Analysis

Las Vegas Metro Police Department Body Camera Video

Published October 3, 2017

AXON FLEX 2 X83027245

2017 – 10 – 02

T05:09:07Z thru T05::09:59Z

Fence Buldge Near 5 Sec. Mark

Revision 0.0

(January, 22, 2018)

Table of Contents

Summary

On October 3, 2017, the Las Vegas Police Department published to their You Tube channel a three minute video containing a "sampling" of police worn body camera footage of officers responding (October 1, 2017) to shots fired at or near the Route 91 Harvest Festival on South Las Vegas Blvd, (east) of the Luxor Hotel.

This report focuses on the first fifty-eight seconds of this video, with particular emphasis near the five second mark, where a pecular and momentary (1 sec) "buldge" appears in the dark netting of the chain link barrier betweeen the sidewalk and festival.

Conclusion

The "buldging" of the fence netting was likely caused by bullet fragments as a result of a slug hitting one or more support posts on the barrier fence comprising an unmarked gate, near the southeast portion of the festival and between Gate 1 and the Gate 2.

In Support of Conclusion (briefly)

A buldge event can clearly be seen on the video over several frames. A sound is heard which preceeds this buldge by approximately 1/10th of a second Based on detailed audio analysis, it is established that something hit an object causing it to produce an audible "ring". That "ring" can be placed in time prior to the buldge. Three seperate depressions on the fence near a fence post are objserved a fraction of a second later. Analysis of all "percussive" sounds on the video establish the "sound" to very likely be a supersonic projectile. Multiple points of pressure arriving at different times but very close to one another are seen in the video further supporting a bullet theory which fragmented on impact and flew into the fence.

5.111 Hear Sonic Crack

5.123 Bullet Hits Fence Post

5.150 Hear Fence Post Ring

5.266 (5.233-5.300) Fragment A & B Hits

5.300 (5.266-5.333) Fragment C Hits

Cause and effect? Possible and probable.

Was gunshot:

Was gunshot prior to and close enough to cause:

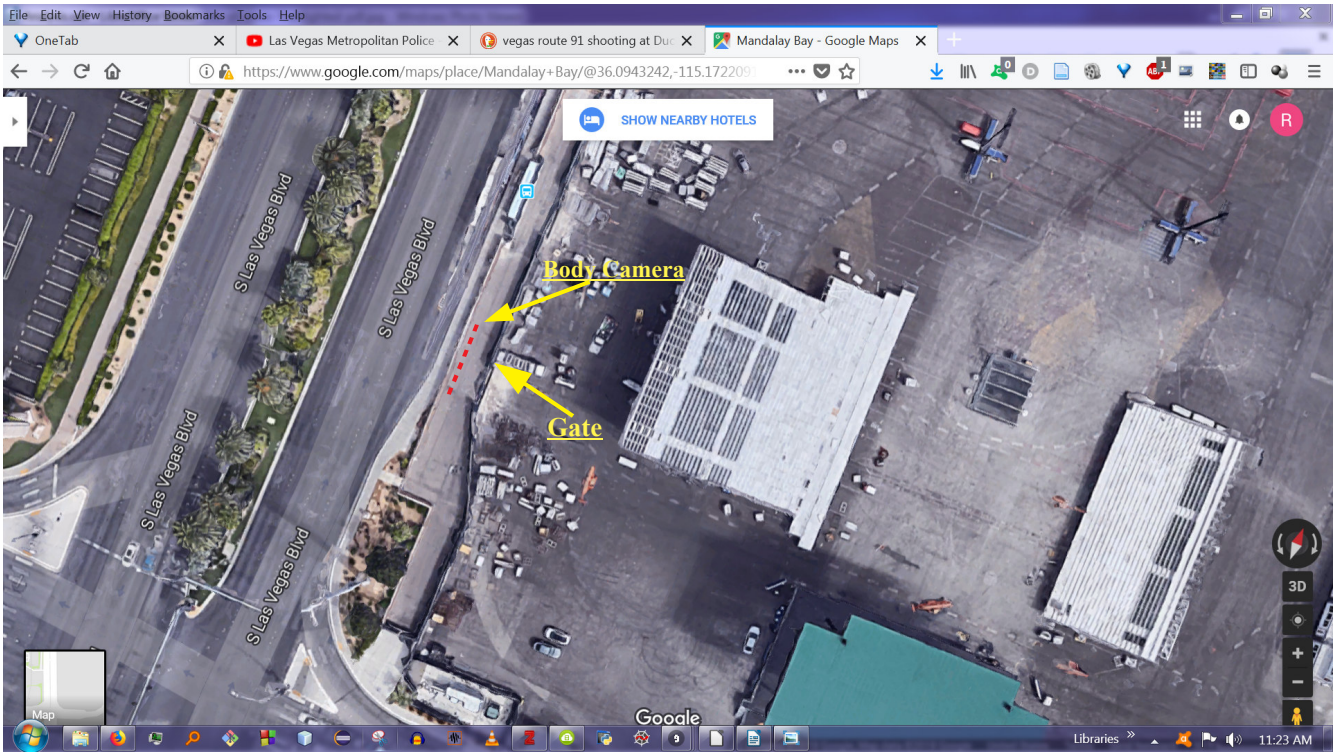
Was event possible with gunshot:

