Quick Acoustic Analysis

of

Volley 5, 3rd Burst

Front Row – Center Stage

author
date
version

Table of Contents

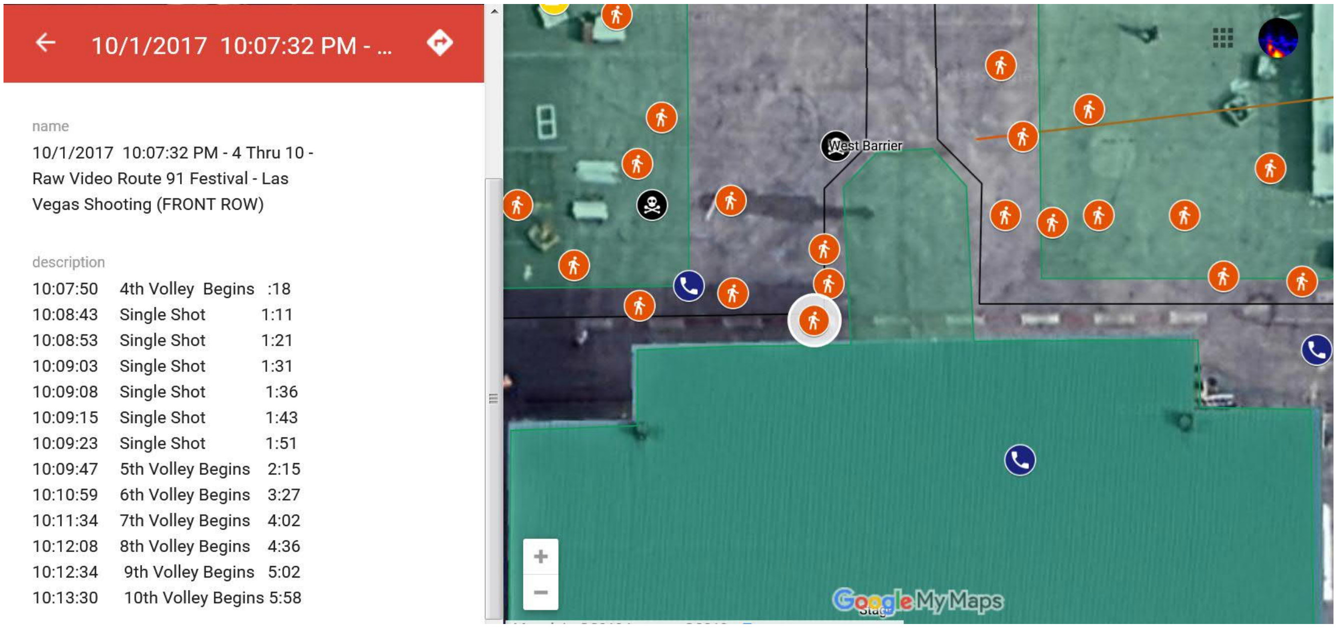
Introduction

This paper presents a simple acoustical analysis of one part of a volley of gunshots. Purposely very little math or technical jargon is used, just enough to present the observations and introduce the reader to a portion of the tools and techniques used in forensic gunshot analysis. Links are provided to background material for the inquisitive.

Background Material

As explained in many texts (1–4), a weapon that fires a supersonic projectile will produce several sounds, the most dominant of which are (a) muzzle blast (b) shock wave from supersonic projectile, reflections (ground or otherwise) from (a) and (b), as well as possible sounds of the projectile hitting an object.

Video Source



Very near front of stage in middle, hidden by lattice.

