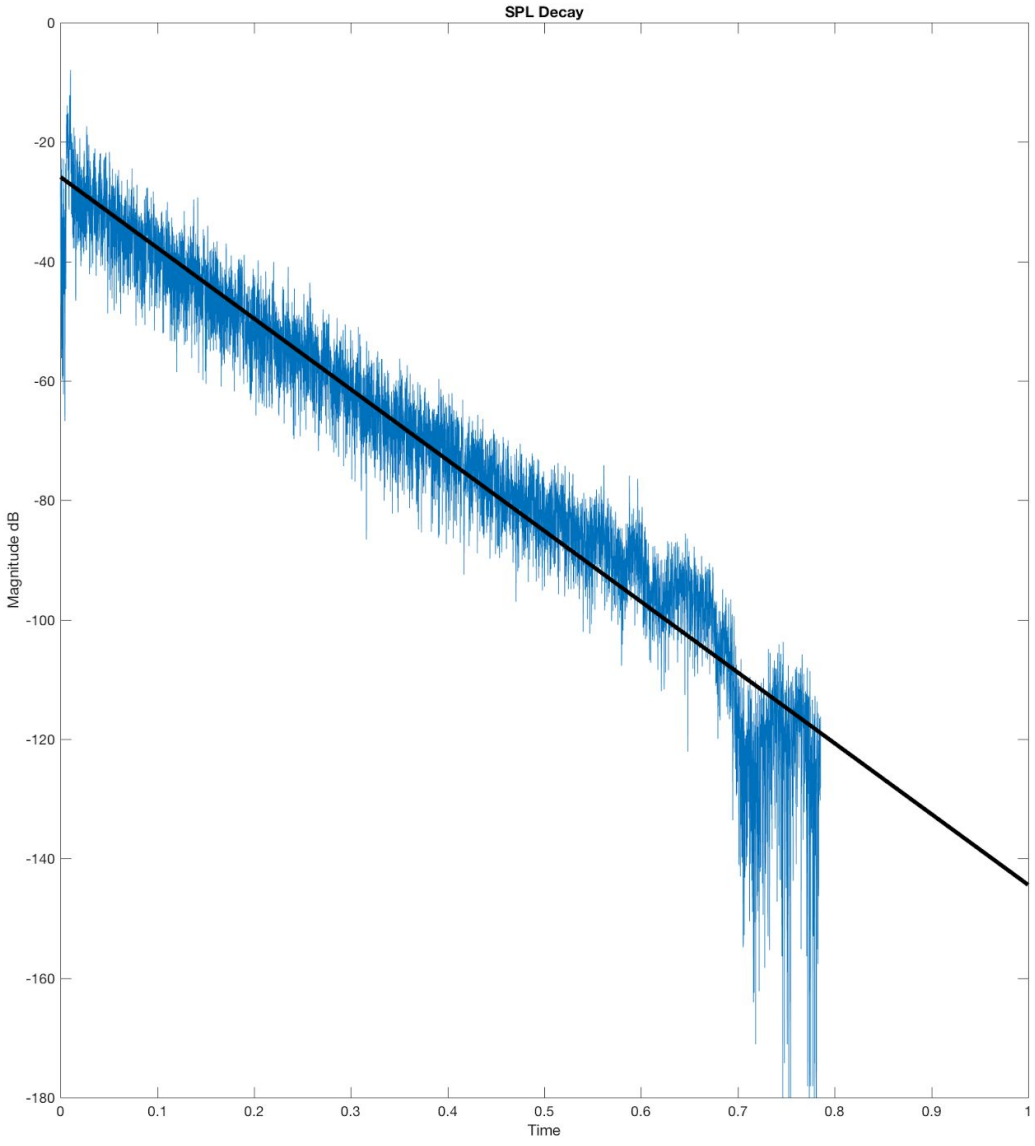


Filtered Frequency Response

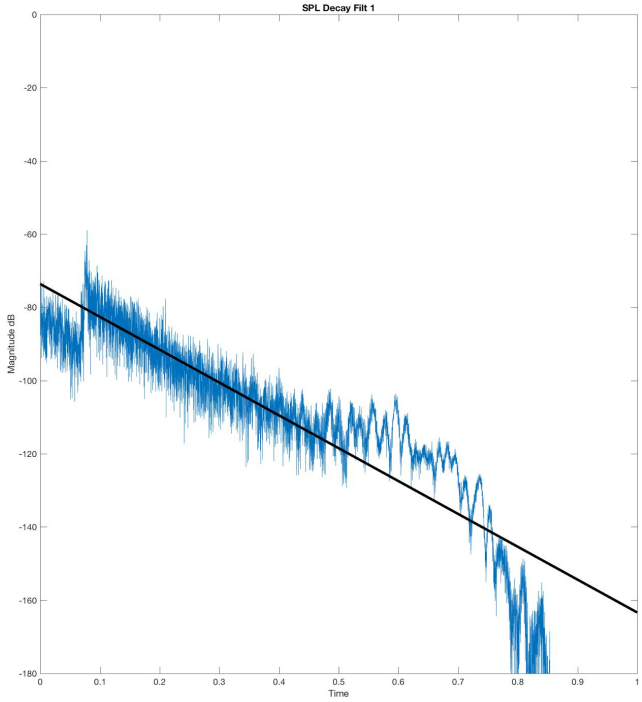


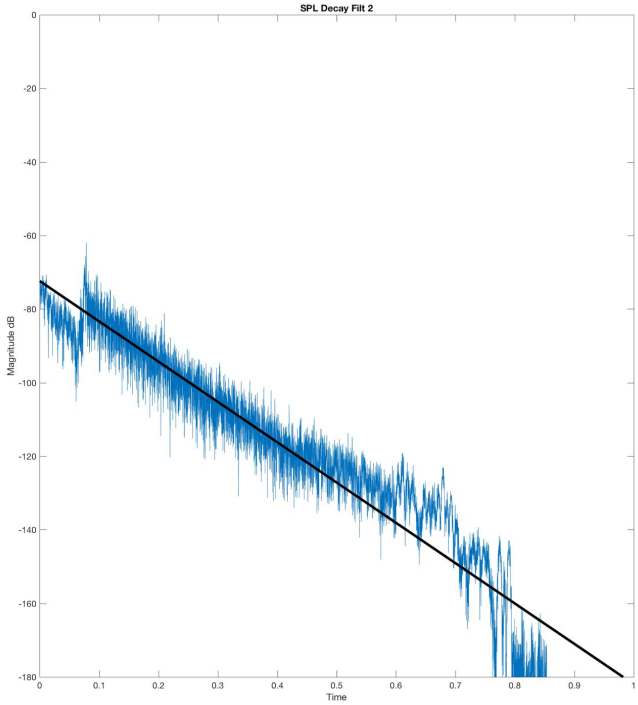
Average Squared Pressure Curves

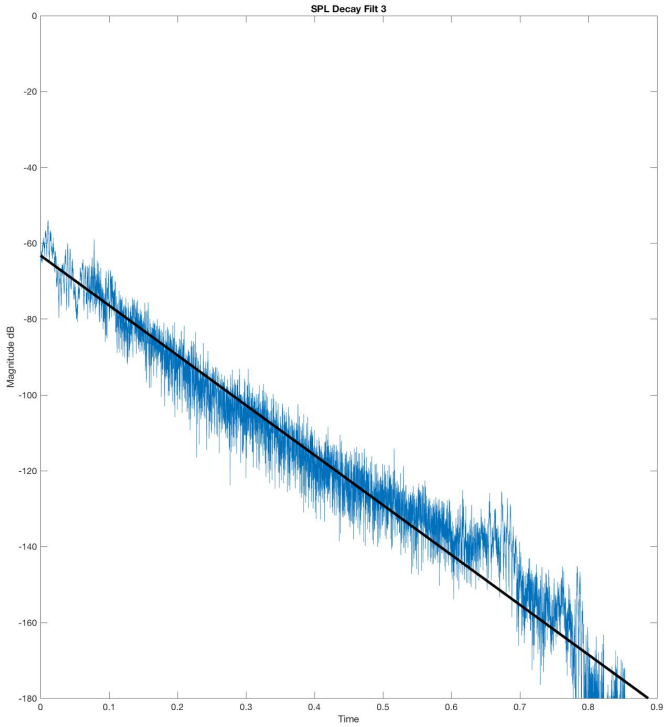
Unfiltered

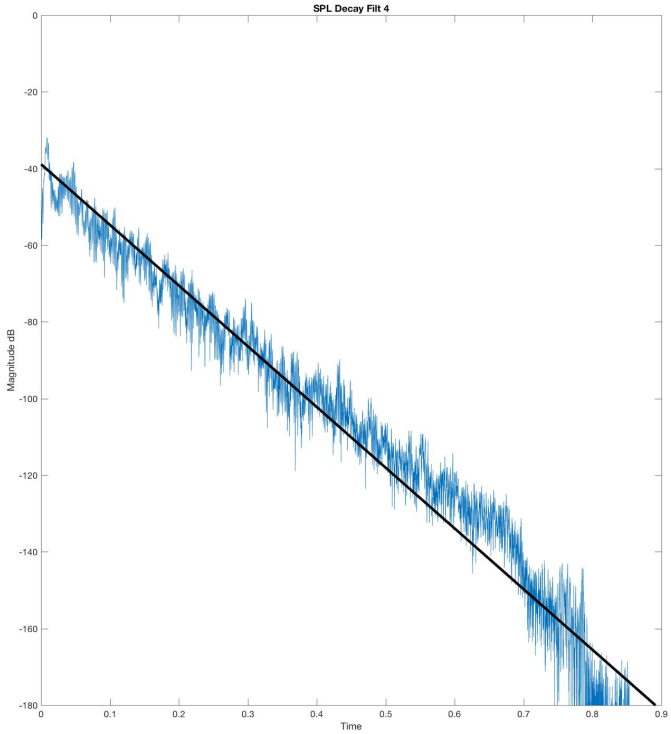


