STATE OF SOUTH CAROLINA COUNTY OF HORRY JENNIFER SPIVEY FOLEY, as Personal Representative of the Estate of SCOTT RYAN SPIVEY, Plaintiff, vs. CHARLES WELDON BOYD and KENNETH WILLIAMS, Defendants.	IN THE COURT OF COMMON PLEAS THE FIFTEENTH JUDICIAL CIRCUIT CASE NO.: 2024-CP-26-03798 **RULE 32(a)(5) PLAINTIFF'S DEPOSITION DESIGNATION EXCERPTS OF ROBERT C. MAHER, PhD, PE**

YOU WILL PLEASE TAKE NOTICE that Plaintiff hereby designates from the deposition of Robert C. Maher, PhD, PE taken in *Jennifer Spivey Foley, as Personal Representative of the Estate of Scott Ryan Spivey vs. Charles Weldon Boyd and Kenneth Williams,* C/A #2024-CP-26-03798, State of South Carolina, County of Horry, on September, 2025 to publish the following:

1. **Robert C. Maher, Phd., PE**

   a) Page 6, line 4 – Page 29, line 5;

   b) Page 30, line 1 – Page 43, line 8;

   c) Page 43, line 19 – Page 55, line 14;

   d) Page 152, line - 6 beginning with "if another", line 22;

   e) Page 164, line 25 – Page 165, line 14;

   f) Page 165, line 2 – Page 175, line 7; and

   g) and all included exhibits.

[SIGANTURE ON NEXT PAGE]

GOODING AND GOODING, P.A.

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January 27, 2026

CERTIFICATE OF SERVICE

On January 27, 2026, I served *Plaintiff's Designation of Deposition Excerpts* pursuant to Order 2022-05-06-04 of the South Carolina Supreme Court, the attached is being served on the following by email, to the lawyer's primary email address listed on the Attorney Information System (AIS), only and no hard copy will follow.

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Re:
Spivey v. Boyd, etal
Case No. 2024-CP-26-03798

s/ Rhonda F. Lawson
Rhonda F. Lawson
Paralegal

Figure 1: Waveform and spectrogram of gunshot sounds in Mobile Phone recording (3:33 – 3:58 FET).

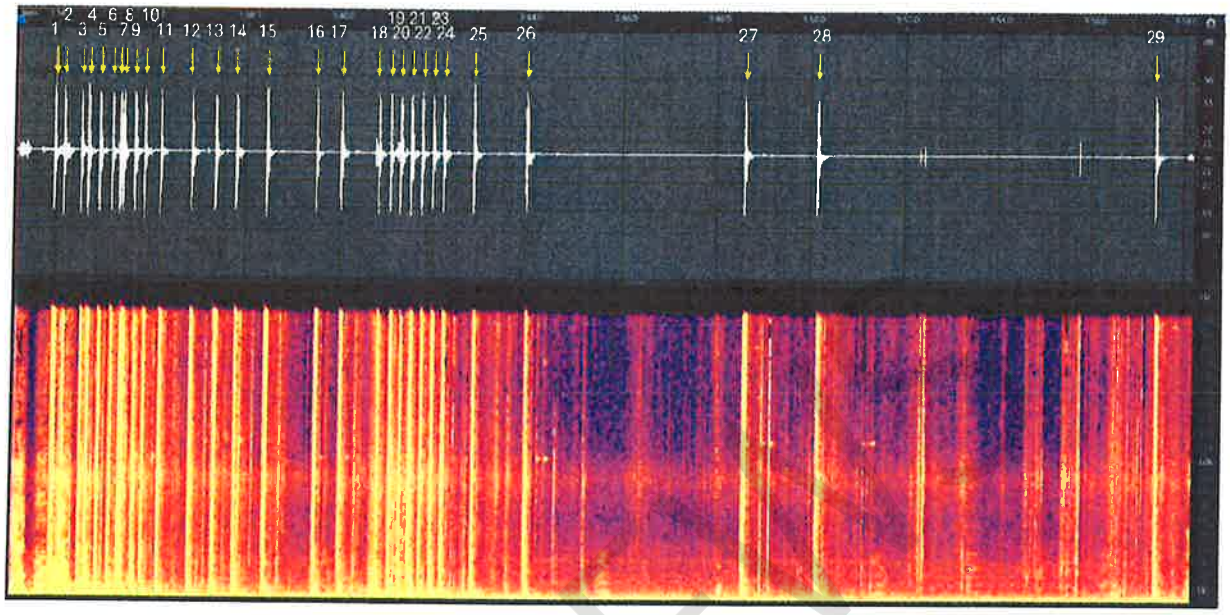


Figure 2: Audio from Mobile Phone recording, 3:19.5 - 3:34.0 FET.

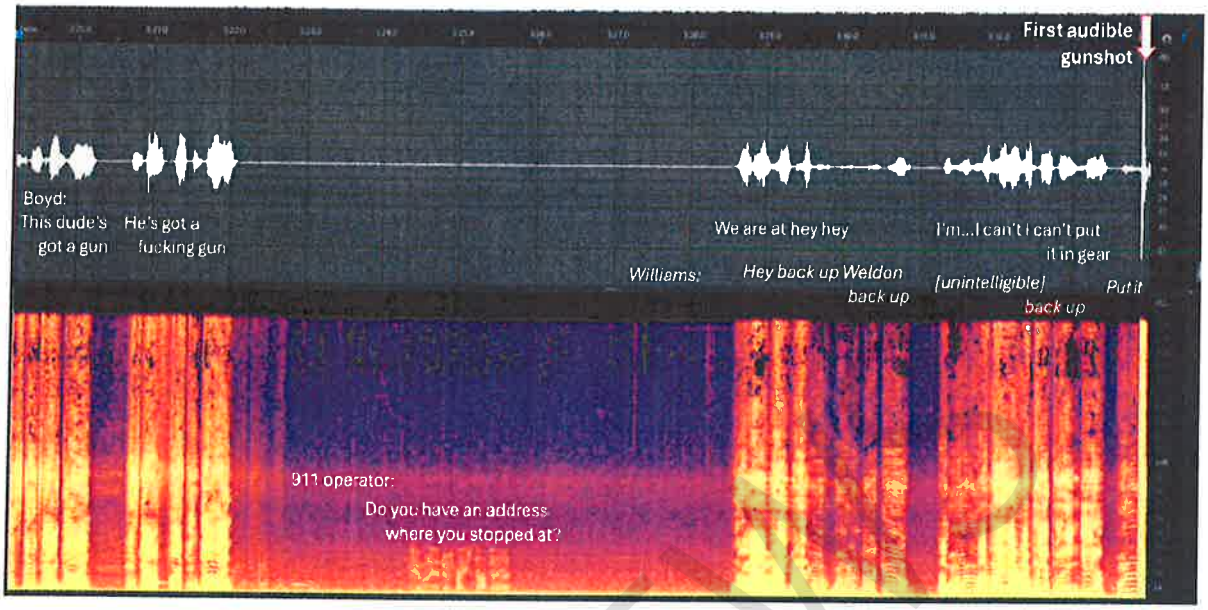


Figure 3: RMS amplitude envelope for the first 17 audible shots.

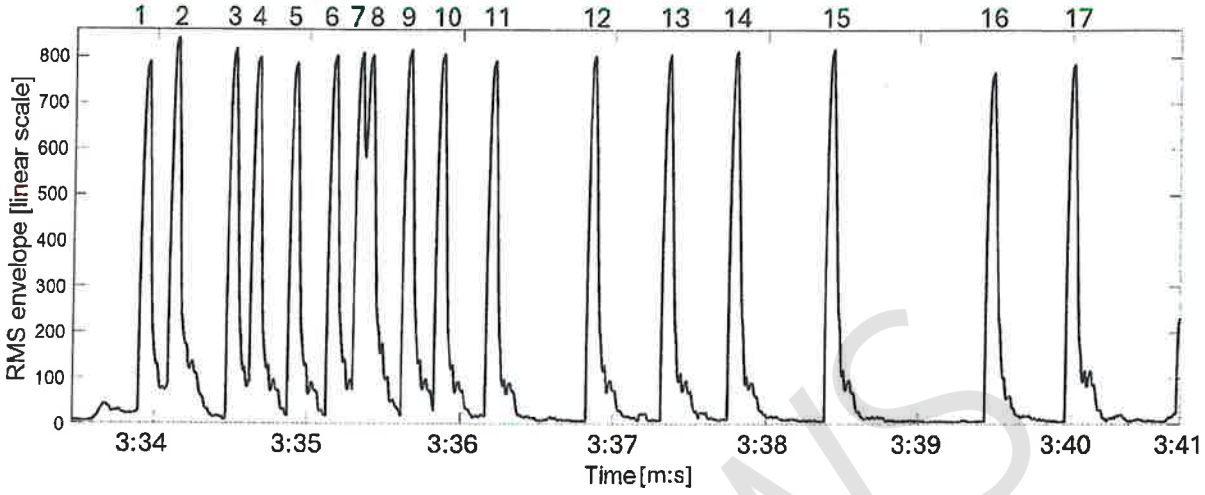
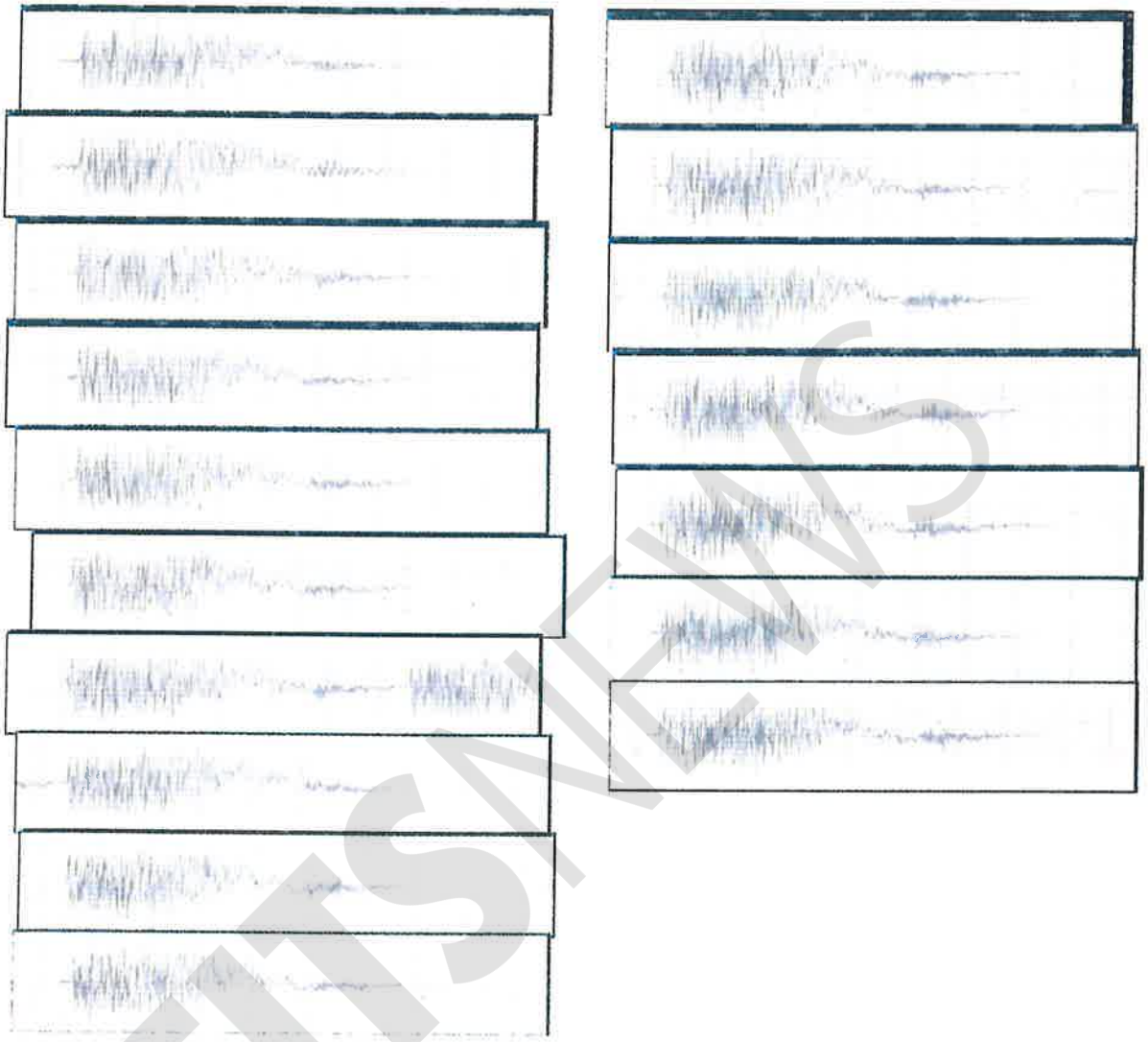


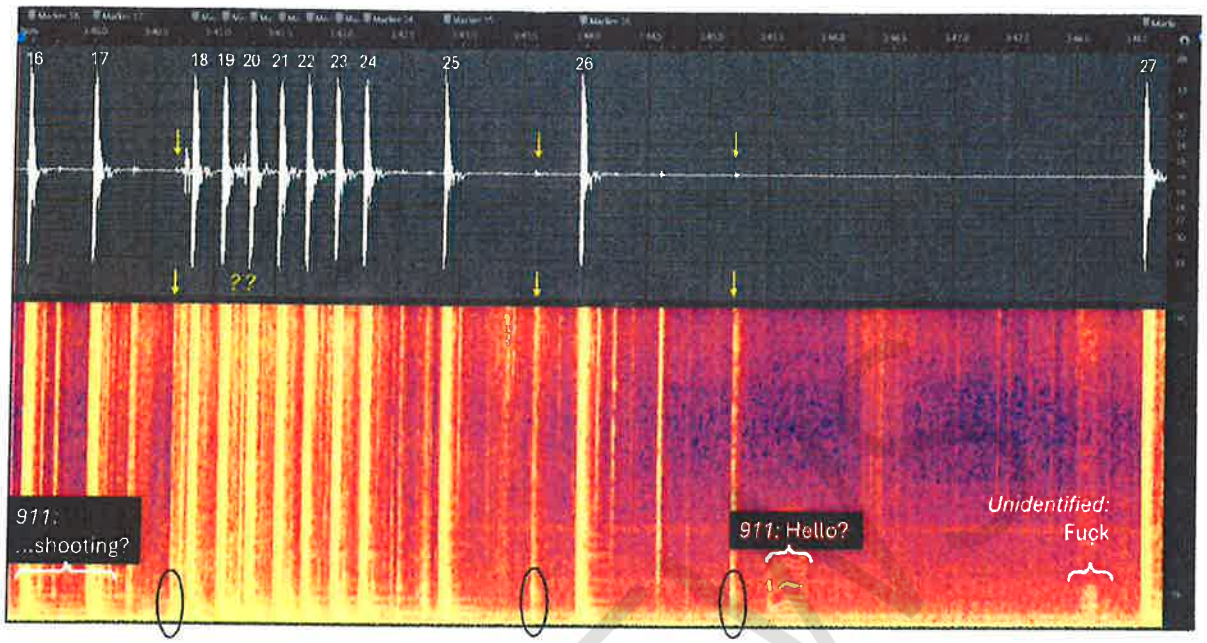
Figure 4: Waveform lineup for first 17 audible shots.