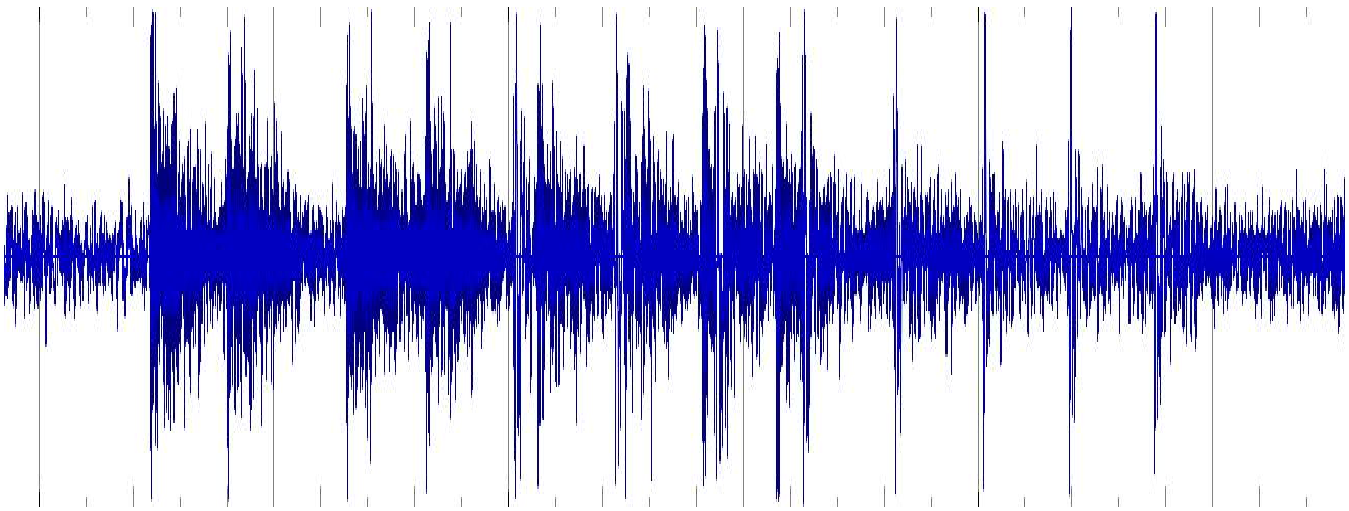
https://youtu.be/l-IEme0aGMA

A 1.37 second segment beginning at 2:23.05. This is the 3rd burst of volley 5.

Listen

The first step is always to listen to the audio to identify regions of interest. In this audio clip I hear about twelve distinct “shots”. The first shots are like a “snap” or “crack” while the later ones are more similar to a “boom” or “thud”. In the middle of those two groups are sounds with a bit more robustness to them than the snap like sounds. I also hear screaming in the background as well as siren.

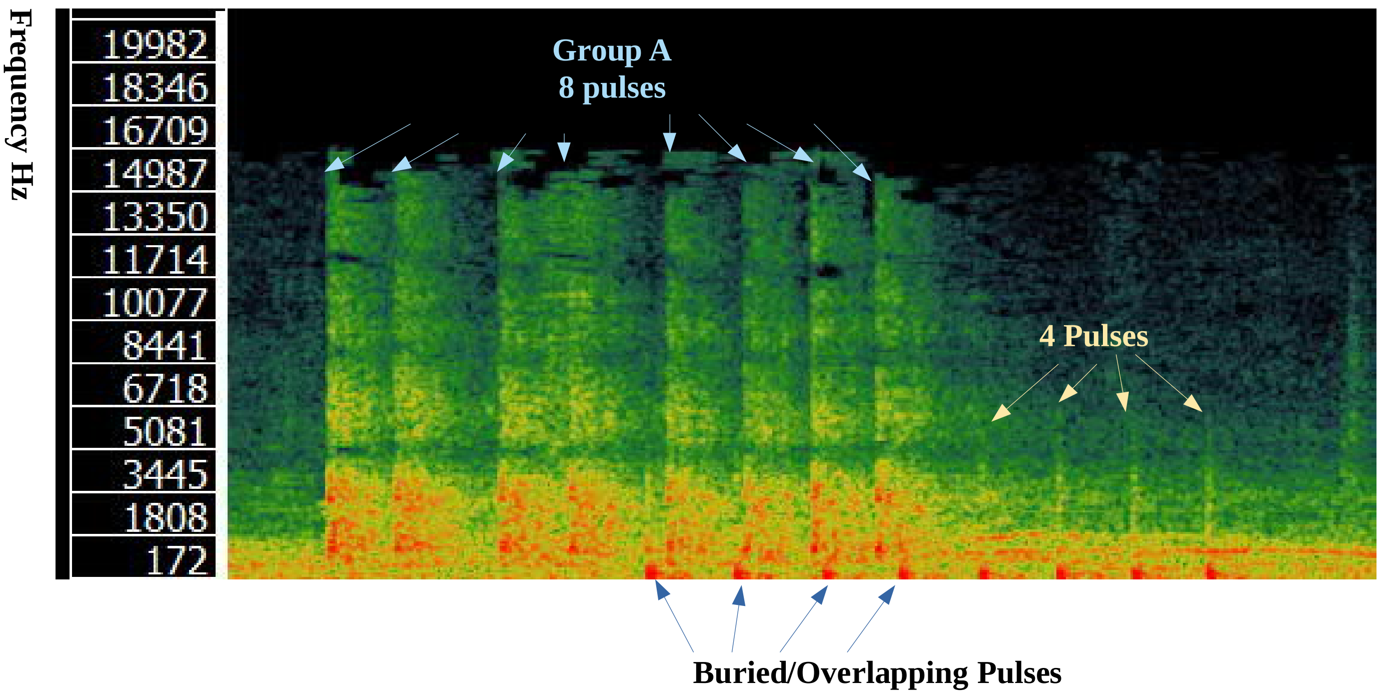
Waveform (plot of signal amplitude v. time)