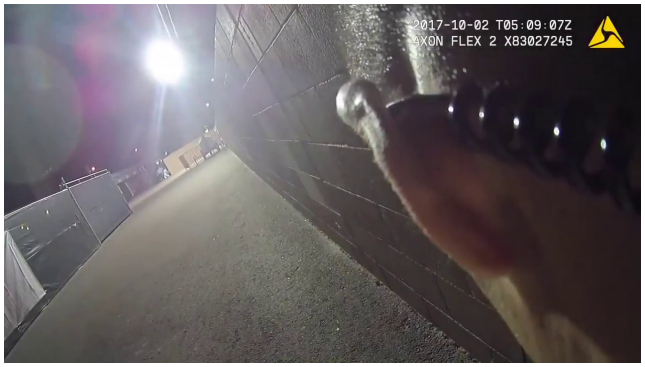
- we can hear the sound
- Theres 3

- sounds like a gunshot
- theres a ring
- theres a hit
- theres a miss
- .1 sec bfore buldge
- need more for cause and effect
- rate of buldge
- 3 fragments
- lights not being blocked by shadows => lower probability of fight
- disappearing post => poor quality video at times
- cop not doing anything => probably not a fight or people doing bad things

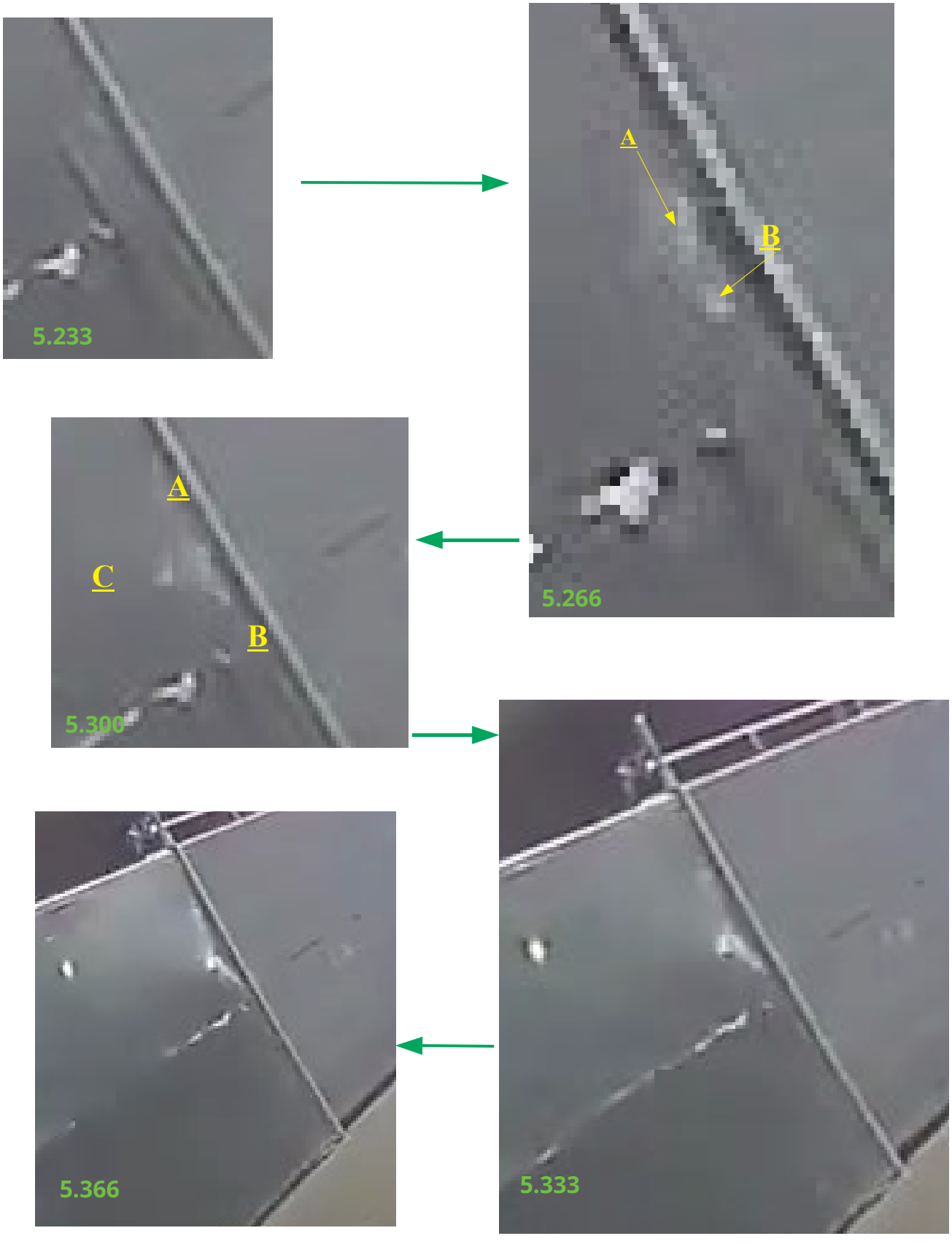
Location

This video is filmed on the sidewalk, west side of Las Vegas Blvd., west of the Luxor Hotel, and seperates the Route 91 Harvest Festival from the boulevard. On one side of the sidewalk is four foot cinder block wall, and on the other side is a five foot tall chain link fence which also uses black netting as a visual barrier into the venu. The film starts with an officer crouching behind the cinderblock wall, and adjacent to the VIP tent. This is the southerly and eastward corner of the venue adjacent to both the boulevard and Mandalay Bay Rd. The initial position of the body camera and fence gate are noted below on an excerpt from google maps for this location. Also below are images of the gate from behind and from the officers initial perspective.





The Buldge



Caveats & Concerns

Video

1. The video is at best a copy of multiple sources which have been edited and processed before presentation to the public. Both the purpose (agenda) and the contents are therefore suspect as evidence.