Plaintiff Exhibit

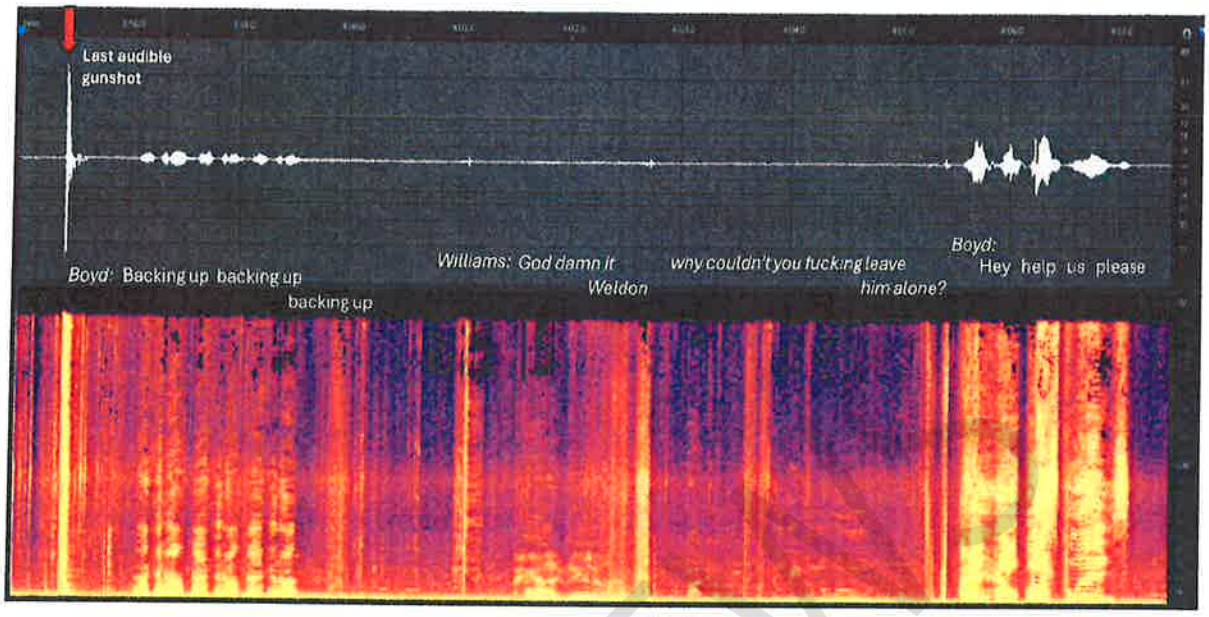
Figure 7: Waveform lineup for audible shots 18-29.

Figure 8: Segment of Mobile Phone recording with possible background audible gunshots.



Plaintiff Exhibit

Figure 9: Segment of Mobile Phone recording following final audible shot.



Forensic Audio Analysis Report

Prepared at the request of Mark Tinsley, Attorney At Law, Allendale, SC

Topic: Gunshot sounds from audio recording of September 9, 2023, incident on Camp Swamp Road, near Loris, SC.

Report prepared by:

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Date: 31 May 2025

Contents: Report (14 pages) and attached CV (15 pages)

Introduction

This report was prepared at the request of Mr. Mark Tinsley, an attorney representing a party in litigation in South Carolina. I was first contacted by Mr. Tinsley via email and telephone voicemail on May 8, 2025, regarding a case in which a mobile phone audio recording containing gunshot sounds was of interest to his investigation. The audio recording was included as an email attachment. Mr. Tinsley explained that he was interested in whether the various gunshot sounds in the recording could be analyzed to understand the shooting sequence and circumstances. He also emailed me a recording that appears to be from a 911 emergency call center audio recording. On May 9, 2025, I spoke with Mr. Tinsley via telephone, and I agreed to do a preliminary examination of the recording. I performed an initial review of the recording and sent an email summary of my observations to Mr. Tinsley on May 14, 2025.

Mr. Tinsley requested a telephone consultation on May 15, 2025. During that phone call, I explained my preliminary review of the recording and answered a few questions about the methods of audio forensic analysis. Mr. Tinsley explained that three firearms were believed to have been fired at the scene, and he requested that I prepare a formal report addressing several audio forensic questions. Mr. Tinsley agreed to my standard consulting rate of $250 per hour, and I estimated that I would require five or six hours to prepare the report.

It is my understanding that the audio recordings in this case were obtained as part of routine and official law enforcement and justice activity and are the best available copies of the recordings. I have no prior knowledge of any other aspects of this case and have no connection to the parties involved. I have not visited the scene of the incident, nor have I performed any physical testing of the recording equipment. I have not done any separate research, nor communicated with anyone about this case except Mr. Tinsley.

This report is organized as follows. First, I provide a brief summary of my qualifications and expertise. Next, I describe the nature of the audio material and its handling in my laboratory, followed by the specific observations and findings addressed by my investigation.

Qualifications

My professional Curriculum Vitae (CV) is attached to this report. Please allow me to summarize my qualifications and professional background in the field of audio forensic analysis.

I am currently a full Professor with the Electrical & Computer Engineering Department at Montana State University, Bozeman, MT. I have been affiliated with Montana State University since 2002. I am also the sole proprietor of a consulting firm specializing in audio digital signal processing and audio forensics. This report is provided under the auspices of my consulting practice, not as an official part of my responsibilities to Montana State University.

I received the BS degree from Washington University (St. Louis) in 1984, the MS degree from the University of Wisconsin (Madison) in 1985, and the PhD from the University of Illinois (Urbana-Champaign) in 1989, all in the field of electrical engineering. My career has also included university faculty positions with the University of Nebraska-Lincoln and the University of Colorado-Boulder, as well as experience in the digital audio signal processing industry as an entrepreneur and engineering manager.

I am a licensed Professional Engineer in the State of Montana (License no. 18993), a Fellow of the Audio Engineering Society, a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE), and an Associate Member of the American Academy of Forensic Sciences. I am also a member of the Acoustical Society of America, the American Society for Engineering Education, and a duly inducted member of the Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi, and Sigma Xi professional honorary societies. I publish research in the field of audio forensics, and I have served as Deputy Editor-in-Chief of the Journal of the Audio Engineering Society. My academic research includes three successive competitively-awarded grants for audio forensic research from the U.S. Department of Justice-National Institute of Justice.

I have consulted on more than fifty prior formal audio forensic investigations, and I have analyzed dozens of evidentiary recordings in the course of my more than 30 years working professionally in the audio signal processing field. I have previously been qualified as an expert witness for audio forensic analysis in California, Massachusetts, Montana, Missouri, Pennsylvania, Ohio, Washington D.C., and Texas, and I have provided sworn testimony in court nine times, and been deposed nine times.

A selection of my publications, book chapters, and presentations relevant to the field of forensic audio analysis are listed here. My CV includes a complete list of professional publications.

R.C. Maher, "Interpreting user-generated recordings from the Trump assassination attempt on July 13, 2024," Proc. 187th Meeting of the Acoustical Society of America—Virtual, November 21, 2024.

R.C. Maher, "Close and Distant Gunshot Recordings for Audio Forensic Analysis," Express Paper 122, Proc. 155th Audio Engineering Society Convention, New York, NY, October, 2023.

R.C. Maher, "Interpretation of audio forensic information from the shooting of journalist Shireen Abu Akleh," Express Paper 22, Proc. 153rd Audio Engineering Society Convention, New York, NY, October, 2022.

R.C. Maher, *Principles of Forensic Audio Analysis*, book, Springer Publishing, 2018.

R.C. Maher, "Gunshot recordings from a criminal incident: who shot first?" J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2024 (abstract), April, 2016.

R.C. Maher, "Lending an ear in the courtroom: forensic acoustics," Acoustics Today, vol. 11, no. 3, pp. 22-29, 2015.

R.C. Maher, "Audio forensic examination: authenticity, enhancement, and interpretation," IEEE Signal Processing Magazine, vol. 26, no. 2, March, 2009.

R.C. Maher, "Acoustical characterization of gunshots," Proc. IEEE SAFE 2007: Workshop on Signal Processing Applications for Public Security and Forensics, Washington, DC, pp. 109-113, April, 2007.

R.C. Maher, "Modeling and signal processing of acoustic gunshot recordings," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, pp. 257-261, September, 2006.

Initial Examination of the Material

As indicated above, Mr. Tinsley made available to me the three audio recordings, entitled
"0_P_Fire_F6_19_VoIP_2023_09_09_17_54_42_by_Start_.wav",
"New Recording.m4a", and
"911_1_1694296459608.mp3".

It is my understanding that the digital file information I received was copied from the original audio/video digital recordings. My work is based upon my good-faith assumption that the audio and video material provided to me in these files represents the best available audio quality of the evidentiary recordings and are true and faithful renditions of the recordings obtained from the recording devices.

To facilitate my analysis, I transferred the digital files to the hard disk of my laboratory personal computer and verified that the copied data file was identical to the original data using a bit-for-bit digital comparison. The software used for my analysis included the commercially available software Adobe Audition, and signal analysis software MATLAB.

The file "0_P_Fire_F6_19_VoIP_2023_09_09_17_54_42_by_Start_.wav" is a stereo (two audio channels) recording, with duplicate audio in the two channels. The audio sampling rate is 8000 samples per second, 16 bits per sample, with no perceptual compression (.wav file). The file comprises 10 minutes and 17.28 seconds. According to information provided to me by Mr. Tinsley, this recording is from a law enforcement dispatch system (911 emergency call center). I refer to this recording as *911 Call Center*.

The file "911_1_1694296459608.mp3" is a mono (one audio channel) recording. The audio sampling rate is 44,100 samples per second, with MP3 perceptual audio compression. The file comprises 8 minutes and 22.804 seconds. According to information provided to me by Mr. Tinsley, this recording was of a mobile phone conversation between the driver of a vehicle and the 911 emergency dispatcher. The recording was obtained from the mobile phone. I refer to this recording as *Mobile Phone*.

The file "New Recording.m4a" is a stereo (two audio channel) recording. The audio sampling rate is 48,000 samples per second, 16 bits per sample, with MP4 perceptual audio compression. Mr. Tinsley described this file as being a "time-stretched" version of a portion of the recording "911_1_1694296459608.mp3" that an acquaintance of his had manipulated to slow down the time evolution of the gunshot sounds. Because this recording was altered from the original information, I did not utilize it for any of my analysis.

I examined the audio portion of the 911 Call Center recording and the Mobile Phone recording using the Adobe Audition software to observe the recorded waveforms and *spectrograms*, which are special graphs depicting the frequency content of the signal as a function of time, as described later in this report. I was able to identify sounds and utterances by the vehicle driver (identified to me by Mr. Tinsley as Weldon Boyd), passenger (identified to me by Mr.Tinsley as Kenneth Williams), emergency call center dispatcher, and sounds from the vicinity of the vehicle. In the Mobile Phone recording I was also able to identify 29 impulsive sounds that appear to be audible gunshots, as discussed below.

For the remainder of this report, I will express the time scale of each event in terms of *file elapsed time* (or FET[1]), so that the audio signal features can be clearly identified in the data stream. The timing of events in the recordings differs slightly in terms of FET, i.e., the different recordings are not synchronized.

Preliminary Interpretation

For my preliminary observations I concentrated upon the portion of the recordings corresponding to the audible gunshots. For the 911 Call Center recording, the time range of interest was 3:07.0 FET to 3:38.0 FET. For the Mobile Phone recording, the time range of interest was 3:29.0 FET to 4:00.0 FET.

For the 911 Call Center recording, the utterances of the caller, passenger, and the 911 dispatcher are generally intelligible. However, gunshot sounds are not clearly discernable in the call center recording. This is typical of mobile phone telephone calls recorded at the far end of the conversation, since the speech coding algorithm of the mobile phone detects and transmits only speech sounds for the telephone channel. Loud, impulsive sounds such as gunfire are not interpreted as speech sounds by the telephony coding algorithm, and so gunshot sounds are not conveyed effectively through the mobile telephone.

For the Mobile Phone recording, the audio was recorded directly at the phone and not sent through the speech telephony coding algorithm and telephone channel. Thus, the sound of gunfire in the vicinity of the mobile recording device is clearly audible. My preliminary observation of the recording from critical listening and waveform analysis indicated 29 clearly discernable gunshot sounds, as depicted in Figure 1.

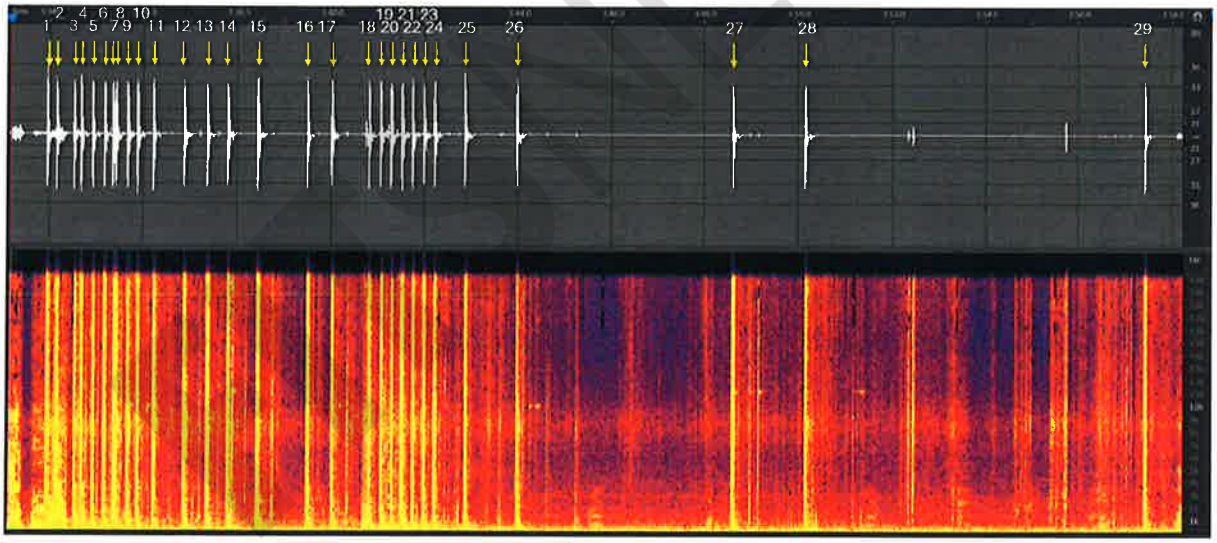

Figure 1: Waveform and spectrogram of gunshot sounds in Mobile Phone recording (3:33 – 3:58 FET).