Observations:

- possible 12 – 16 total pulses.
- possible 8 pulses starting from end of segment that are fairly narrow in scope.
- 8 wide/noisy pulses at start of segment
- 3 or 4 of the narrow pulses overlap with earlier “wider” pulses
- most of all pulses are larger in amplitude than background sounds.
- Spacing between narrow pulses more regular than spacing between wider pulses.
-

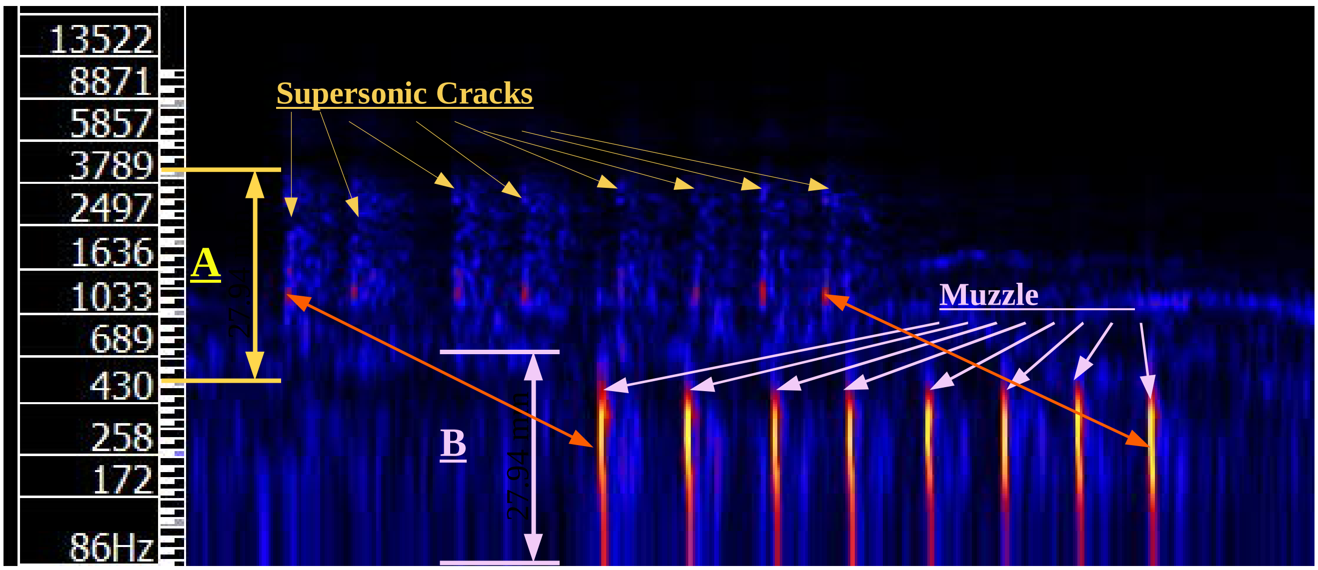
Spectrogram – Db² (a measure of energy)



Observations:

- at least 12 distinct pulses
- two unique frequency groups
- first 8 pulses (group A) are broadband and have their energy spread over a large range of frequencies.
- First 8 pulses are spread (smeared/fuzzy) over time.
- Last 4 pulses (group B) much narrower frequency band (shorter up and down)
- Last 4 pulses more confined over time (narrower pulse, wider left and right)
- close examination (large magnification) suggest 4 more pules buried within the first 8 that are similar to last 4 bringing total to possible 16 total pulses.