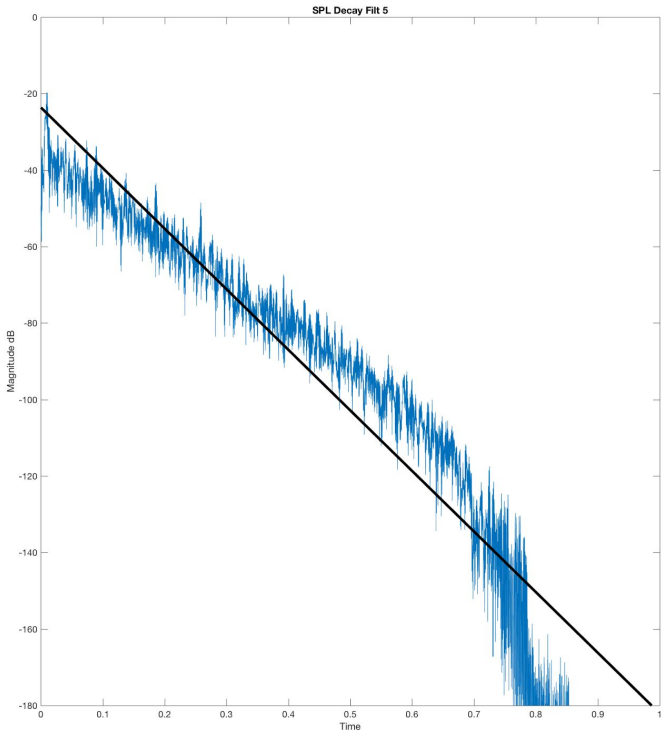
Filtered

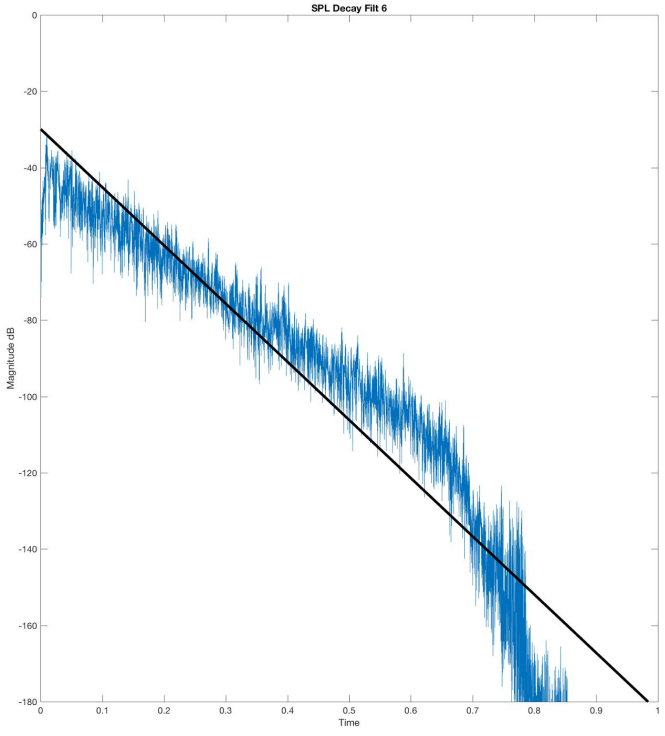

SPL Decay Filt 1
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

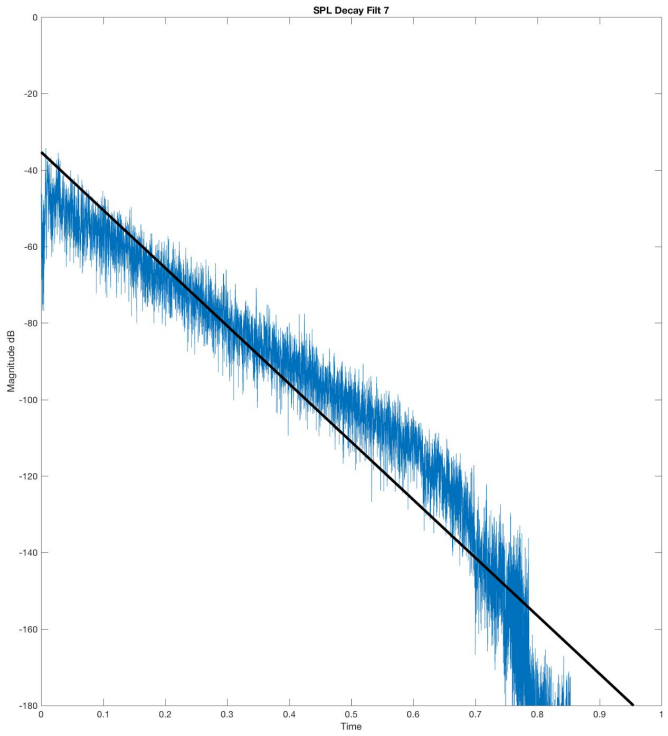

SPL Decay Filt 2
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