[1] *File Elapsed Time*, abbreviated *FET*, refers to the time elapsed between the beginning of the file and the point of interest in the file. The FET is calculated using the audio sample data position in the file, the number of bytes per sample, and the sampling rate (samples per second). The time between different events in the file can be determined by subtracting the FET of the earlier event from the FET of the later event. Converting FET to time-of-day requires knowledge of the precise time-of-day corresponding to the beginning of the file.

At the request of Mr. Tinsley, I considered the following audio forensic analysis questions:

(1) *Can it be determined to a reasonable degree of certainty in the field of audio forensic analysis whether there are any gunshots audible in the Mobile Phone recording in the several seconds prior to the first obvious gunshot at 3:33.0 FET?*

(2) *Can it be determined to a reasonable degree of certainty in the field of audio forensic analysis whether there are sounds in the background that would correspond to gunshots from outside the cabin of the vehicle in which the Mobile Phone recording was made?*

To address these questions about the recorded gunshot sounds, it is important to understand several basic principles of gunshot acoustics.

Gunshot acoustics summary

A conventional firearm uses a confined combustion of gunpowder to propel the bullet out of the gun barrel. The sound of the rapid combustion is emitted from the gun in all directions, but the majority of the acoustic energy is expelled in the direction the gun barrel is pointing. The shock wave and related sound energy emanating from the barrel is referred to as the *muzzle blast*, and typically lasts for less than 3 milliseconds. The muzzle blast acoustic wave propagates through the air at the speed of sound (e.g., 343 m/s at 20°C), and is partially reflected, absorbed, and diffracted by the surrounding ground surface and obstacles. Over large distances, the muzzle blast sound may also be attenuated by spherical spreading, as well as being refracted and attenuated by temperature gradients, wind, and atmospheric absorption. On the other hand, if the firearm is discharged inside an enclosure, like a room in a building or within the cabin of an automobile, the recorded sound will be loud and shaped by the acoustical properties within that enclosure.

Recording an impulsive sound such as a gunshot includes the direct sound from the source traveling through the air directly to the microphone position, transmission through structures and other obstacles, early reflections of the sound that appear as discrete reflections off the ground, nearby surfaces, and other obstacles, and reverberation of the sound that comprises overlapping sound reflections arriving at the microphone from more distant surfaces and multiple-order reflections. The early reflections and the reverberation depend upon the acoustical environment where the recording is made, and therefore the recorded signal will differ if the source and/or microphone are moved between recordings. This inevitable mixture of sound due to the direct sound of the firearm alone and the overlapping acoustic reflections and reverberation creates a complicated pattern that depends upon the firearm type, orientation, acoustical surroundings, and relative location of the microphone.

If the recording microphone is located close to the firearm, the direct sound and initial reflections of the muzzle blast are the primary acoustical signals and often will be sufficiently loud to overload the recording microphone. If the microphone is located at a greater distance from the firearm, or if the direct sound path is blocked by an obstacle between the shooting position and the microphone, the recorded signal amplitude may be reduced and not sufficient to overload the recording system. With a more distant microphone location the recording will be dominated by acoustic reflections (echoes) and reverberation.

Similarly, a recording made inside an enclosure or surrounded by highly reflective surfaces, such as the location of the incident in this case, will also have significant sound reverberation.

An additional factor for interpreting gunshot sounds is the effect of the recording system and signal encoding format. Mobile phones, for example, have microphones and recording properties designed to encode and convey intelligible human speech, and therefore the signal reproduced in a recording may not represent subtle details of non-speech sounds such as gunshots.

Observations from the audio recording

It is standard practice in audio forensic analysis that particular sound events are identified using a combination of critical listening of the audio playback, identifying peaks and other features in the time waveform, and observing the spectrographic display.

Identification 1—Sounds prior to the first clearly audible gunshot at 3:33.0 FET

The portion of the Mobile Phone recording in the span of approximately 15 seconds preceding the first audible gunshot is shown in Figure 2. The manual transcriptions in the figure are my subjective interpretation of what was uttered, based upon my critical listening of the recording. I discerned the utterances of the two individuals in the vehicle, identified to me by Mr. Tinsley as Weldon Boyd and Kenneth Williams. The utterance of the 911 call center dispatcher is also audible, as indicated.

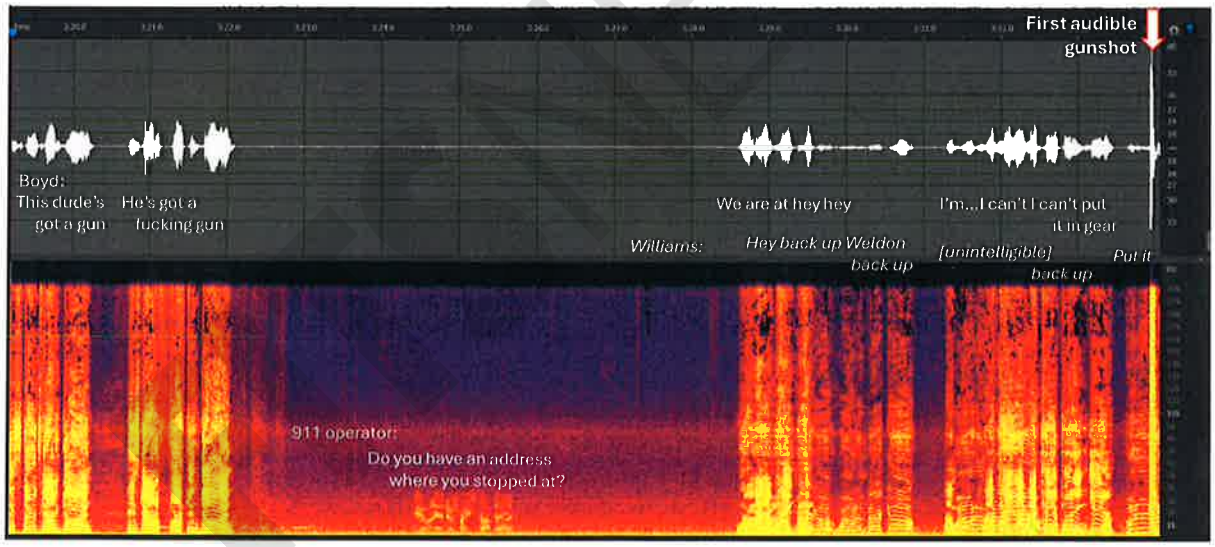

Figure 2: Audio from Mobile Phone recording, 3:19.5 - 3:34.0 FET.

The upper portion of Figure 2 (white on black) shows the *time waveform* of the recording. The amplitude of the audio waveform is proportional to the loudness of the sound. The lower portion of the figure (orange hue) is the *spectrogram* of the audio signal. The spectrogram is a special graph that depicts the frequency content of the signal as a function of time. The spectrogram is a common representation for audio signal analysis that presents audio signal energy with the frequency scale on the vertical axis and the time scale on the horizontal axis. Bright areas represent high energy and dark areas represent low energy. The spectrogram is produced by calculating the short-time Fourier transform magnitude of

successive and overlapping short time intervals of the input signal. In the spectrographic view, an impulsive sound such as a gunshot will appear as a vertical line, indicating that there is energy across frequency (broad along the vertical axis) but that it lasts for a brief instant (short along the horizontal axis). Conversely, a continuous hum or tone appears as a horizontal line, indicating that it is confined in frequency but long in duration.

The first clearly audible gunshot at 3:33.95 FET is seen at the right edge of the waveform and the spectrogram of Figure 2. The abrupt vertical amplitude in the waveform and the bright vertical line in the spectrogram denote the gunshot sound. I discern no evidence of gunshot sounds in the interval prior to that first audible gunshot, based upon critical listening, waveform analysis, and spectrographic analysis. Had there been a firearm discharged outside the vehicle in which the Mobile Phone recording was made, it is my professional opinion that the sound of such a muzzle blast would have been audible in the recording. I found no indication of any gunshot sounds prior to the fist clearly audible gunshot at 3:33.95 FET.

Identification 2—Sounds during and after the prominent interval of gunshot sounds 3:33.0 – 3:58.0 FET

The 29 audible gunshot sounds during the interval 3:33.0 – 3:58.0 FET (see Figure 1) are all of similar amplitude and spectro-temporal characteristics. While a mobile phone will have limited ability to record accurately the extremely loud and abrupt sounds of nearby muzzle blasts, and the waveform accuracy will also be limited by the MP4 perceptual audio coding used during the recording, the Mobile Phone audio does show notable consistency of the loud, clearly audible shots. The time corresponding to the onset of each audible shot is given in Table 1.

Shot	*Onset time*	*Time between [ms]*	*Shot*	*Onset time*	*Time between [ms]*
1	03:33.950	--	16	03:39.492	1061
2	03:34.141	191	17	03:40.014	522
3	03:34.517	376	18	03:40.823	809
4	03:34.674	157	19	03:41.067	244
5	03:34.922	248	20	03:41.293	226
6	03:35.177	255	21	03:41.521	228
7	03:35.351	174	22	03:41.747	226
8	03:35.415	64	23	03:41.984	237
9	03:35.664	249	24	03:42.214	230
10	03:35.876	212	25	03:42.866	652
11	03:36.212	336	26	03:43.969	1103
12	03:36.872	660	27	03:48.597	4628
13	03:37.363	491	28	03:50.146	1549
14	03:37.796	433	29	03:57.428	7282
15	03:38.431	635			

Table 1: Timing of 29 audible shots.

As indicated in Table 1, the time interval between shots is generally at least 150 milliseconds, except for the timing between shots 7 and 8, which is only 64 milliseconds. That time interval is sufficiently short so that it could indicate the gunshot reports were from two different firearms discharged almost simultaneously, or it could indicate some sort of double-shot malfunction of one firearm.

The amplitude envelopes of the first 17 audible shots are shown in Figure 3, and a lineup of the gunshot waveforms is given in Figure 4. The similarity in amplitude envelope, waveshape, and critical listening comparison, indicates that it is likely these first 17 audible shots, occurring over approximately 7 seconds, came from one firearm.

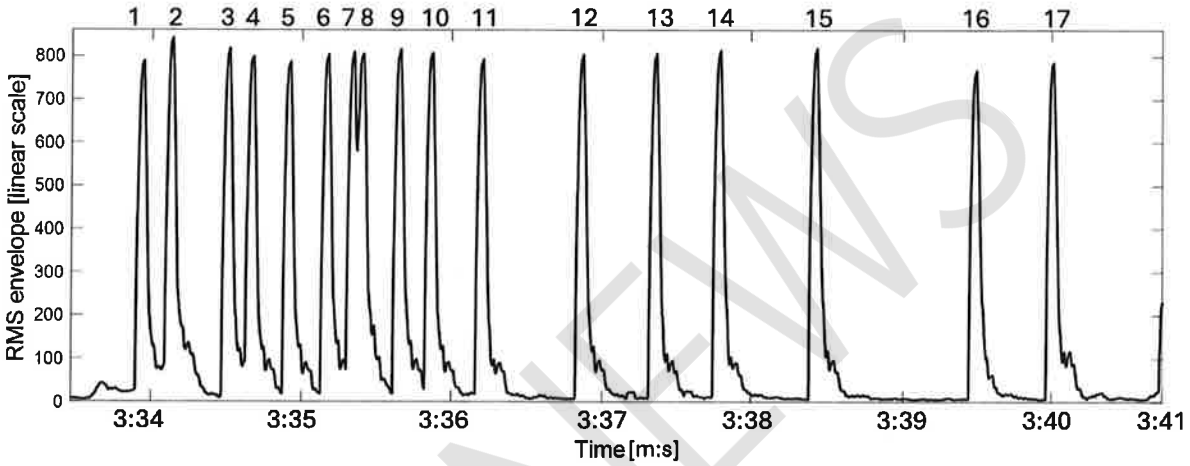

Figure 3: RMS amplitude envelope for the first 17 audible shots.

Following the first 17 audible shots, the next 12 audible shots (18-29) start with a more rapid cadence and a different audible character. As indicated in Table 1 and shown in the amplitude envelope plot of Figure 5, shots 18-24 have a consistent pace of roughly 230 milliseconds between shots. The pace then slows considerably for shots 25-29, as seen in Figure 5 and Figure 6. Also, the details of the waveforms shown in Figure 7 differ in shape and audible character compared to the first 17 shots (Figure 4). The similarity in amplitude envelope, waveshape, and critical listening comparison indicates that it is likely that shots 18-24 came from one firearm, but a different firearm than shots 1-17.

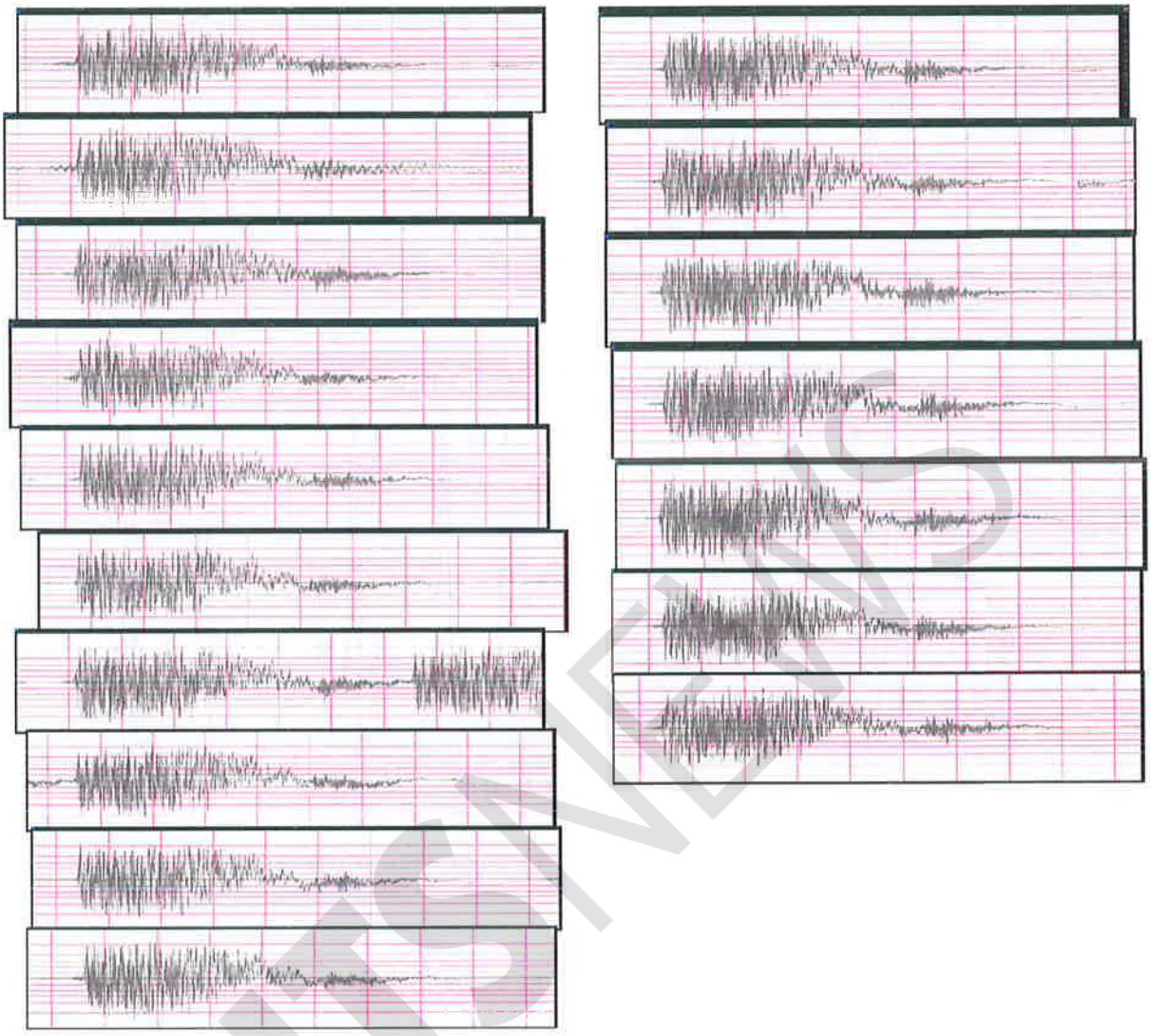

Figure 4: Waveform lineup for first 17 audible shots.