2. No obvious manipulation within segment one, the first fifty-eight seconds, was observed, other segments were not evaluated.
3. The color bit depth of the video results in substantial posterization and is inadequate to completely rule out or support some alternate theories, other evidence is used for this purpose.
4. The pixel/focus loss creates many "artifacts" that can be misleading

Events B05a, B05b, B05c

5. None of these events presented an acceptable proto-typical sonic wave followed by muzzle blast. The muzzle blast is missing.
6. The sonic wave of each event is less "crisp" than typical when using both channels as source for the spectographs. A more clear graph can be obtained by using channel 1 only. Channel 2 has a different frequency response, lower amplitude, and phase delay.
7. The sonic wave sound is heard as a sound that is above a muzzle blast but slightly lower than similiarly situated sonic blasts from the burst events.
8. Each event is preceeded a fraction of a second by some unknown and non-classified disturbance in the high frequency portion of the power spectrum. This disturbance presented as a small smudge.

Quick Audio (graphical) Overview

Big Audio Events on Recording

24 gun shots in 3 single, 3 small burst

Cop Vocalizations (3 sets)

Constant siren noice throught, at times very load

General backround noise

Single Shots

Generally

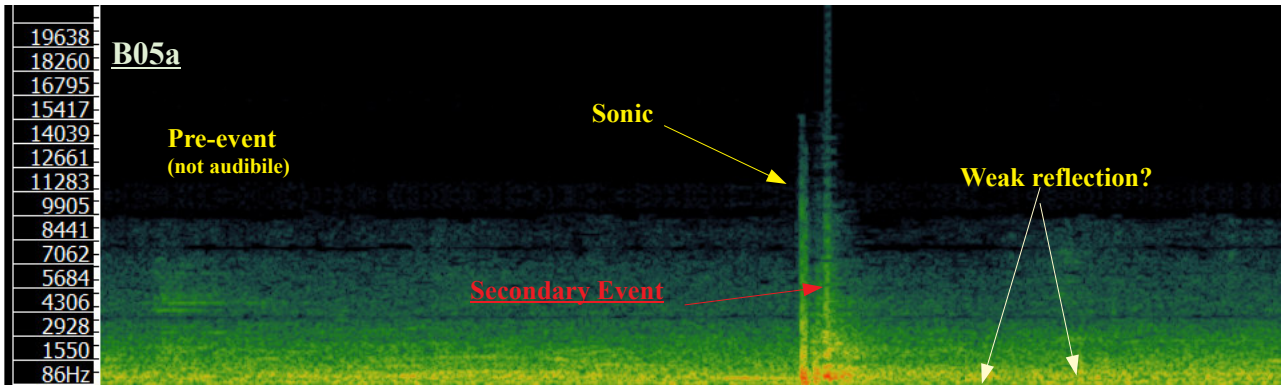
Single percussive events are problematic. In this case we have three somewhat similiar events.