SPL Decay Filt 3
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


SPL Decay Filt 4
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


SPL Decay Filt 5
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


SPL Decay Filt 6
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


SPL Decay Filt 7
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
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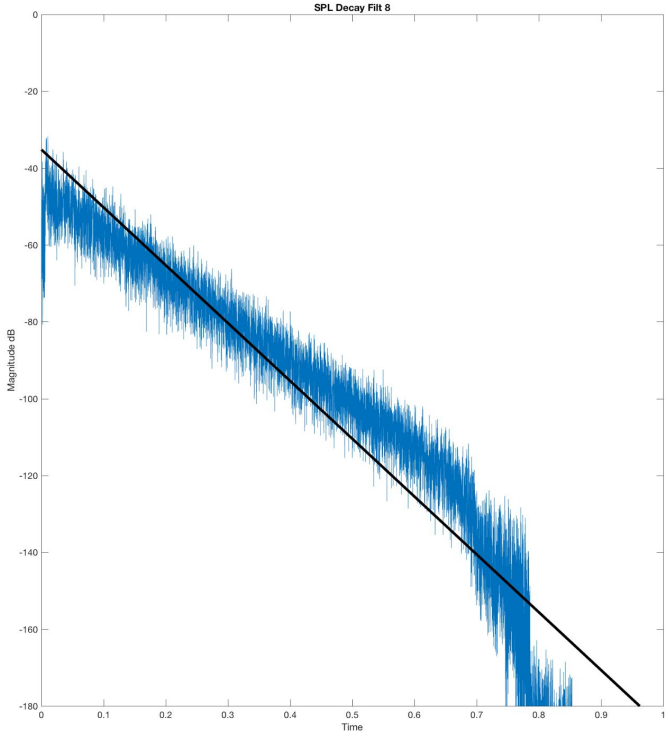
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