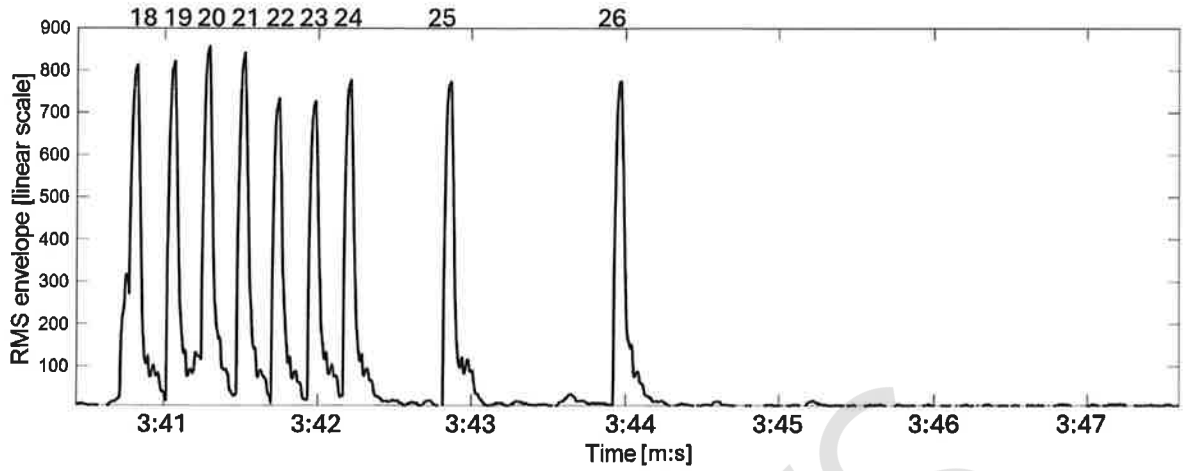

Figure 5: RMS amplitude envelope for audible shots 18-26.

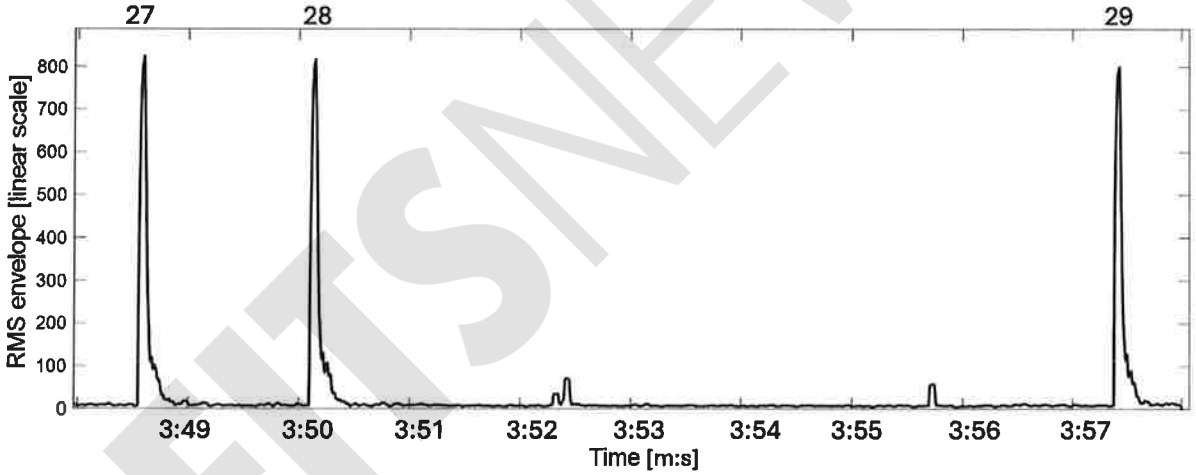

Figure 6: RMS amplitude envelope for audible shots 27-29.

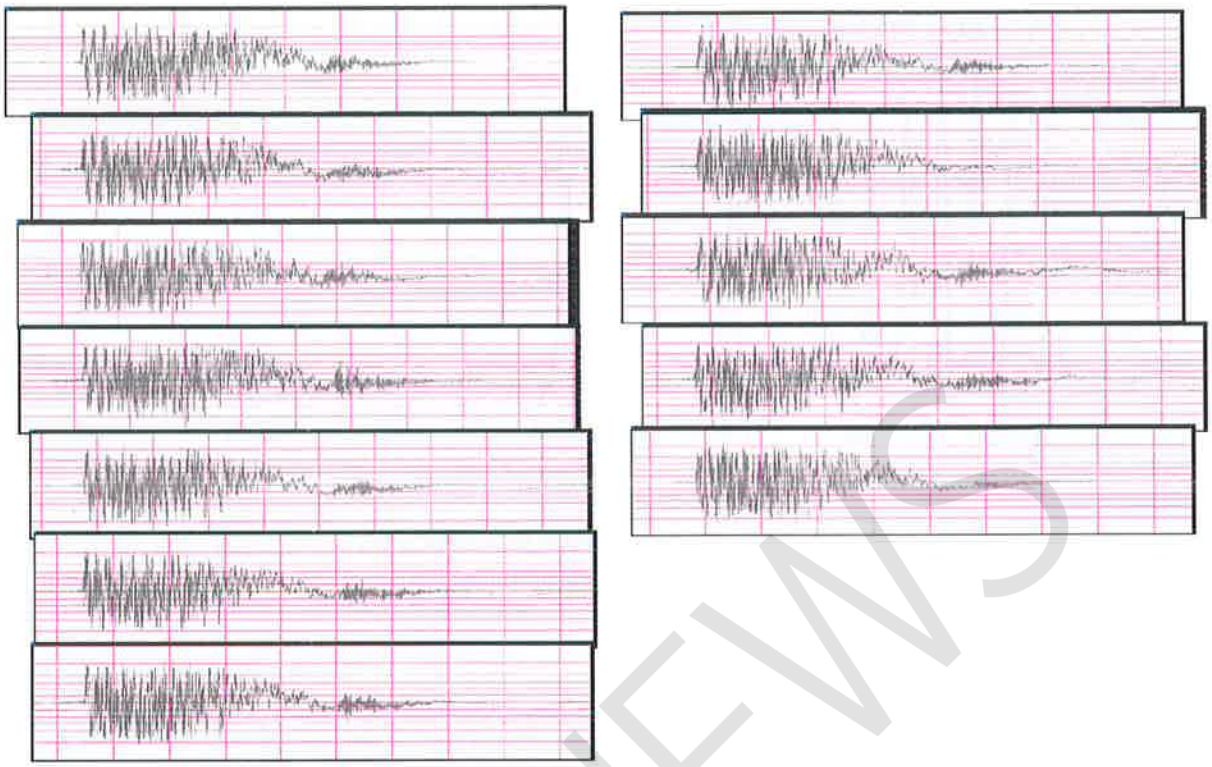

Figure 7: Waveform lineup for audible shots 18-29.

Considering the audio forensic question regarding background sounds of gunshots during and after the time interval of the clearly audible gunshots (3:33 – 3:58 FET), a few observations can be made.

First, the relatively loud gunshot reports from firearms presumably in the cabin with the recording device overwhelm much of the audible range, but there are several background sounds of utterances from the 911 dispatcher and from one of the vehicle occupants. Second, there are several impulsive click sounds that appear to be related to handling the firearms, and possibly the sound of spent cartridge casings being ejected. Finally, I discern several impulsive audible sounds that have a low-frequency emphasis that could possibly be attributed to a firearm discharged from some distance away from the vehicle in which the recording is made. Three of those relatively subtle sounds are indicated with yellow arrows in Figure 8. Although it is not possible for me to determine the source of those sounds with scientific certainty, it is plausible that those reports could be attributed to a firearm being discharged from inside the cabin of another vehicle located "30-40 yards away," which is the configuration of the shooting scene described to me by Mr. Tinsley.

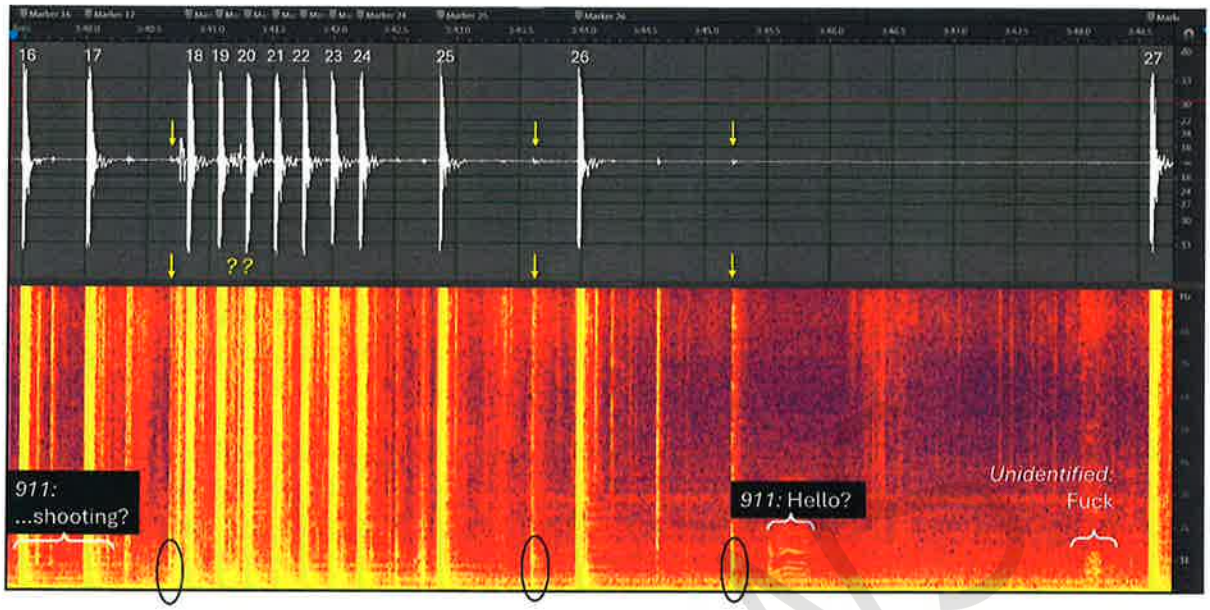

Figure 8: Segment of Mobile Phone recording with possible background audible gunshots.

Following the final audible shot 29, I did not identify any additional background gunshot sounds. As shown in Figure 9, there are a few intelligible utterances, including "Backing up, backing up, backing up" stated by, I believe, Weldon Boyd. Then Kenneth Williams says "God damn it Weldon, why couldn't you fucking leave him alone?" Boyd is then heard saying "Hey help us please," apparently to the 911 dispatcher.

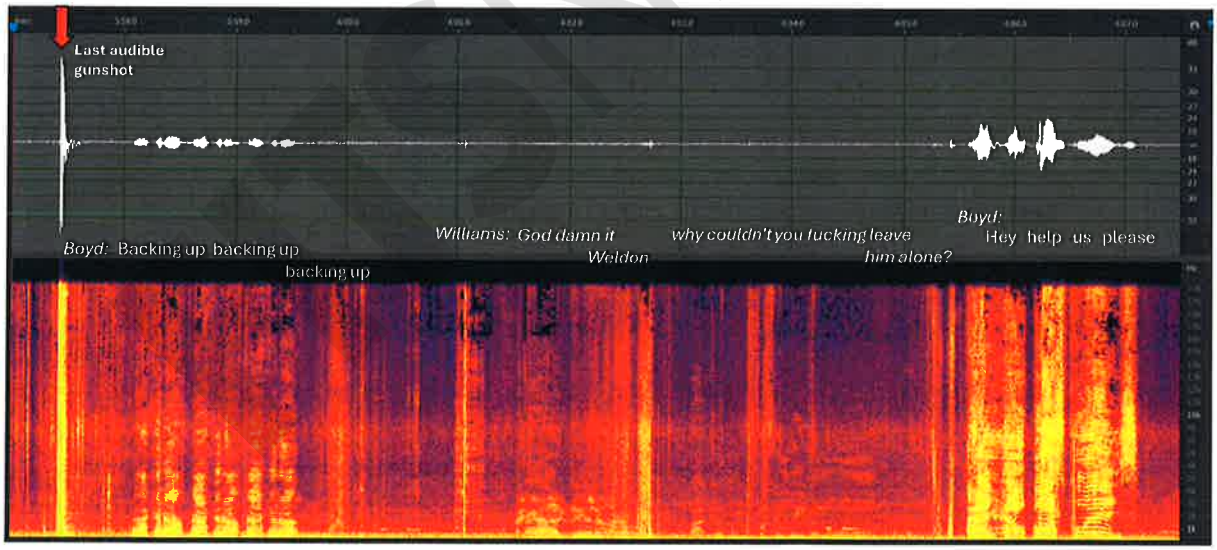

Figure 9: Segment of Mobile Phone recording following final audible shot.