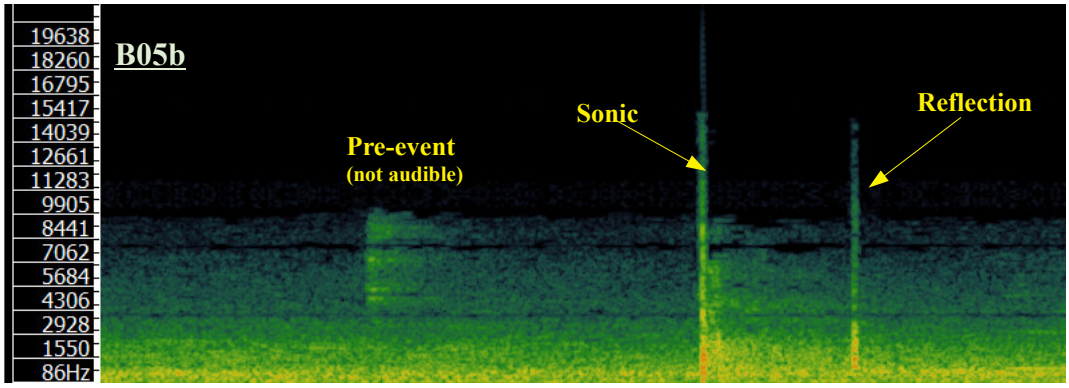
1. Each single event is seperated from the next by approximately 7 seconds, indicating a non-random sequence, and propably of mechanical or human origin.
2. All three events have a well known, and reliable supersonic signature.
3. Each supersonic sound (when listened too) is consistent with other single shots, slightly different among each other and noteably different than those in the bursts.
4. None of these events have a traditional muzzle blast, unlike the bursts later on the tape, all of which have muzzle blasts for each shot, and are of consistant "lag" time from the corresponding sonic signature.
5. All three shots have, a precursor event that is is inaudable, but yet very distinct in the spectograph(s). How can any event preceed the sonic wave from the bullet?
    1. Inaudable
    2. clearly visible and distinct in db2 spectograph(s)
    3. invisible on linear spectograph(s)
    4. smudged in db2 spectograph(s)
    5. Duration is $1/10^{th}$ second
    6. looks like dispersing energy over time
    7. frequency response is high end of human range (and/or above)
    8. The timing of the pre event is about 1/2 second on the 2nd and 3rd shots but about 1 second on the first.
6. Frequency response of the pre-event is very similiar to portions of the sonic event, indicating that the two are probably of the same origin. How can this possibly be?
7. Reflection
    1. none in 1st
    2. strong in 2nd shot

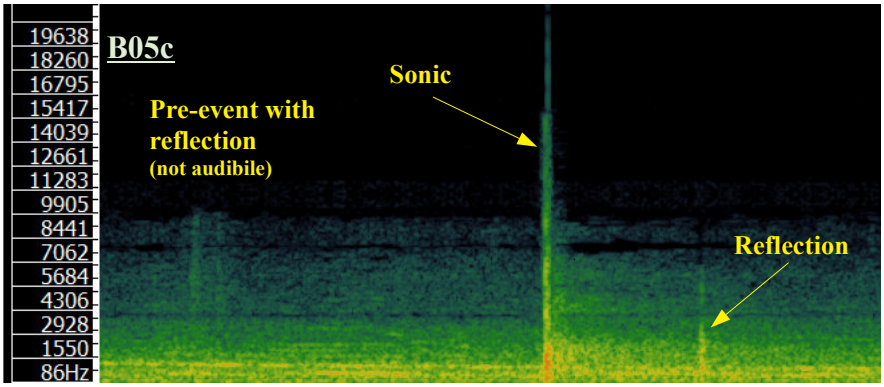
3. weak in 3rd event
4. 0.288 after 2 and 0.2xx after3rd shot
5. what is source of reflection and why does it differ from shot to shot in amplitude

1. Single Shot (near 5)
    1. 512/db2
        1. -1.01 – pre smudge,
        2. 0.00 – broadband, 16k – 0
        3. +0.288 -- ?? something very very small in lower frequencies
2. Single Shot (near 12)
    1. 512/db2
        1. -0.505 -- pre smudge, 5-10k band, 0.1 s duration, fading
        2. 0.000 – broadband, narrow, 16k,
        3. +0.233 – post reflection, 12k
3. Single Shot
    1. 512/db2
        1. 0.537 – pre smudge, very weak, 9k-4k, 0.048 duration, fading
        2. 0.000 – broadband, narrow, 20k
        3. +0.240 – post reflection, weak, 6k-0