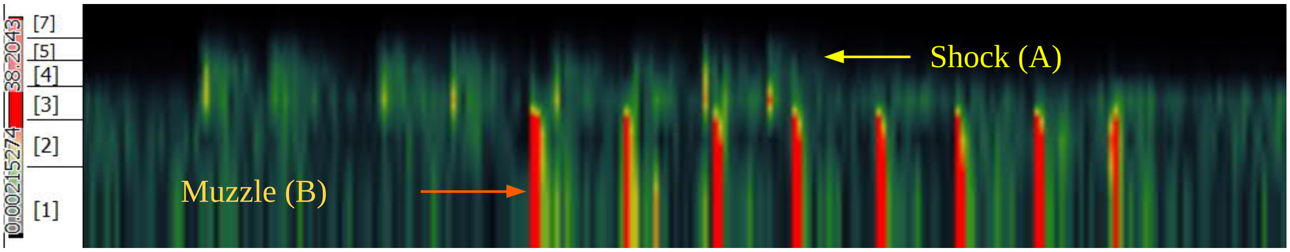
Spectrogram – Log Frequency v Time



Observations

- Supersonic “Cracks” – sonic shock wavefront
    - 8 pulses in group A (upper frequencies)
    - group A consistent with theory predicted frequencies
    - Cracks (A) centered between 3,789-450 Hz
    - wave/sound smeared over time producing fuzzy delineation
    - possible indirect path of propagation
    - irregular timing between rounds
- Muzzle blast wavefront
    - 8 pulses in group B (lower frequencies)
    - group B consistent with theory predicted frequencies
    - Muzzle (B) centered between 689-86 Hz.
    - Fairly regular timing between rounds, near 0.nnn secs
        - some overlap in frequencies between two groups
- “red” lines indicate “lag” between arrival of supersonic “Crack” sound and arrival of muzzle wave sound.
- For “Cracks” 5,6,7,8, the arrival of muzzle events 1,2,3,4 occur close to each accordingly and will be heard as 4 single events due to the limitations of the hearing process. Each of these 4 events will have a “richer” / “fuller” sound than either the “Crack” alone or the muzzle alone. This phenomena leads to a total of 12 sounds “heard” while listening to the recorded audio.
-

Spectral Contrast Color Plot



Observations:

- spectral contrast confirms and preserves groups A and B from log frequency plot.
- Group A – Shock waves
  - 8 weaker pulses in bands 3 and 4.
  - contrast with background noise weak, most likely due to “smearing” of energy
  - still 8 pulses, but of varying contrast, may indicate substantial trajectory deviations for rounds 2,3, and 6

- Group B – Muzzle
  - 8 strong pulses in the band 1 and 2

Muzzle Wave Data

Plus or minus 2 m.s.
Raw data (all digits) taken directly from an "instants" layer of the above spectrograms created in Sonic Visualiser.

Vid. Time	**Delta**	**Delta Delta**	**R.P.M.**	**Delta - Mean**	
2:23.505215					
2:23.612698	0.107483			0.010183	
2:23.719954	0.107256	-0.000227		0.009956	
2:23.812925	0.092971	-0.014285		-0.004329	
2:23.909297	0.096372	0.003401			
2:24.004535	0.095238	-0.001134			
2:24.095011	0.090476	-0.004762			
2:24.186621	0.091610	0.001134			
Avg.	**0.0973**		**616 r.p.m.**		

Shock Wave Data

Lag Calculations

Shot	Lag	Lag - Avg.			
1	0.388	-0.004			
2	0.411	0.019			
3	0.394	0.002			
4	0.400	0.008			
5	0.377	-0.015			
6	0.378	-0.014			
7	0.389	-0.003			
8	0.400	0.008			
Avg.	**0.392**				

Summary

Compare to Other Video/Audio

Other Observations

Theory Would Predict

Bibliography

1. Maher RC. Summary of Gun Shot Acoustics. :7.

2. Peterson S, Schomer P. Acoustic Analysis of Small Arms Fire: [Internet]. Fort Belvoir, VA: Defense Technical Information Center; 1994 Jan [cited 2019 Aug 20]. Available from: http://www.dtic.mil/docs/citations/ADA278306

3. Introduction ot Acoustic Analysis.pdf.

4. Sallai J, Lédeczi Á, Völgyesi P. Acoustic shooter localization with a minimal number of single-channel wireless sensor nodes. In ACM Press; 2011 [cited 2018 Jun 14]. p. 96. Available from: http://dl.acm.org/citation.cfm?doid=2070942.2070953