Conclusions

The audio forensic analysis questions addressed to me by Mr. Tinsley were:

(1) *Can it be determined to a reasonable degree of certainty in the field of audio forensic analysis whether there are any gunshots audible in the Mobile Phone recording in the several seconds prior to the first obvious gunshot at 3:33.0 FET?*

(2) *Can it be determined to a reasonable degree of certainty in the field of audio forensic analysis whether there are sounds in the background that would correspond to gunshots from outside the cabin of the vehicle in which the Mobile Phone recording was made?*

Based on both my preliminary and my additional examination and interpretation of the audio evidence provided to me, and my consideration of the sound characteristics, waveforms, amplitude envelopes, and spectrographic analysis, it is my opinion to a reasonable degree of scientific certainty in the field of forensic audio analysis that there are no audible gunshot sounds in the Mobile Phone recording prior to the first clearly audible gunshot at 3:33.950 FET. In addition to finding no acoustical evidence in the recording of earlier shots, the utterances of the vehicle occupants do not indicate that any gunfire has occurred during the interval prior to 3:33.950 FET.

Also based on my preliminary and my additional examination and interpretation of the audio evidence provided to me, and my consideration of the sound characteristics, waveforms, amplitude envelopes, and spectrographic analysis, it is my opinion to a reasonable degree of scientific certainty in the field of forensic audio analysis that there are no distinctly identifiable audible gunshot sounds in the Mobile Phone recording other than the 29 obvious shots indicated in Figure 1. Nevertheless, I find that there are several subtle indications of impulsive sounds that could plausibly be the report of a firearm being discharged from the cabin of another vehicle located some distance from the vehicle with the recording device.

While these conclusions from the audio evidence are supported by the methods of audio forensic analysis, it is clearly necessary for the investigators to examine physical evidence of firearm use, such as spent shell casings, bullets and bullet holes, gunshot residue, firearms in the possession of suspects, earwitness and eyewitness reports, etc. My observations are based only on the videos provided to me, and the very basic background information presented orally to me by Mr. Tinsley.

This concludes my findings regarding the analysis question posed to me by Mr. Tinsley. In the event that at some point in the future I should receive additional information, clarification, and/or new evidence related to this investigation, I reserve the right to amend this report to include my findings and opinions based upon review of the new information.

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May 31, 2025
Date

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PROFESSIONAL EXPERIENCE

MONTANA STATE UNIVERSITY, Bozeman, Montana **2002-PRESENT**

Professor of Electrical and Computer Engineering with tenure (7/08 – present)

Affiliate Professor of Music Technology (05/09-present)

Chair-Elect of MSU Faculty Senate (08/24-present)

Department Head, Electrical and Computer Engineering (8/07-8/17)

Associate Professor of Electrical and Computer Engineering with tenure (5/05-8/07)

Associate Professor of Electrical and Computer Engineering (8/02-5/05)

- Academic administration, teaching, research and service responsibilities.
- Established a funded research program in audio DSP.
- Teaching a variety of courses at both the undergraduate and graduate levels.

UNIVERSITY OF COLORADO, Boulder, Colorado **2001-2002**

Associate Professor Adjunct of Electrical and Computer Engineering

- Academic instructional assignment for Senior Design Lab, and DSP Microprocessor Lab.

EUPHONICS, INC./3COM CORPORATION/U.S. ROBOTICS CORPORATION **1997-2001**

EUPHONICS was acquired by 3COM in 1998 and spun off as part of U.S. ROBOTICS in 2000.

Engineering Manager, Research and Development, U.S. ROBOTICS (6/00-6/01)

Engineering Manager for Audio Product Development, 3COM (11/98-6/00)

Vice President of Engineering, EUPHONICS (5/97-11/98)

Director of Engineering, EUPHONICS (1/97-5/97)

- Hands-on experience creating new DSP algorithms, publications, and patents.
- Hired, trained and supervised ten DSP software engineers (including guidance, annual evaluations, and individual goal setting).

UNIVERSITY OF NEBRASKA, Lincoln, Nebraska **1989-1997**

Associate Professor of Electrical Engineering with tenure (8/95-1/97)

Assistant Professor of Electrical Engineering (8/89-8/95)

- Initiated and directed a funded research and teaching program in audio DSP.
- Supervised theses of 19 graduate students in the field of digital audio signal processing.

AUDIO DSP CONSULTING **1989-PRESENT**

Sole Proprietor, Consulting and Contracting Professional Services

- Consulting services to clients in digital signal processing for audio and entertainment products.
- Supervision of sub-contractors for embedded software development.

PROFESSIONAL EXPERIENCE (cont.)

UNIVERSITY OF ILLINOIS, Urbana, Illinois **1985-1989**

Research Assistant, Electrical Engineering

- Software development for digital audio applications and musical acoustics demonstrations (DSP and Intel assembler, and C).

EDUCATION

Ph.D. - Electrical Engineering, University of Illinois,
College of Engineering, Urbana, Illinois, 1989
Thesis: "An Approach for the Separation of Voices in Composite Musical Signals"
Thesis Advisor: James W. Beauchamp

MS - Electrical Engineering, University of Wisconsin,
College of Engineering, Madison, Wisconsin, 1985
Report: "Development of a Software-Based Real-Time Digital Synthesizer"

BS - Electrical Engineering, *Magna Cum Laude,* Washington University,
School of Engineering, St. Louis, Missouri, 1984

RESEARCH FUNDING SPONSORS (COMPETITIVE)

National Institute of Justice, U.S. Department of Justice
KEEN Foundation
National Science Foundation
U.S. National Park Service
NASA/Montana Space Grant Consortium
The Engineering Foundation
Advanced Acoustic Concepts, Inc.
Ariel Corporation
EuPhonics, Inc.
General Atomics, Inc.
Motorola Corporation, DSP Support
Sanchez Industrial Design, Inc.
Northwest Academic Computing Consortium
MSU Space Science and Engineering Laboratory
Montana Institute on Ecosystems
University of Illinois Research Board
UNL Center for Communication and Information Science
Nebraska Research Initiative

LEADERSHIP ACTIVITIES and PROFESSIONAL AFFILIATIONS

- Licensed Professional Engineer, Montana, License #18993
- Fellow, Audio Engineering Society
- Senior Member, Institute of Electrical and Electronics Engineers (IEEE)
- Member, Acoustical Society of America
- Member, American Society for Engineering Education
- Associate Member, American Academy of Forensic Sciences
- Deputy Editor-in-Chief, Journal of the Audio Engineering Society (2022-2024)
- Associate Technical Editor, Journal of the Audio Engineering Society (2007-2024)
- Review Board Member, Audio Engineering Society (1998-present)
- Papers Co-Chair, Audio Engineering Society 141st Convention (2016)
- Papers Co-Chair, Audio Engineering Society 137th Convention (2014)
- Papers Co-Chair, Audio Engineering Society 129th Convention (2010)
- Papers Co-Chair, Audio Engineering Society 125th Convention (2008)
- Papers Co-Chair, Audio Engineering Society 121st Convention (2006)
- Papers Co-Chair, Audio Engineering Society 117th Convention (2004)
- Student Technical Paper Awards Coordinator, Audio Engineering Society (2008-2024)
- Chairman, Audio Engineering Society Colorado Section (1998-2001)
- Member, Audio Engineering Society Technical Committee on Audio Forensics
- Member, Audio Engineering Society Technical Committee on Signal Processing
- International Program Committee member, IEEE Electro Information Technology conference (2005)
- Publications Chair, IEEE Digital Signal Processing Workshop (2006)
- Chairman, IEEE Nebraska State Section (1995-1996)
- Chairman, IEEE Central Montana Section (2017-2019)
- Publications Chair, IEEE Workshop Applications of Signal Processing to Audio & Acoustics (1995)
- MSU Sigma Xi (Scientific Research Society) chapter co-president (2007-present)
- MSU Campus Advising Action Team (CAAT) (2016-2024)
- MSU Planning Council Representative for College of Engineering (2011-2015, 2018-2023)
- MSU Graduate Council Representative for College of Engineering (2003-2009)
- MSU Advising Council Representative for College of Engineering (2005-2007)
- External Advisory Board, University of Nebraska Electrical Engineering (1998-2000)
- FCC Amateur Radio License, Amateur Extra class, Call Sign NR7B

ACADEMIC HONOR SOCIETIES

Tau Beta Pi, Eta Kappa Nu, Phi Kappa Phi, and Sigma Xi.

AWARDS and HONORS

- MSU Faculty Senate Chair-Elect (2024-2025)
- MSU Provost's Award for Exemplary Service and Fidelity to the Public Land-Grant Mission (2023)
- MSU President's Award for Excellence in Teaching (2022)
- MSU College of Engineering Advising Award (2020)
- MSU Anna K. Fridley Phi Kappa Phi Award for Distinguished Teaching (2020)
- MSU Vice President for Research Award for Meritorious Technology/Science (2019)
- MSU College of Engineering Outreach Award (2017)
- MSU Academic Advising Award (2013)
- National Academic Advising Association (NACADA) Outstanding Faculty Advisor Award (2012)
- MSU James and Mary Ross Provost's Award for Excellence (2009)
- U. of Nebraska College Distinguished Teaching Award (1995)
- U. of Nebraska Parents' Association Recognition Award for Contributions to Students (1991, 93, 94)
- U. of Nebraska IEEE Student Chapter: Outstanding Faculty Award (1990, 1994); Tau Beta Pi: Outstanding Teacher Award (1993); College of Engineering: College Teaching Award (1992)

SCHOLARSHIPS/FELLOWSHIPS

- NSF Graduate Fellowship
- Audio Engineering Society Educational Grant
- University of Illinois and University of Wisconsin Graduate Fellowships
- Washington University Langsdorf Undergraduate Fellowship
- National Merit and National Honor Society Scholarships

UNITED STATES PATENTS

(4) D. Kosek and R.C. Maher, "Audio Spectral Noise Reduction Method and Apparatus," Patent Number 7,742,914, June 22, 2010.

(3) R.C. Maher and J. Barish, "Scalable Audio Processing on a Heterogeneous Processor Array," Patent Number 6,301,603, October 9, 2001.

(2) R.C. Maher, "Audio Spatial Enhancement Apparatus and Methods," Patent Number 6,111,958, August 29, 2000.

(1) R.C. Maher, "Audio Spatial Localization Apparatus and Methods," Patent Number 6,078,669, June 20, 2000.

FULLY REFEREED JOURNAL ARTICLES

These are formal papers invited or accepted for scholarly publication based on full peer review of the completed manuscript.

(15) H. Fraser, V. Aubanel, R.C. Maher, C. Mawalim, X. Wang, P. Počta, E. Keith, G. Chollet, K. Pizzi, "Forensic Speech Enhancement: Toward Reliable Handling of Poor-Quality Speech Recordings Used as Evidence in Criminal Trials," J. Audio Eng. Soc., vol. 72, no. 11, pp.748-753, 2024.

(14) R.C. Maher, "Lending an ear in the courtroom: forensic acoustics," Acoustics Today, vol. 11, no. 3, pp. 22-29, 2015.

(13) R.C. Maher, "Audio forensic examination: authenticity, enhancement, and interpretation," IEEE Signal Processing Magazine, vol. 26, no. 2, March, 2009.

(12) R.C. Maher, "Control of synthesized vibrato during portamento musical pitch transitions," J. Audio Eng. Soc., vol. 56, no. 1/2, pp. 18-27, 2008.

(11) Z. Chen and R.C. Maher, "Analytical expression for impulse response between two nodes in 2-D rectangular digital waveguide mesh," IEEE Signal Processing Letters, vol. 15, pp. 221-224, 2008.

(10) Z. Chen and R.C. Maher, "Semi-automatic classification of bird vocalizations using spectral peak tracks," J. Acoust. Soc. Am., vol. 120, no. 5, pp. 2974-2984, 2006.

(9) R.C. Maher, "Wavetable synthesis strategies for mobile devices," J. Audio Eng. Soc., vol. 53, no. 3, pp. 205-213, 2005.

(8) P.K. Ramarapu and R.C. Maher, "Methods for reducing audible artifacts in a wavelet-based broad-band denoising system," J. Audio Eng. Soc., vol. 46, no. 3, pp. 178-190, 1998.

(7) S.M. Joseph and R.C. Maher, "Subjective evaluation of four low-complexity audio coding schemes," J. Acoust. Soc. Am., vol. 97., no. 6, pp. 3657-3662, 1995.

(6) R.C. Maher, "A method for extrapolation of missing digital audio data," J. Audio Eng. Soc., vol. 42, no. 5, pp. 350-357, 1994.

(5) R.C. Maher and J.W. Beauchamp, "Fundamental frequency estimation of musical signals using a Two-Way Mismatch procedure," J. Acoust. Soc. Am., vol. 95., no. 4, pp. 2254-2263, 1994.

(4) R.C. Maher, "On the nature of granulation noise in uniform quantization systems," J. Audio Eng. Soc., vol. 40, no. 1/2, pp. 12-20, 1992.

(3) R.C. Maher, "A method for envelope warping in digital audio synthesis," J. Audio Eng. Soc., vol. 39, no. 12, pp. 934-944, 1991.

(2) R.C. Maher, "Evaluation of a method for separating digitized duet signals," J. Audio Eng. Soc., vol. 38, no. 12, pp. 956-979, 1990.

(1) R.C. Maher and J.W. Beauchamp, "An investigation of vocal vibrato for synthesis," Applied Acoustics, vol. 30, no. 2-3, pp. 219-245, 1990.

BOOKS AND CHAPTERS

These are books and chapters of published reference books with peer review of the completed manuscript.

(5) R.C. Maher, "Forensic Audio Analysis," book chapter, *Handbuch der Audiotechnik*, 2nd edition, Stefan Weinzierl, ed., Heidelberg: Springer-Verlag, 2022.

(4) R.C. Maher, *Principles of Forensic Audio Analysis*, book, Springer Nature Switzerland, 2018.

(3) R.C. Maher, "Overview of Audio Forensics," book chapter, *Intelligent Multimedia Analysis for Security Applications*, Berlin: Springer-Verlag, pp. 127-144, 2010.

(2) R.C. Maher, "Lossless Audio Coding," book chapter, *Lossless Compression Handbook*, K. Sayood, ed., San Diego: Academic Press, 2003.

(1) J.W. Beauchamp and R.C. Maher, "Digital Audio," book chapter, *Handbook of Acoustics*, M. Crocker, ed., New York: John Wiley & Sons, pp. 1967-1978, 1997.

FULLY REFEREED CONFERENCE PROCEEDINGS

These are formal papers invited or accepted for a scholarly conference based on full peer review of the completed manuscript.

(21) R.C. Maher, "Examining tell-tale sounds in forensic gunshot recordings," elib 22634, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.

(20) S.B. Nesar, B.M. Whitaker, and R.C. Maher, "A geometric approach for generating synthetic gunshot acoustic signals," elib 22631, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.

(19) S.B. Nesar, B.M. Whitaker, and R.C. Maher, "Machine learning analysis on gunshot recognition," 2024 Intermountain Engineering, Technology and Computing (IETC) Conference, Utah State University, Logan, UT, May 13-14, 2024.