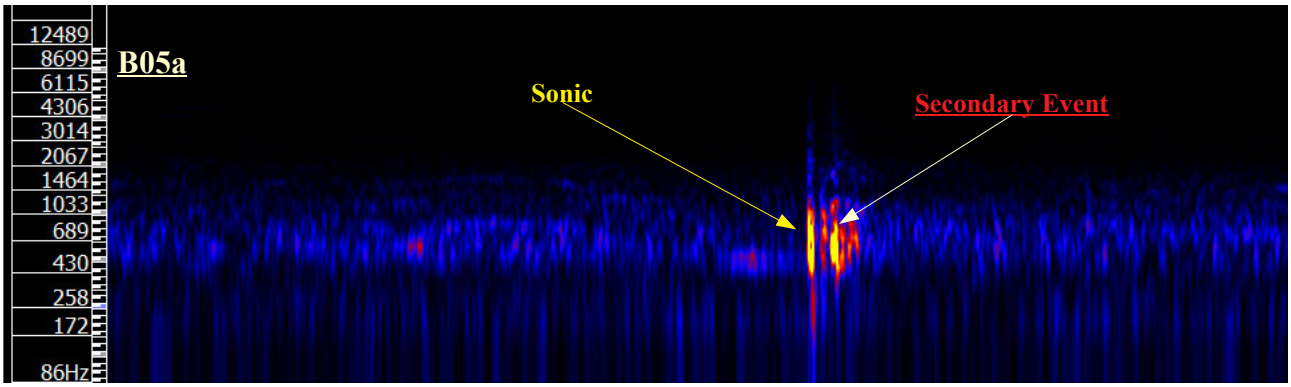
Three Single Shots (db^2 spectrgraphs)

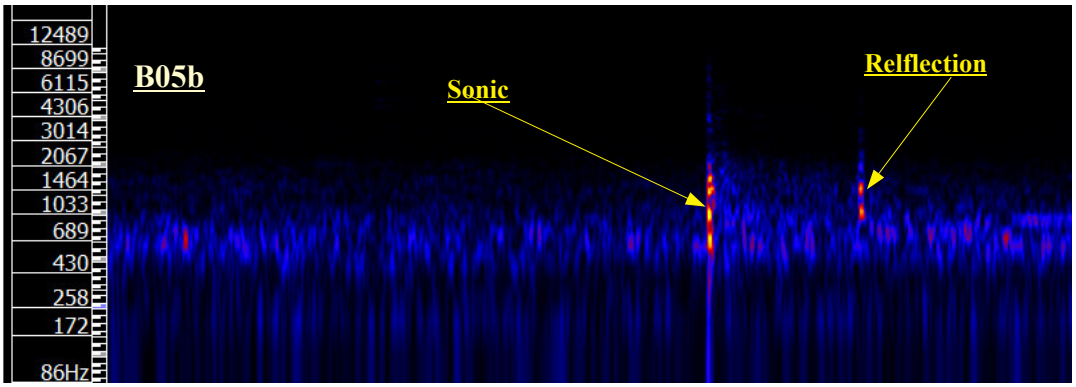


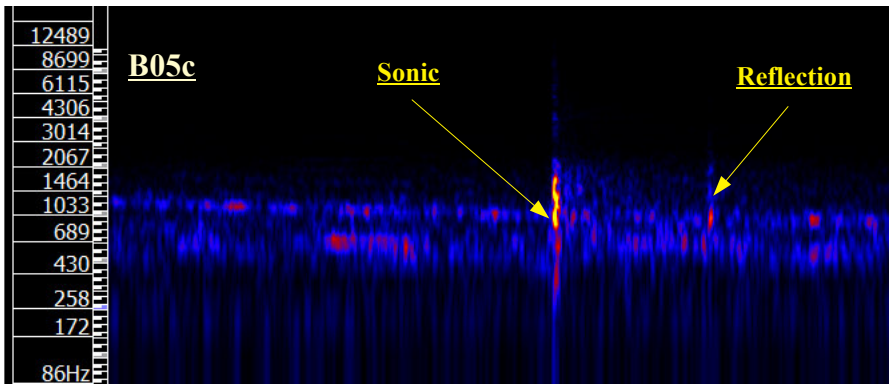




Three Single Shots (linear spectographs)