SPL Decay Filt 8
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
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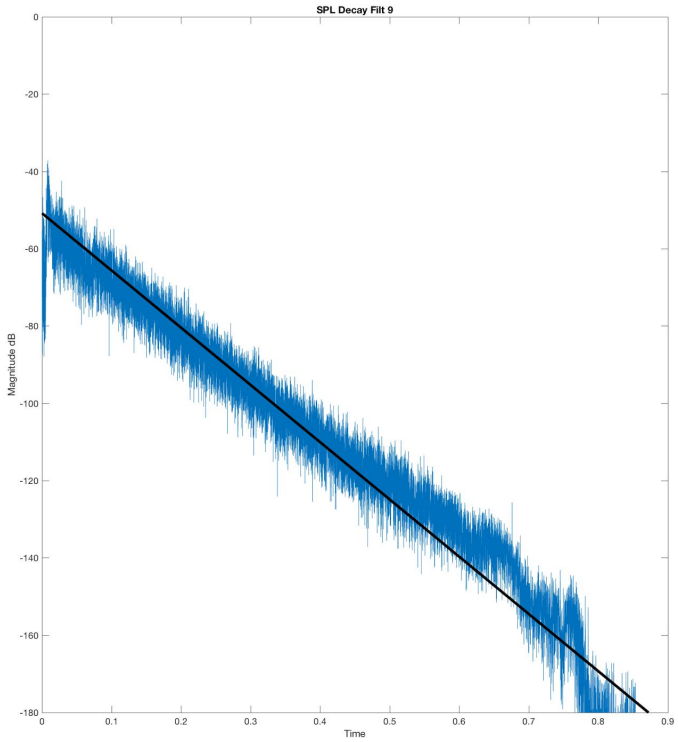
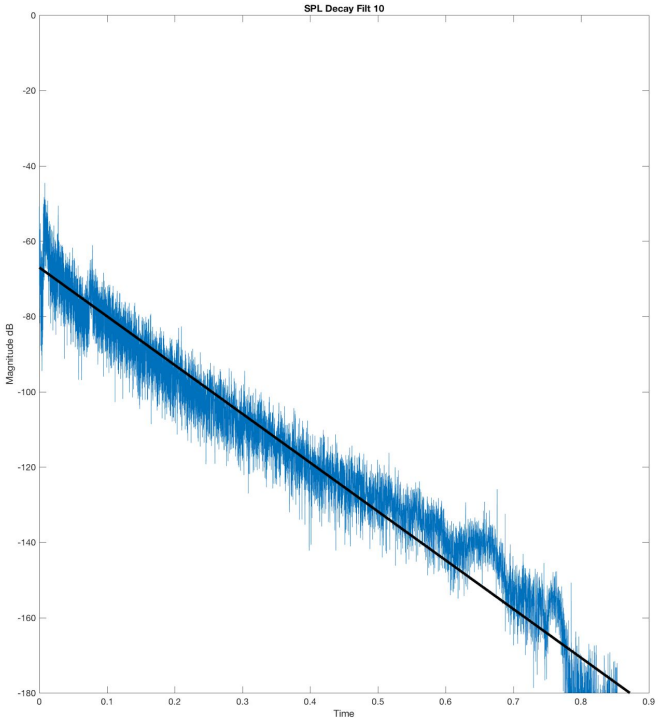
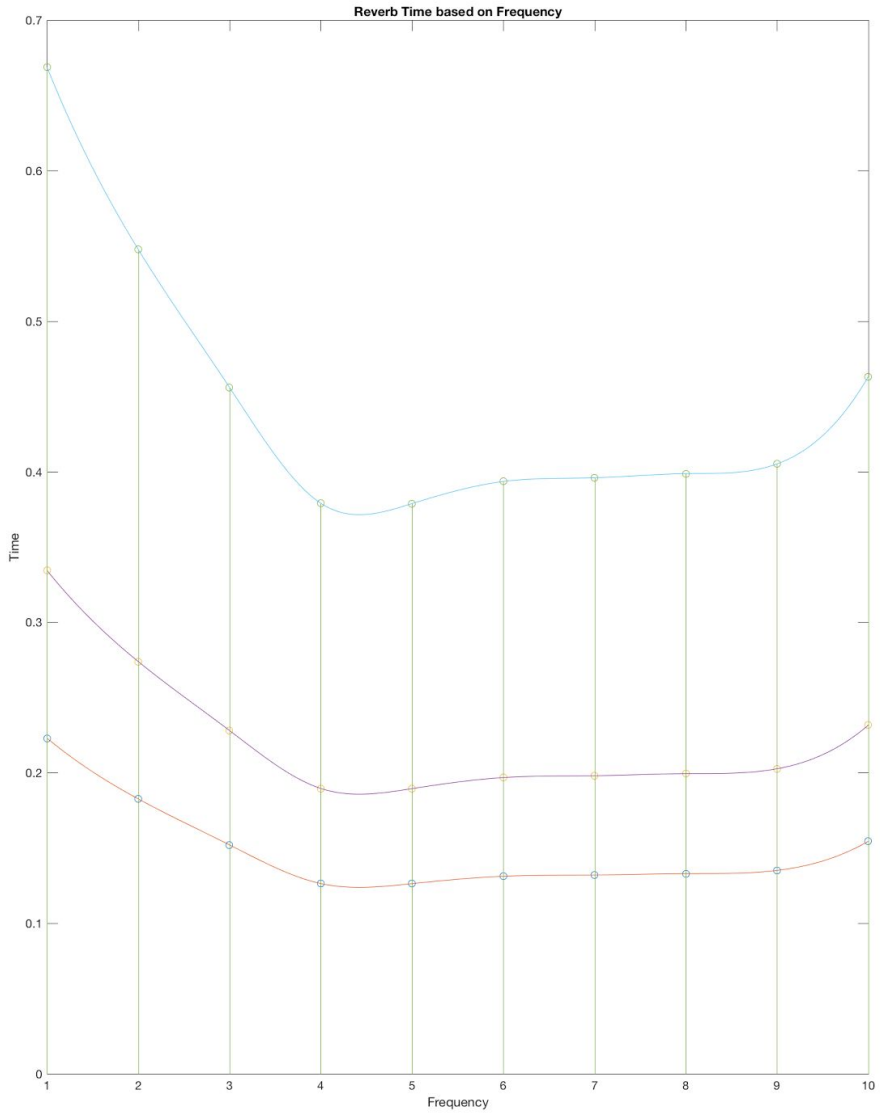
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


SPL Decay Filt 9
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


SPL Decay Filt 10
Magnitude dB
Time
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

Tabulated Results

	T20 (ms)	T30 (ms)	T60 (ms)
Band 1	222.9	334.4	668.7
Band 2	182.6	273.8	547.6
Band 3	152.0	228.0	456.0
Band 4	126.3	189.5	379.0
Band 5	126.3	189.4	378.8
Band 6	131.2	196.8	393.5
Band 7	132.0	198.0	395.9
Band 8	133.0	199.3	398.7
Band 9	135.1	202.6	405.3
Band 10	154.4	231.6	463.2


Reverb Time based on Frequency
Time
Frequency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1
2
3
4
5
6
7
8
9
10