(18) R.C. Maher, "Shot-to-shot variation in gunshot acoustics experiments," elib 20461, Proc. 2019 Audio Engineering Society International Conference on Audio Forensics, Porto, Portugal, June, 2019.

(17) D.R. Begault, S.D. Beck, and R.C. Maher, "Overview of forensic gunshot analysis techniques," elib 20475, Proc. 2019 Audio Engineering Society International Conference on Audio Forensics, Porto, Portugal, June, 2019.

(16) R.C. Maher and T.K. Routh, "Gunshot acoustics: pistol vs. revolver," Proc. Audio Engineering Society Conference, Audio Forensics—Finding Signal in the Noise, Arlington, VA, June, 2017.

(15) Â.M.C.R. Borzino, R.C. Maher, J.A. Apolinário and M.L.R. de Campos, "Employing wavelet-based texture features in ammunition classification", Proc. SPIE 10184, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security, Defense, and Law Enforcement Applications XVI, 101840D; doi:10.1117/12.2262282, May, 2017.

(14) R.C. Maher and S.R. Shaw, "Gunshot recordings from digital voice recorders," Proc. Audio Engineering Society 54th Conference, Audio Forensics—Techniques, Technologies, and Practice, London, U.K., June, 2014.

(13) R.C. Maher and J. Studniarz, "Automatic search and classification of sound sources in long-term surveillance recordings," Proc. Audio Engineering Society 46th Conference, Audio Forensics—Recording, Recovery, Analysis, and Interpretation, Denver, CO, June, 2012.

(12) R.C. Maher and S.R. Shaw, "Directional aspects of forensic gunshot recordings," Proc. Audio Engineering Society 39th Conference, Audio Forensics—Practices and Challenges, Hillerød, Denmark, June, 2010.

(11) R.C. Maher, J. Becker, T. Sharpe, J. Peterson, and B.A. Towle, "Development and implementation of a robot-based freshman engineering course," Proc. 2005 American Society for Engineering Education Annual Conference, Portland, OR, June, 2005.

(10) B.J. Gregoire and R.C. Maher, "Harmonic Envelope Detection and Amplitude Estimation Using Map Seeking Circuits," Proc. IEEE International Conference on Electro Information Technology (EIT2005), Lincoln, NE, May, 2005.

(9) R.C. Maher, "Concurrent Audio And Modem Acceleration," Proc. 1999 Windows Hardware Engineering Conference (WinHEC), Los Angeles, CA, March, 1999.

(8) R.C. Maher, "Single-ended spatial enhancement using a cross-coupled lattice equalizer," Proc. 1997 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1997.

(7) R.C. Maher, "Simple But Useful Tools for Interactive WWW Development," Proc. 1996 Frontiers in Education Conference, Salt Lake City, UT, November, 1996.

(6) Y.J. Chen and R.C. Maher, "Subband coding of audio using a recursively indexed quantizer," Proc. 1995 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1995

(5) R.C. Maher, "Computationally efficient compression of audio signals by means of RIQ-DPCM," Proc. 1993 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, October, 1993.

(4) R.C. Maher, "Control of interharmonic beating in polyphonic music," Proc. 1991 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, pp. 1-2, October, 1991.

(3) R.C. Maher, "Development and evaluation of a method for the separation of musical duet signals," Proc. IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Mohonk, NY, pp. 1-2, October, 1989.

(2) J.W. Beauchamp and R.C. Maher, "Significance of frequency vs. time variations and amplitude beating in additive synthesis of piano tones," Iowa Acoustics Colloquium, Iowa City, IA, p. 1, 1987.

(1) J.W. Beauchamp and R.C. Maher, "Musical acoustics demonstrations, lessons," Proc. IBM Advanced Education Projects Conference, San Diego, CA, 1986.

FORMAL PROFESSIONAL CONFERENCE PROCEEDINGS

These are formal papers invited or accepted for a scholarly conference by peer review of an abstract or extended summary.

(69) R.C. Maher, "Interpreting user-generated recordings from the Trump assassination attempt on July 13, 2024," Proc. 187th Meeting of the Acoustical Society of America—Virtual, November 21, 2024.

(68) R.C. Maher, "Advanced Audio Forensics Analysis," invited presentation, Bellingfest: 10th anniversary of Bellingcat independent investigative organization, Amsterdam, Netherlands, November 14-15, 2024.

(67) R.C. Maher, "Interpreting user-generated audio from war zones," Express Paper 265, Proc. 157th Audio Engineering Society Convention, New York, NY, October 9, 2024.

(66) R.C. Maher, "Where is Audio Forensics Heading Today?" invited keynote address, AES 8th International Conference on Audio Forensics, Denver, CO, June 27-29, 2024.

(65) R.C. Maher, "On Ramp: Engineering Algebra," 89th Annual ASEE Pacific NW Section Conference, Bozeman, MT, March 27-29, 2024.

(64) R.C. Maher, "Getting Things Started With a Bang: Interpreting Gunshot Sounds in Audio Forensic Analysis," Luncheon Seminar, 76th Annual Conference of the American Academy of Forensic Sciences, Denver, CO, February 22, 2024.

(63) R.C. Maher, "Close and distant gunshot recordings for audio forensic analysis," Express Paper 122, Proc. 155th Audio Engineering Society Convention, New York, NY, October 25, 2023.

(62) R.C. Maher, "Audio forensic analysis procedures for user generated audio recordings," presentation with interactive webinar, National Institute of Justice Forensic Technology Center of Excellence, November, 2022.

(61) R.C. Maher, "Interpretation of audio forensic information from the shooting of journalist Shireen Abu Akleh," Express Paper 22, Proc. 153rd Audio Engineering Society Convention, New York, NY, October 20, 2022.

(60) R.C. Maher, "Forensic interpretation of user generated audio recordings," 2022 National Institute of Justice Forensic Science Research and Development (R&D) Symposium, virtual event, Online, March 1-2, 2022.

(59) B.F. Miller, F.A. Robertson, and R.C. Maher, "Forensic handling of user generated audio recordings," Preprint 10515, Proc. 151st Audio Engineering Society Convention, Las Vegas, NV, Online, October, 2021.

(58) R.C. Maher, "Forensic interpretation and processing of user generated audio recordings," Preprint 10419, Proc. 149th Audio Engineering Society Convention, New York, NY, Online, October, 2020.

(57) E.R. Hoerr and R.C. Maher, "Estimating nonlinear impulse response length using time-delayed mutual information," Preprint 10416, Proc. 149th Audio Engineering Society Convention, New York, NY, Online, October, 2020.

(56) R.C. Maher and E.R. Hoerr, "Forensic comparison of simultaneous recordings of gunshots at a crime scene," Preprint 10281, Proc. 147th Audio Engineering Society Convention, New York, NY, October, 2019.

(55) E.R. Hoerr and R.C. Maher, "Using Volterra series modeling techniques to classify black-box audio effects, " Preprint 10225, Proc. 147th Audio Engineering Society Convention, New York, NY, October, 2019.

(54) R.C. Maher and E.R. Hoerr, "Audio forensic gunshot analysis and multilateration," Preprint 10100, Proc. 145th Audio Engineering Society Convention, New York, NY, October, 2018.

(53) R.C. Maher, "Challenges of audio forensic evaluation from personal recording devices," Preprint 9897, Proc. 143rd Audio Engineering Society Convention, New York, NY, October, 2017.

(52) T.K. Routh and R.C. Maher, "Determining muzzle blast duration and acoustical energy of quasi-anechoic gunshot recordings," Preprint 9635, Proc. 141st Audio Engineering Society Convention, Los Angeles, CA, October, 2016.

(51) R.C. Maher and T.K. Routh, "Wideband audio recordings of gunshots: waveforms and repeatability," Preprint 9634, Proc. 141st Audio Engineering Society Convention, Los Angeles, CA, October, 2016.

(50) T.K. Routh and R.C. Maher, "Recording anechoic gunshot waveforms of several firearms at 500 kHz sampling rate, " Proc. Mtgs. Acoust. 26, 030001 (2016); http://dx.doi.org/10.1121/2.0000262, May, 2016.

(49) R.C. Maher, "Explaining microphones and loudspeakers in a musical acoustics course for non-scientists," invited paper, J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2096 (abstract), April, 2016.

(48) T. Routh and R.C. Maher, "Recording anechoic gunshot waveforms of several firearms at 500 kilohertz sampling rate," J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2066 (abstract), April, 2016.

(47) R.C. Maher, "Gunshot recordings from a criminal incident: who shot first?" J. Acoust. Soc. Am., vol. 139, no. 4, part 2, p. 2024 (abstract), April, 2016.

(46) R.C. Maher and T. Routh, "Advancing forensic analysis of gunshot acoustics," Preprint 9471, Proc. 139th Audio Engineering Society Convention, New York, NY, October, 2015.

(45) J. Studniarz and R.C. Maher, "Sound identification from MPEG-encoded audio files," Preprint 8984, Proc. 135th Audio Engineering Society Convention, New York, NY, October, 2013.

(44) R.C. Maher, "A method for enhancement of background sounds in forensic audio recordings," Preprint 8731, Proc. 133rd Audio Engineering Society Convention, San Francisco, CA, October, 2012.

(43) R.C. Maher, "Teaching and learning musical acoustics in a music technology program," J. Acoust. Soc. Am., vol. 132, no. 3, part 2, p. 1958 (abstract), October, 2012.

(42) R.C. Maher, "Soundscape collaboration for science, management, and public outreach at a national historic site," invited paper, J. Acoust. Soc. Am., vol. 130, no. 4, part 2, p. 2497 (abstract), October, 2011.

(41) R.C. Maher, "Acoustical modeling of gunshots including directional information and reflections," Preprint 8494, Proc. 131st Audio Engineering Society Convention, New York, NY, October, 2011.

(40) R.C. Maher, "Automated analysis and interpretation of long-term soundscape audio recordings," invited paper, J. Acoust. Soc. Am., vol. 129, no. 4, part 2, p. 2570 (abstract), April, 2011.

(39) R.C. Maher, "Maintaining Sonic Texture with Time Scale Compression by a Factor of 100 or More," Preprint 8250, Proc. 129th Audio Engineering Society Convention, San Francisco, CA, November, 2010.

(38) R.C. Maher, "Cultural soundscape of the Grant-Kohrs Ranch national historic site," invited paper, J. Acoust. Soc. Am., vol. 127, no. 3, part 2, p. 1745 (abstract), April, 2010.

(37) D. Reed and R.C. Maher, "An investigation of early reflection's effect on front-back localization in spatial audio," Preprint 7884, Proc. 127th Audio Engineering Society Convention, New York, NY, October, 2009.

(36) R.C. Maher, "Acoustics of national parks and historic sites: the 8,760 hour MP3 file," Preprint 7893, Proc. 127th Audio Engineering Society Convention, New York, NY, October, 2009.

(35) R.C. Maher, "Baseline sound monitoring plan for Grant-Kohrs Ranch national historic site," J. Acoust. Soc. Am., vol. 125, no. 4, part 2, p. 2716 (abstract), 2009.

(34) R.C. Maher, "All about PHASE," Proc. IEEE Signal Processing Society 5th Signal Processing Education Workshop, Marco Island, FL, pp. 218-222, January, 2009.

(33) R.C. Maher and S.R. Shaw, "Deciphering gunshot recordings," Proc. Audio Engineering Society 33rd Conference, Audio Forensics—Theory and Practice, Denver, CO, June, 2008.

(32) Z. Chen and R.C. Maher, "Addressing the Discrepancy Between Measured and Modeled Impulse Responses for Small Rooms," Preprint 7239, Proc. 123rd Audio Engineering Society Convention, New York, NY, October, 2007.

(31) Z. Chen and R.C. Maher, "Modeling room impulse response by incorporating speaker polar response into image source method," J. Acoust. Soc. Am., vol. 121, no.5, part 2, p. 3174 (abstract), 2007.

(30) R.C. Maher, "Acoustical characterization of gunshots," Proc. IEEE SAFE 2007: Workshop on Signal Processing Applications for Public Security and Forensics, Washington, DC, pp. 109-113, April, 2007.

(29) R.C. Maher, "Modeling and signal processing of acoustic gunshot recordings," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, pp. 257-261, September, 2006.

(28) B.J. Gregoire and R.C. Maher, "Map seeking circuits: a novel method of detecting auditory events using iterative template mapping," Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, September, 2006.

(27) R.C. Maher, "Crossing the bridge: taking audio DSP from the textbook to the DSP design engineer's bench," Proc. IEEE Signal Processing Society 4th Signal Processing Education Workshop, Jackson Lake, WY, September, 2006.

(26) S.M. Pascarelle, B. Stewart, T.A. Kelly, A. Smith, and R.C. Maher, "An Acoustic / Radar System for Automated Detection, Localization, and Classification of Birds in the Vicinity of Airfields," 8th Joint Annual Meeting of Bird Strike Committee USA/Canada, St. Louis, MO, August, 2006.

(25) R.C. Maher, J. Gregoire, and Z. Chen, "Acoustical monitoring research for national parks and wilderness areas," Preprint 6609, Proc. 119th Audio Engineering Society Convention, New York, NY, October, 2005.

(24) R.C. Maher, "Audio enhancement using nonlinear time-frequency filtering," Proc. Audio Engineering Society 26th Conference, Audio Forensics in the Digital Age, Denver, CO, July, 2005.

(23) G. Sanchez, R.C. Maher, and S. Gage, "Ecological and environmental acoustic remote sensor (EcoEARS) application for long-term monitoring and assessment of wildlife," U.S. Department of Defense

Threatened, Endangered and at-Risk Species Research Symposium and Workshop, Baltimore, MD, June, 2005.

(22) J. Gregoire and R.C. Maher, "Map seeking circuits for audio pattern recognition," Music Information Processing Workshop, Whistler, British Columbia, Canada, December, 2004.

(21) R.C. Maher, "AES Technical Committee on Signal Processing Educational CD Project," Proc. 117th Audio Engineering Society Convention, Preprint 6313, San Francisco, CA, October, 2004.

(20) R.C. Maher, "Compression and Decompression of Wavetable Synthesis Data," Proc. 2003 Audio Engineering Society Convention, Preprint #5937, New York NY, October, 2003.

(19) M. Phillips, J. Barish, and R.C. Maher, "The modeling and synthesis of musical signals with PRISM," Proc. 2000 Audio Engineering Society Convention, Preprint #5187, Los Angeles, CA, September, 2000.

(18) D.K. Reinhardt and R.C. Maher, "A real time DSP kernel for concurrent audio tasks," Proc. 1998 Audio Engineering Society Convention, Preprint #4825, San Francisco, CA, September, 1998.

(17) R.C. Maher, "A low complexity spatial localization system," Proc. 1997 Audio Engineering Society Convention, Preprint #4567, New York, NY, November, 1997.