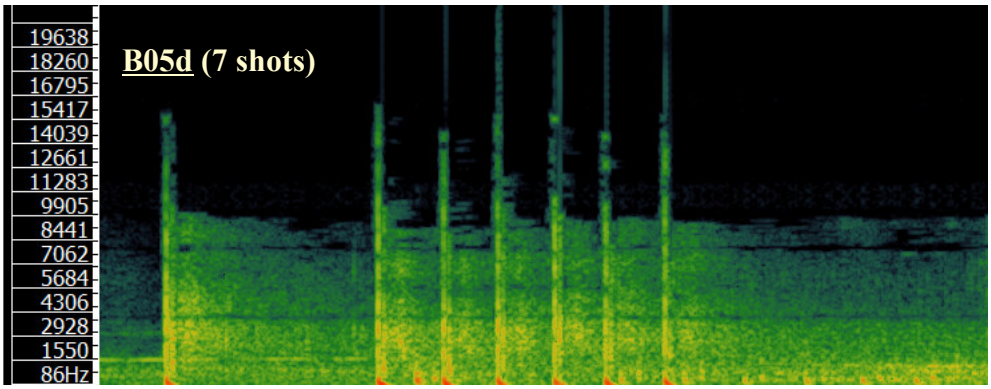


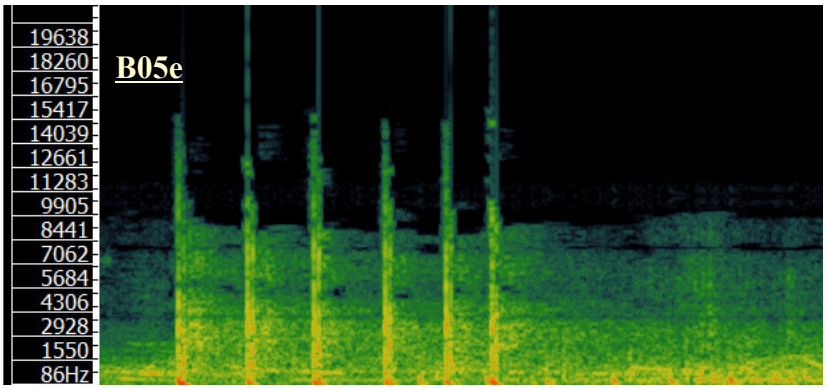


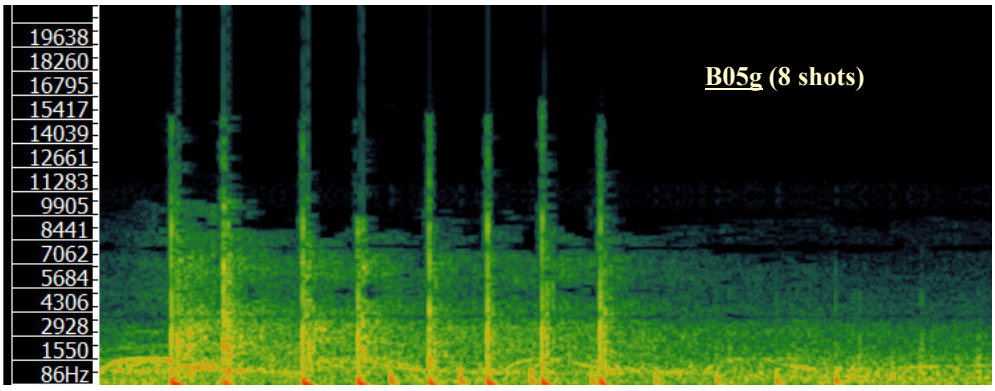


Bursts

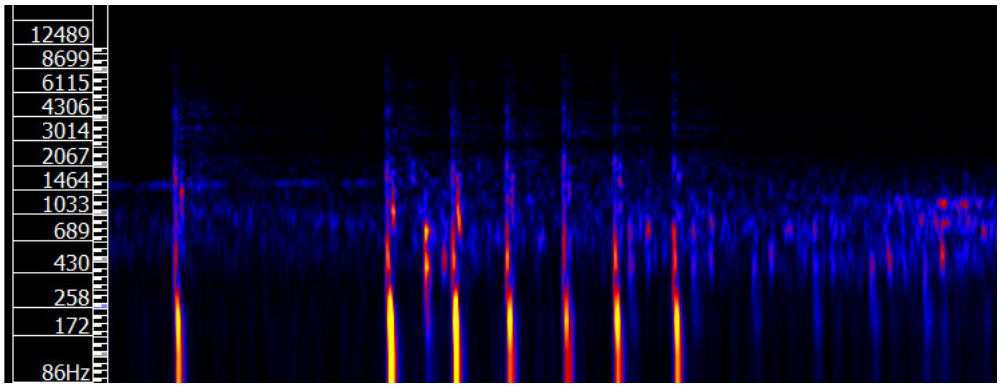
Three Burst Shots (db^2 spectographs)

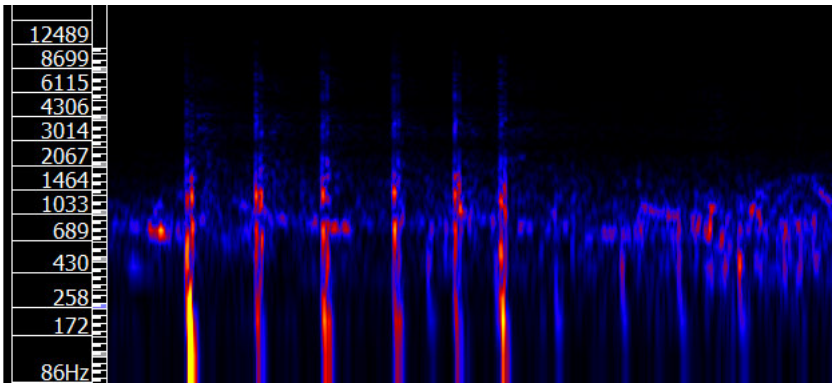


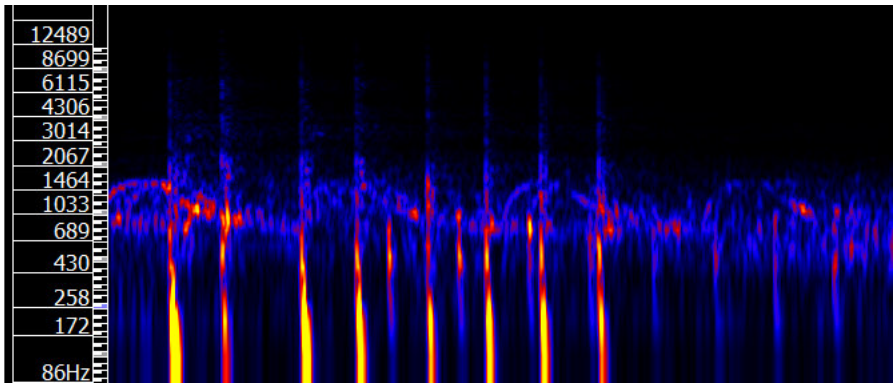




Three Burst Shots (linear spectographs)







Techniques & Criteria

In evaluating the video and audio of the body camera, the following techniques were used:

1. watch the tape (first 58 seconds) 5 times while taking notes
2. extract the audio and listen to it seperately 5 times while taking notes
3. apply software to the video and audio to check for gaps, forgery, and suspicious activities
4. apply software, to produce a viewable text file of "significant" audio events
5. manually review the automatically produced events to cull and augment
6. use software to produce multiple transforms of the significant events including visual representations of:
    a) the raw waveform
    b) power spectrum
    c) frequency spectrum
    d) "percussive" events
    e) vocal characteristics
    f) segmentation of audio into "music" and non-music
    g) energy decay curves
7. evaluate, compare, contrast all events with known events from other tapes, and within the current tape, cull the noise, promote the interesting
8. annotate some spectrums with notes
9. feed results to software that keeps track of all events
10. where possible lock down the events in global real time (syncronize)
11. re-evaluate for global timing and content consistancy
12. repeat steps 6-11 until closure is reached or run out of time & interest
13. draw conclusion
14. document
15. publish for comment and feedback

Generally

- Does it sound like a "gunshot" ?
- What type of gunshot does it sound like?
- Does it look and act like a gunshot?
- Does the waveform look like a gunshot?
- Does a frequency analysis reveal a gunshot?
- Is it similar to other "gunshots" on this tape?

- Is it similiar to other "gunshots" on other tapes?
- How similiar is it to other non-gunshot events?
- Is the signal to noise level good or poor?
- Is this recording closer or futher away from the source?
- Are there any echos?
- Is there something unusual about the recording device or situation?
- How reliable is the video source?
- Are there signs of tampering?
- Do all the observations make sense physically?
- Are there simpler and/or more likely explanations?
- Is the gunshot preceeded by or followed by something out of the ordinary?
- Does the energy decay curve behave?
- Is it a known and quantified sound which is not a gunshot?
- Is it proceeded or followed by other vocal or loud events which foul the spectrum?
- Must be identifiable on at least three other tapes

Sonic Shock Wave

- Must have some "broadband" characteristics
- Primary Impulse Signal <= 7 ms
- **db** spectrum noteibly higher than background noise
- Redily visible on **db^2** Spectrum
- Should have corresponding muzzle blast (but not always)
- Crisp and clean frequency impulse response
- May peak above noise (sometimes not by much)
- Has substantial intensity dominate in appropriate frequency range
- Closer to "N" waveform, more reliable
- Should be "positive pressure" wave, if negative examine carefully before accepting

Muzzle Blast

- Primary Impulse Signal < 24 ms
- Primary Impulse Signal > corresponding sonic shock wave
- Must dominate appropriate frequency (typically lower) range
- Redily visible on linear scale frequency spectrum
- Must have typical "boom" when listened too, even if very low
- Does it have corresponding sonic wave?