(16) R.C. Maher, E. Lindemann, and J. Barish, "Old and new techniques for artificial stereophonic image enhancement," Proc. 1996 Audio Engineering Society Convention, Preprint #4371, Los Angeles, CA, November, 1996.

(15) R.C. Maher, "Tunable bandpass filters in music synthesis," Proc. 1995 Audio Engineering Society Convention, Preprint #4098, New York, NY, October, 1995.

(14) R. Peddibhotla, R.C. Maher and K. Sayood, "A low complexity audio coding scheme for wideband audio," Proc. 1994 Asilomar Conf. on Circuits and Systems, Pacific Grove, CA, vol. 2, pp. 1222-1226, November, 1994.

(13) R.C. Maher, "An efficient scheme for lossy real-time audio data compression," Proc. 1994 Audio Engineering Society Convention, San Francisco, CA, Preprint #3922, pp. 1-13, November 10, 1994.

(12) R.C. Maher and J.L. Varner, "Laboratory development for digital signal processing education," Proc. 1994 ASEE Midwest Section Meeting, Lincoln, NE, pp. 1-4, March 31 - April 2, 1994.

(11) R.C. Maher, "A method for extrapolation of missing digital audio data," Proc. 1993 Audio Engineering Society Convention, New York, NY, Preprint #3715, pp. 1-19, October, 1993.

(10) J.W. Beauchamp, R.C. Maher, and R. Brown, "Detection of musical pitch from recorded solo performances," Proc. 1993 Audio Engineering Society Convention, Berlin, Germany, Preprint #3541, pp. 1-15, March, 1993.

(9) D.J. Cheenne, R.D. Kubik, R.C. Maher, and E. Bahar, "Full-wave modeling of the transmission of sound over theater seats: far field investigation," J. Acoust. Soc. Am., vol. 92, no. 4, part 2, p. 2347 (abstract), 1992.

(8) R.C. Maher and J.W. Beauchamp, "Frequency tracking of solo and duet passages using a harmonic two-way mismatch procedure," invited paper, J. Acoust. Soc. Am. , vol. 92, no. 4, part 2, p. 2429 (abstract), 1992.

(7) E.P. Moss and R.C. Maher, 1992, "Synthesis and processing of audible notification and warning signals," Proc. 1992 Audio Engineering Society Convention, San Francisco, CA, Preprint #3354, pp. 1-10, October, 1992.

(6) R.C. Maher, "Sinusoidal additive synthesis revisited," Proc. 1991 Audio Engineering Society Convention, New York, NY, Preprint #3128, pp. 1-19, October, 1991.

(5) R.C. Maher, "Computer processing of audio signals by exclusion filters," J. Acoust. Soc. Am. Suppl. 1, vol. 88, p. 188 (abstract), 1990.

(4) J.W. Beauchamp and R.C. Maher, "Partial synchrony in musical sounds: some recent results using time-variant spectral analysis," invited paper, J. Acoust. Soc. Am. Suppl. 1, vol. 84, pp. 103-104 (abstract), 1988.

(3) R.C. Maher and J.W. Beauchamp, "Is there a single vibrato waveform?" J. Acoust. Soc. Am. Suppl. 1, vol. 83, p. 31 (abstract), 1988.

(2) R.C. Maher and J.W. Beauchamp, "A microcomputer-based demonstration system for acoustics education" J. Acoust Soc. Am. Suppl. 1, vol. 81, p. 32 (abstract), 1987.

(1) R.C. Maher, J.H. Scandrett, R.E. Crawford, Jr., and K. Grant, "A low-cost digital synthesizer system for music applications and psychoacoustical research," J. Acoust Soc. Am. Suppl. 1, vol. 77, p. 75 (abstract), 1985.

FORMAL PROFESSIONAL PRESENTATIONS

These are formal, invited lectures for an engineering group, academic seminar, employment interview, or technical meeting.

(70) S. Wettstein, B. LaMeres, P. Gannon, and R.C. Maher, "Implementing a College-Wide Entrepreneurial Mindset Intervention," workshop presentation, 2024 KEEN National Conference, Austin, TX, February 8-10, 2024.

(69) R.C. Maher, "Gunshot analysis in audio forensics," invited workshop tutorial presentation, SoundThinking, Inc., Washington, D.C., May 25, 2023.

(68) R.C. Maher, "How to be a great peer reviewer for the AES Journal," invited workshop tutorial presentation, *Audio Engineering Society 153rd Convention,* New York, NY, October 20, 2022.

(67) R.C. Maher, J. Reiss, V. Välimäki, and B. Kostek, "What does it take to write a paper for the Journal of the Audio Engineering Society?" invited workshop tutorial presentation, *Audio Engineering Society 151st Convention,* Las Vegas, NV, Online, October, 2021.

(66) R.C. Maher, "Courage, Responsibilities, and Obligations: Teaching and Learning Ethics in Engineering Education," invited lecture presentation, Allan J. McDonald Symposium, *Engineering Courage: Ethics and Professionalism in a Complicated World*, Bozeman, MT, October 2021.

(65) R.C. Maher, "Understanding acoustics and the principles of sound location via multilateration," live interactive online training course, 6 hours total, Cook County Office of the Public Defender, Chicago, IL, May, 2021.

(64) R.C. Maher, "Sound Science," live interactive online seminar course, 8 hours total, Osher Lifelong Learning Institute (OLLI), Montana State University, Bozeman, MT, February, 2021.

(63) R.C. Maher, E. Brixen, K. McElveen, G. Reid, and J. Smith, "What's that sound? An introduction to the field of audio forensic analysis," invited workshop tutorial presentation, *Audio Engineering Society 149th Convention*, New York, NY, October, 2020.

(62) R.C. Maher, "What's that sound? Audio forensics in 2020," invited lecture presentation, Montana State University "Wonderlust" Special Presentation, Bozeman, MT, June 25, 2020. https://youtu.be/Rux0ZeRbiwg

(61) R.C. Maher, "A half century later, a look back: Apollo 11," invited lecture presentation, moon landing commemorative event, Bozeman Public Library, Bozeman, MT, July 20. 2019. https://www.youtube.com/watch?v=6ZjjxOhPpJk

(60) R.C. Maher, "Examining multiple recordings of the same gunshot incident," invited workshop presentation, *Audio Engineering Society International Conference on Audio Forensics*, Porto, Portugal, June 19, 2019.

(59) R.C. Maher, "Blockchain and Cryptocurrency," invited seminar presentation, *Quest for Knowledge Club*, Bozeman, MT, April 17, 2019.

(58) R.C. Maher, "Renewable energy: What's going on with the electrical grid?" video presentation, *TEDx Bozeman*, Bozeman, MT, April 13, 2019. https://www.youtube.com/watch?v=0oo2CeEkn40

(57) R.C. Maher, "A Half Century Later, A Look Back: America in 1968," Montana State University "Wonderlust" Special Presentation, Belgrade Public Library, Belgrade, MT, March 21, 2019. https://youtu.be/vt3HxMRfhrI

(56) R.C. Maher, "Advanced Forensics of Gunshot Acoustics," invited seminar presentation, *10x10 Innovation Roadshow*, Montana State University, Bozeman, MT, March 14, 2019. https://youtu.be/nPE2F4STwQ0

(55) R.C. Maher, "Gunshot Acoustics," invited webinar presentation, Forensic Technology Center of Excellence, RTI International, February 26, 2019.

(54) R.C. Maher, "Audio Forensics of Gunshot Sounds," invited seminar presentation, *Leadership MSU*, Bozeman, MT, February 21, 2019.

(53) R.C. Maher, "Sounds of Science: Connections Over a Career," invited keynote address, *Phi Kappa Phi Initiation*, Montana State University, Bozeman, MT, January 29, 2019.

(52) R.C. Maher, "My Sonic Journey: A Love Story," *MSU 994-Calling Seminar*, Bozeman, MT, December 3, 2018.

(51) R.C. Maher "Signal Processing of Acoustic Gunshot Recordings," *MSU Applied Mathematics Seminar*, Bozeman, MT, October 25, 2018.

(50) R.C. Maher, "Understanding Soundscape Ecology in Wilderness, Rural, and Urban Settings," *MSU Institute on Ecosystems Rough Cut Seminar*, November 8, 2017.

(49) R.C. Maher, "The Science of Sound: Blending Music, Physics, and Engineering," MSU Honors Program Seminar, February 23, 2017.

(48) R.C. Maher, "Audio Forensics of Gunshot Sounds," invited seminar presentation, *National Institute of Justice Forensic Science Research and Development Symposium*, American Academy of Forensic Sciences 69th Annual Scientific Meeting, New Orleans, LA, February 14, 2017.

(47) R.C. Maher, "Research in Audio Forensic Analysis," MSU Office of Sponsored Programs Roundtable, April 26, 2016.

(46) R.C. Maher, "Principles of Audio System Grounding and Signal Integrity," invited seminar presentation, *Montana Joint Engineers Conference*, Helena, MT, November 6, 2015.

(45) R.C. Maher, "Gunshot Acoustical Interpretation," invited workshop presentation, *Audio Engineering Society 139th Convention*, New York, NY, October 30, 2015.

(44) R.C. Maher, "Found Sound: Recording Studio, National Park, Courtroom," invited seminar presentation, *MSU Physics Colloquium*, Bozeman, MT, September 18, 2015.

(43) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2015 New Faculty Orientation*, Bozeman, MT, August 20, 2015.

(42) R.C. Maher, "Acoustical Fingerprinting," invited seminar presentation, *ES23 Executive Summit 2015*, American Board of Recorded Evidence, Santa Barbara, CA, August 7, 2015.

(41) R.C. Maher, "Forensic Audio Authenticity," invited panel presentation, *ES23 Executive Summit 2015*, American Board of Recorded Evidence, Santa Barbara, CA, August 7, 2015.

(40) R.C. Maher, "Environmental Soundscape Recording," invited workshop presentation, *Third Annual Research and Creative Activity Symposium*, College of Arts and Architecture, Bozeman, MT, January 28, 2015.

(39) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2014 New Faculty Orientation*, Bozeman, MT, August 21, 2014.

(38) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2013 New Faculty Orientation*, Bozeman, MT, August 22, 2013.

(37) R.C. Maher, G. Young, B. Clinton, and J.P. Miller, "The Science of Sound: Decomposing Music," invited seminar presentation and live demonstration, *Montana State University President's Fine Arts Series*, Bozeman, MT, March 4, 2013.

(36) R.C. Maher, "Sounds of silence and sounds of rivers," invited seminar presentations, *Montana Institute on Ecosystems Rough Cut Seminar Series*, Missoula, MT, September 17, 2012, and Bozeman, MT, September 19, 2012.

(35) R.C. Maher, "Introduction to academic advising at Montana State University," invited workshop presentation, *2012 New Faculty Orientation*, Bozeman, MT, August 23, 2012.

(34) R.C. Maher, "Soundscape management: the impact of change on soundscape," invited workshop presentation, *2012 Teacher Workshop, Grant-Kohrs Ranch National Historic Site*, Deer Lodge, MT, June 13, 2012.

(33) R.C. Maher, "The Science of Sound: Acoustics and Audio Engineering," invited seminar presentation, *Aspen Pointe Speakers Series*, Bozeman, MT, September 23, 2010.

(32) R.C. Maher, "Speech Production and Intelligibility," invited seminar presentation, *Gallatin Ham Radio Club*, Bozeman, MT, March 4, 2010.

(31) R.C. Maher, "Forensic Acoustical Interpretation," invited workshop presentation, *Audio Engineering Society 127th Convention*, New York, NY, October, 2009.

(30) R.C. Maher, "Baseline Sound Monitoring at Grant-Kohrs Ranch National Historic Site," invited workshop presentation, *National Cooperative Ecosystem Study Unit (CESU) Coordinators Meeting*, Deer Lodge, MT, May, 2009.

(29) R.C. Maher, "Gunshot Acoustics for Audio Forensics," invited workshop presentation, *Audio Engineering Society 125th Convention*, San Francisco, CA, October, 2008.

(28) R.C. Maher, "Research Trends in Digital Audio," invited seminar presentation, *MSU Physics Colloquium*, Bozeman, MT, January 18, 2008.

(27) R.C. Maher, "Audio Science for Ham Radio Operators," invited seminar presentation, *Gallatin Ham Radio Club*, Bozeman, MT, December 6, 2007.

(26) R.C. Maher, "Science and engineering demonstrations and opportunities," general interest PR presentation, *MSU For a Day*, Belgrade, MT, November 27-28, 2007.

(25) R.C. Maher, "Acoustical gunshot analysis," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, October 24, 2007.

(24) R.C. Maher, "MS or PhD in EE/CS: Should I Go To Graduate School?" invited seminar presentation, *Audio Engineering Society 121st Convention*, San Francisco, CA, October, 2006.

(23) R.C. Maher, "Robots for Space Exploration," invited seminar presentation, Laurel High School seminar, *Montana Space Grant Consortium*, Bozeman, MT, January, 2006.

(22) R.C. Maher, "A Primer on Microphones and Loudspeakers," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, August, 2005.

(21) R.C. Maher, "Robots for Space Exploration," invited seminar presentation, Winifred High School teleconference, *Burns Telecommunications Center*, March, 2005.

(20) R.C. Maher, "Ear Training, Audio Illusions, and Psychoacoustics," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, July, 2004.

(19) R.C. Maher, "Principles of MP3 and Other Perceptual Audio Coders," invited seminar presentation, *Montana Society of Engineers—Bozeman Chapter*, Bozeman, MT, April, 2004.

(18) R.C. Maher, "Engineering: Solving Problems, Designing Solutions," general interest PR presentation, *MSU For a Day*, Butte, MT, March, 2004.

(17) R.C. Maher, "Nuts and Bolts Introduction to Digital Audio Effects," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, January, 2004.

(16) R.C. Maher, "Technical Report on the 115th Audio Engineering Society Convention," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, October, 2003.

(15) R.C. Maher, "Principles of Perceptual Audio Data Compression," invited seminar presentation, *Research Methods in Engineering Graduate Course*, Bozeman, MT, October, 2003.

(14) R.C. Maher, "3-D Audio Using Time Delay, Filtering, and Cross-Talk Cancellation," invited seminar presentation, *Montana Audio and Acoustics Society*, Bozeman, MT, July, 2003.

(13) R.C. Maher, "Perceptual Audio Coding: MP3, AC3, WMA, and AAC," invited seminar presentation, *Gilhousen Telecommunications Colloquium*, Bozeman, MT, April, 2003.

(12) R.C. Maher, "Digital Methods for Noise Removal and Quality Enhancement of Audio Signals," invited seminar presentation, *Creative Advanced Technology Center*, Scotts Valley, CA, April, 2002.

(11) R.C. Maher, "Simulating Spatial Hearing Cues with Digital Signal Processing," invited seminar presentation, *Montana State University*, Bozeman, MT, November, 2001.