- Must have some "broadband" characteristics
- May have some "smearing"

Videos Referenced

Several videos were used to confirm and characterize the B05a event. Five videos were selected based on their proximity to the event. In addition to these five videos, the Mandalay Bay Bus Stop video was used as a reference for the two final shots heard on that video following all multiple bursts. This document refers to these two shots as "pistol" shots, for lack of any supersonic wave associated with them.

#	Id	Events Used	Description	Location
1	lvmpd	all	Body Camera	Sidewalk
2	ray	B05a, Pistol(s)	Raymond Page	Sidewalk
3	woman	B05a	Concert	Stage Right
4	bleachers	B05a	Concert	Under Bleachers
5	killing	B05a	Concert	Stage Left
6	bus	pistol shots	Mandalay Bay	Bus Stop

Video for back shot of gate

Toolset

Tools used in analysis:

- Audacity
- Sonic Visualizer
- InfraView
- VLC Player
- VHDC Video Editor
- Python
- Python libraries for image and audio analysis/manipulation
- Libre Office
- MediaInfo
- Various Web Utilities

Gunshot Characteristics

To interpret the sounds recorded on videos, requires more than just listening and noting the bangs, booms, snaps and thuds. Much more. Complex mathematics is always involved, and while computers are not strictly necessary, they expand the cababilties of analysis 100 fold.

The Vegas mass shooting provides a wealth of recorded sounds, under wildly different conditions, and with a mish match of equipment.

Ultimately all sounds must be explained by any theory of proposed shooter(s), location(s), and phenomena.

Below is a very brief introduction to the theory, and application of gunshots as it applies to this situation.

Theory

Rule out things that look like gunshots but are inverted, that is they start with a negative pressure. Unless can clearly explain why, cull. At the tail end of the ladies tape there are quite a few of these type of events. Seems to be caused by bumping the phone against things.

- The largest amplitudes occur at or near resonance.
- As dampening becomes weaker, resonance sharpens and amplitude at resonance increases.
- Underdamped system
  - the restoring force is large compared to the dampening force
  - the system oscillates with decaying amplitude
- Mechanical energy decays exponentially in a "weakly damped" oscillator

The Sonic Wave

There is only one primary sonic wave, it is created by the bullet traveling through the air at faster than sound velocoties. This wave, like all other sounds, after creation expands in size away from it's source (the bullet). If the bullet stops, the wave previously created continues to expand.

Insert figure here.

The sonic wave, like all waves traveling through a medium is subject to deformation. EXPLAIN

From a listeners point of view, which portion of the sonic wave is "heard" is a matter of potsition and angle relative to the bullet path of travel.

Sound Position When Bullet Hits

If a supersonic bullet hits an object, and that sound is recorded, at what time in the recording does the sound appear compared to the sonic shockwave?

The sound of the hit is simply the distance of the recorder divided by the speed of sound at that location

and temperature etc.

The sound of the hit always is recorded after the sound of the sonic wave, never before.

INSERT FIGURE HERE

INSERT GRAPH HERE

Syncronization of Video with Sound for Fence Bullet

what is skew between video and sound because of recording device

what is skew between video and sound because of manipulation/compression

what is skew between video and sound because of running time offset

fps determines at least 1/2 frame error by observation

total error may be the max of the sum of the above errors or significantly less because of cancellation

On the Field (what you hear)

You hear whatever is happening at the time limited by what the mind will permit, and for the most part that was music, screaming, sirens, people talking, and some loud gunshot like sounds.

What is recorded on devices is substantially different in content, frequency range and amplitude. In this section are given some generalizations about what could be heard in a relatively quite environment where the signal to noise ratio is large.

Clasically referred to as the "crack" and "thud", a supersonic rifle shot at a distant location will have two components that are generally audible to the human ear. First comes the sound of the supersonic wave created by the bullet and some time later the sound created by the muzzle blast. Of course if the bullet hits something that may also produce an audible sound, which will be that third sound as well.

Every sound travels at the speed of sound for the medium it travels through, the speed of sound in air that night is approximately 1,100 feet per second.

The supersonic bullet traveling faster than sound will approach the listener quicker, that portion of the sonic wave then has a shorter distance to travel to the listener. Ultimately it is the shortest distance between the sound wave and the listener that determines when it is heard. This shortest listening distance occurs at a position which is perpindicular to the direction of travel of the wave.

INSERT FIGURE

At postions very close to the travel path of the bullet, the sonic wave arrival time approximates the arrival time of the bullet. As the distances grow further away from the travel path of the bullet, listening times for the sonic wave also grow.

Muzzle Time