(10) R.C. Maher, "Essential features and characteristics of digital audio and digital music synthesis," formal continuing education presentation, *AKM Semiconductor*, Boulder, CO, July, 1998.

(9) R.C. Maher, "Music from Sinewaves: Applications of Frequency Domain Processing," invited seminar presentation, *Colorado Section of the Audio Engineering Society*, Denver, CO, February, 1996.

(8) R.C. Maher, "Audio Data Compression and Gap Extrapolation," invited seminar presentation, *Chicago Section of the Audio Engineering Society*, Chicago, IL, January, 1995.

(7) R.C. Maher, "Fundamental Frequency Estimation for Audio Signals," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, October, 1992.

(6) R.C. Maher, "Granulation Noise in Uniform Quantization Systems for Audio," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, September, 1991.

(5) R.C. Maher, "Signal Processing Aspects of Electronic and Computer Music," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, January, 1991.

(4) R.C. Maher, "Noise Removal and Quality Enhancement in Digital Audio Signal Processing," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, October, 1990.

(3) R.C. Maher, "Some Recent Trends in Digital Audio Signal Processing Research," *Communications and Control Seminar Series*, University of Nebraska-Lincoln, February, 1990.

(2) R.C. Maher, "Digital Audio with a Microcomputer," *Seminars in Music Computation*, University of Illinois-Urbana, October, 1987.

(1) R.C. Maher, "The Digital Phase Vocoder," *Seminars in Music Computation*, University of Illinois-Urbana, April, 1987.

WHITE PAPERS AND RESEARCH MONOGRAPHS

These are formal articles prepared in response to a specific funding solicitation, a required progress report, or a specific query by a research sponsor.

(16) R.C. Maher, "Bobcat 4x4: A Critique of Process and Prospects," white paper, Montana State University, www.montana.edu/rmaher/bobcat_4x4/, 21 pages, February 5, 2018.

(15) R.C. Maher, "Advancing audio forensics of gunshot acoustics," project final report for the National Institute of Justice, Award number 2014-DN-BX-K034, 48 pages, August 2, 2017.

(14) R.C. Maher, "Report from the Barrier/Gateway Courses Group," task force final report for Provost, Montana State University, 9 pages, September 30, 2013.

(13) R.S. Maher, "Final Report: Baseline Sound Monitoring at Grant Kohrs Ranch National Historic Site," project report prepared for Grant Kohrs Ranch NHS, Deer Lodge, MT, 181 pages, September 7, 2012.

(12) R.C. Maher, "Acoustical Detection Research," project final report prepared for General Atomics Corp., San Diego, CA, 24 pages, January 31, 2008.

(11) R.C. Maher and Z. Chen, "Compound Classifier Framework for the AAC Birdstrike Project," progress report prepared for Advanced Acoustic Concepts, Inc., Hauppauge, NY, 7 pages, November 2, 2006.

(10) R.C. Maher, "Summary of Gunshot Acoustics," white paper prepared for Advanced Acoustic Concepts, Inc., Hauppauge, NY, 7 pages, April 4, 2006.

(9) R.C. Maher, "Status Report 3: Obtaining Sound Level Metrics From .wav Files Using Matlab," progress report prepared for Sanchez Industrial Design, Inc., Middleton, WI, 7 pages, May 16, 2005.

(8) Z. Chen and R.C. Maher, "Bird Species Identification Using Spectral Peak Track Matching," progress report prepared for Advanced Acoustic Concepts, Inc., Hauppauge, NY, 11 pages, May 1, 2005.

(7) R.C. Maher, "Status Report 2: Obtaining Sound Level Metrics From .wav Files Using Matlab," progress report prepared for Sanchez Industrial Design, Inc., Middleton, WI, 10 pages, March 9, 2005.

(6) R.C. Maher "Status Report 1: Obtaining Sound Level Metrics From .wav Files Using Matlab," progress report prepared for Sanchez Industrial Design, Inc., Middleton, WI, 9 pages, January 14, 2005.

(5) Z. Chen and R.C. Maher, "Parabolic Dish Microphone Principles and Characteristics," progress report prepared for Advanced Acoustic Concepts, Inc., Hauppauge, NY, 10 pages, August 12, 2005.

(4) Z. Chen and R.C. Maher, "Atmospheric Sound Propagation Considerations for the Birdstrike Project," progress report prepared for Advanced Acoustic Concepts, Inc., Hauppauge, NY, 10 pages, July 28, 2004.

(3) R.C. Maher, "Acoustical Surveillance," white paper prepared for General Atomics Corp., San Diego, CA, 5 pages, February 27, 2004.

(2) R.C. Maher, "Obtaining Long-Term Soundscape Inventories in the U.S. National Park System," white paper prepared for National Park Service Natural Sounds Program Office, Fort Collins, CO, 12 pages, January 30, 2004.

(1) R.C. Maher, "Data-adaptive time-frequency filters for enhancement of noisy speech signals," white paper prepared for Air Force Research Lab, Rome, NY, 9 pages, April 24, 2003.

OTHER PUBLICATIONS

These are formal articles solicited by the editor of a professional publication, or formal scholarly creative products.

(28) R.C. Maher, "The Proof Is Out There," History Channel television show, remarks as audio forensic expert, Season 4: episodes 1, 3, 4, 5, 6, 7, 10, 11, 13, 14, 15, and 16. October 2023- October 2024. Excerpts: https://www.youtube.com/playlist?list=PLl5Pg7McZuiHi1A4JJI7z2oecNlPSdG2t

(27) R.C. Maher, "Sonata Quarta in D Major, from *Sonatae Unarum Fidium*" (1664) by Johann Heinrich Schmelzer, audio recording, Baroque Music Montana, broadcast nationally on *APM Performance Today*, September 18, 2023, December 28, 2023, and March 28, 2024.

(26) R.C. Maher, "Concerto for Oboe in D minor, Op. 9 No 2: Movement 2" by Tomaso Albinoni, audio recording, Baroque Music Montana, broadcast nationally on *APM Performance Today*, July 15, 2022, and October 18, 2022.

(25) R.C. Maher, "Drive the Cold Winter Away and Three Pieces" by Anthony Holborne, audio recording, Baroque Music Montana, broadcast nationally on *APM Performance Today*, January 21, 2022, and April 19, 2022.

(24) R.C. Maher, "Money Machine," audio forensics expert remarks, film documentary by Ramsey Denison, October, 2020. Excerpt: https://youtu.be/HQ8qasTEoSc

(23) R.C. Maher, "Bridger Foothills Fire Perimeter, North Side," wildfire boundary depiction film with Google Earth, September, 2020. https://youtu.be/LvwbxnqaIbQ

(22) R.C. Maher, "Bridger Foothills Fire Perimeter," wildfire boundary depiction film with Google Earth, September, 2020. https://youtu.be/1BliOLxYBds

(21) R.C. Maher, "Capriccio sopra dodici note Op. 22, No. 15" by Maurizio Cazzati, audio recording, I-90 Collective presented by Baroque Music Montana, broadcast nationally on *APM Performance Today*, February 6, 2020, and May 13, 2020.

(20) Gregory Young and R.C. Maher, "The Hydrologic Cycle: A Yellowstone Soundscape," musical composition for clarinet and pre-recorded sounds, Faculty Recital, Bozeman, MT, November 21, 2019.

(19) R.C. Maher, "AES International Conference Report: Audio Forensics—Trust Powered by Science," conference review article (uncredited), J. Audio Eng. Soc., vol. 67, no. 9, pp. 840-849, 2019.

(18) R.C. Maher, "AES International Conference Report: Audio Forensics—Finding Signal in the Noise," conference review article (uncredited), J. Audio Eng. Soc., vol. 65, no. 9, pp. 762-769, 2017.

(17) Gregory Young and R.C. Maher, "Clarinet for the Birds," musical composition for clarinet and pre-recorded sounds, Montana/Idaho Clarinet Festival, Moscow, ID, September 9, 2016.

(16) R.C. Maher, "AES 54th International Conference: Audio Forensics—Techniques, Technologies, and Practice," conference review article (uncredited), J. Audio Eng. Soc., vol. 62, no. 9, pp. 622-630, 2014.

(15) R.C. Maher, "AES 46th International Conference: Audio Forensics—Recording, Recovery, Analysis, and Interpretation," conference review article (uncredited), J. Audio Eng. Soc., vol. 60, no. 9, pp. 718-728, 2012.

(14) R.C. Maher, "AES 39th International Conference: Audio Forensics—Practices and Challenges," conference review article (uncredited), J. Audio Eng. Soc., vol. 58, no. 10, pp. 842-852, 2010.

(13) R.C. Maher, "AES 33rd International Conference: Audio Forensics—Theory and Practice," conference review article (uncredited), J. Audio Eng. Soc., vol. 56, no. 9, pp. 728-739, 2008.

(12) R.C. Maher, "PC audio subsystems: evolution and design," Electronic Engineering Times, Issue 1540, pp. 36-40, September, 2008.

(11) R.C. Maher, "Musimathics," published book review, J. Audio Eng. Soc., vol. 55, no. 11, pp. 1038-1040, 2007.

(10) R.C. Maher, "Boston Marathon Diary," in *Big Sky Wind Drinkers Running Club Newsletter*, June, 2007.

(9) R.C. Maher, "Sound System Engineering, Third Edition," published book review, J. Audio Eng. Soc., vol. 55, no. 1/2, pp. 90-91, 2007.

(8) R.C. Maher, "Thoughts on Personal Fitness," in *Big Sky Wind Drinkers Running Club Newsletter*, December, 2005.

(7) R.C. Maher, "AES 26th International Conference: Audio Forensics in the Digital Age," conference review article (uncredited), J. Audio Eng. Soc., vol. 53, no. 9, pp. 838-848, 2005.

(6) R.C. Maher, "Running by the Numbers," in *Big Sky Wind Drinkers Running Club Newsletter*, May, 2005.

(5) R.C. Maher, "Acoustic Echo and Noise Control: A Practical Approach," published book review, J. Audio Eng. Soc., vol. 53, no. 5, pp. 457-458, 2005.

(4) R.C. Maher, "Digital Sound Synthesis by Physical Modeling Using the Functional Transformation Method," published book review, J. Audio Eng. Soc., vol. 52, no. 9, p. 980, 2004.

(3) R.C. Maher, "Concurrent audio using a DSP real-time kernel," Multimedia Systems Design, vol. 2, no. 9, pp.18-23, September, 1998.

(2) R.C. Maher, "Music Processing," published book review, J. Audio Eng. Soc., vol. 43, no. 1/2, pp. 84-85, 1995.

(1) R.C. Maher, "A meditation on a theme by Dr. Martin Luther King, Jr.," in "New Electronic Works from the University of Illinois," LP record album, track 1, May, 1989.

2

For the remainder of this report, I will express the time scale of each event in terms of *file elapsed time* (or FET[1]), so that the audio signal features can be clearly identified in the data stream. The timing of events in the recordings differs slightly in terms of FET, i.e., the different recordings are not synchronized.

Preliminary Interpretation

For my preliminary observations I concentrated upon the portion of the recordings corresponding to the audible gunshots. For the 911 Call Center recording, the time range of interest was 3:07.0 FET to 3:38.0 FET. For the Mobile Phone recording, the time range of interest was 3:29.0 FET to 4:00.0 FET.

For the 911 Call Center recording, the utterances of the caller, passenger, and the 911 dispatcher are generally intelligible. However, gunshot sounds are not clearly discernable in the call center recording. This is typical of mobile phone telephone calls recorded at the far end of the conversation, since the speech coding algorithm of the mobile phone detects and transmits only speech sounds for the telephone channel. Loud, impulsive sounds such as gunfire are not interpreted as speech sounds by the telephony coding algorithm, and so gunshot sounds are not conveyed effectively through the mobile telephone.

For the Mobile Phone recording, the audio was recorded directly at the phone and not sent through the speech telephony coding algorithm and telephone channel. Thus, the sound of gunfire in the vicinity of the mobile recording device is clearly audible. My preliminary observation of the recording from critical listening and waveform analysis indicated 29 clearly discernable gunshot sounds, as depicted in Figure 1.

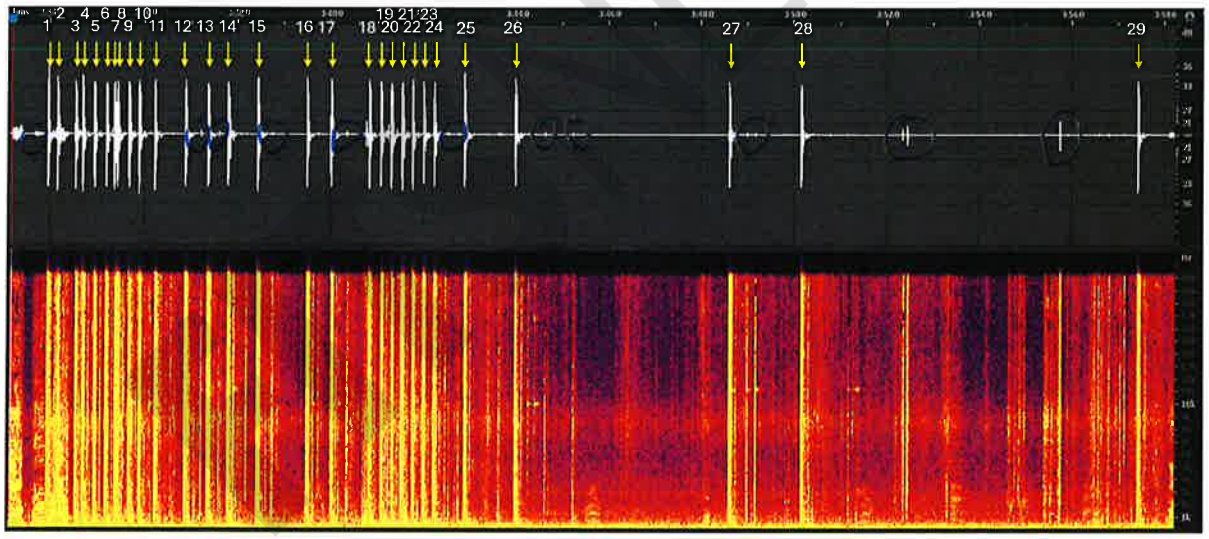

Figure 1: Waveform and spectrogram of gunshot sounds in Mobile Phone recording (3:33 – 3:58 FET).

[1] *File Elapsed Time*, abbreviated *FET*, refers to the time elapsed between the beginning of the file and the point of interest in the file. The FET is calculated using the audio sample data position in the file, the number of bytes per sample, and the sampling rate (samples per second). The time between different events in the file can be determined by subtracting the FET of the earlier event from the FET of the later event. Converting FET to time-of-day requires knowledge of the precise time-of-day corresponding to the beginning of the file.