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Counter investigating the testimony of Andres Temme in relation to the Murder of Halit Yozgat in Kassel, 6 April 2006

Report

18 July 2017

Forensic Architecture

Goldsmiths University of London
8 Lewisham Way
London SE14 6NW
United Kingdom

T+44 (0) 20 7078 5387
F+44 (0) 20 7717 2284

www.forensic-architecture.org

Table of Contents

Forensic Architecture

Forensic Architecture (FA) is a research agency, based at Goldsmiths, University of London. The team includes architects, investigative journalists, cartographers, remote sensing specialists, lawyers, filmmakers, and expert scientists.

Forensic Architecture undertakes advanced architectural and media research on behalf of international prosecutors, human rights organisations, as well as political and environmental justice groups.

We have provided spatial research and evidence for numerous human rights investigations and prosecutions under international law, including at the UN General Assembly in New York in October 2013 and the Human Rights Council in Geneva in 2014 (on drone warfare via the UNSRCT[1]).

We presented evidence in the Israeli High Court for the (Palestinian) village of *Battir vs. the Ministry of Defence* through Michael Sfrad, who won this case on 4 January 2015.

Our report on the *Use of White Phosphorous in Urban Environments* was presented at the UN Human Rights Council Geneva in November 2012 and in March 2011 at the Israeli High Court (for Yesh Gvul via Michael Sfrad).

The Forensic Oceanography team (Charles Heller and Lorenzo Pezzani) from Forensic Architecture presented the case of the *Left to Die Boat* before the French Tribunal de Grand Instance in April 2012, the Brussels Tribunal de première instance in November 2013, and in the courts of Spain and Italy on June 2013.

The *Gaza Platform* and our *Rafah: Black Friday* report about the 2014 Gaza War, developed together with Amnesty International, was submitted to the UN Independent Commission of Inquiry on March 2015 and to the ICC[2] in March and September 2015.

For more information visit: www.forensic-architecture.org

[1] United Nations Special Rapporteur for Counter Terrorism
[2] International Criminal Court

Introduction

Shortly after 17:00 on the 6th of April 2006, Halit Yozgat, 21 years old, was murdered while attending the reception counter of his family-run Internet café in Kassel, Germany. His was the ninth of ten racially-motivated murders performed across Germany by a neo-Nazi group known as the National Socialist Underground or NSU between 2000 and 2007.

At the time of the killing, an intelligence agent from the *State Office for Constitutional Protection* (Landesamt für Verfassungsschutz) of the German state of Hessen named Andreas Temme was present in the shop. He did not disclose this fact to the police, but was later identified from his internet records. Temme was a frequent customer at the internet café, where he would usually spend one to two hours online. On this day, he only used the computer for 15 minutes.

In his interrogation by the police and in the subsequent NSU trial in Munich, Temme denied being a witness to the incident and claimed he did not notice anything out of the ordinary. The court accepted his testimony and determined that Temme was present at the back room of the internet café at the time of the murder. It also accepted that, based on his position in the café, it was possible to have not witnessed the killing.

Within the 77 square meters of the Internet café and the 9 minute and 26 second duration of the incident, various actors — including members of migrant communities, a state employee, and the murderers — crossed paths and were architecturally disposed in relation to each other. The shop was thus a microcosm of the entire social and political controversy that makes up the “NSU Complex”.

In November 2016, eleven years after the murder, the People’s Tribunal “Unravelling the NSU Complex” commissioned Forensic Architecture to investigate Temme’s testimony and determine whether it could be truthful.

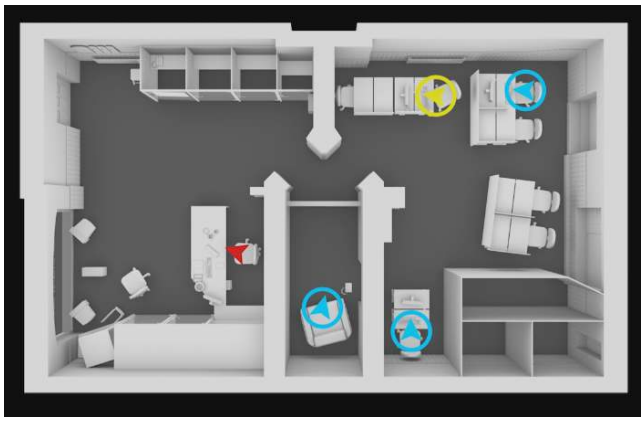

Fig. 1 - left: front/phone room; right: back/computer room;
red arrow: Halit Yozgat; blue arrows: witnesses; yellow arrow: Andreas Temme

Investigative Framework

This investigation thus engages with several questions:

1. *At what time did the murder take place?*

2. *Where are the possible locations that Temme could have been in at the time of the shooting?*

    2a. In the back room of the internet café?
    2b. In the front room of the internet café?
    2c. Outside/away from the internet café?

3. *What are the possible degrees of Temme's involvement in the killing given his presence in each of these locations?*

    3a. Is he committing perjury or could he be telling the truth?
    3b. Might he be involved in the killing?
    3c. Could he be innocent of perjury/involvement in the killing?

4. *Could Temme have witnessed[3] the murder?*

    4a. Could Temme have heard the gunshots if he was in the back room at the time of the killing?
    4b. Could he have seen the body when he left the shop through the front room?
    4c. Could he have smelled the residue of gun powder lingering in the front room?

If Temme's testimony was false or it could be suggested that he colluded with the killers, larger questions regarding the handling of the case should be raised.

The investigation thus set out to examine not only the act of killing itself, but also the subsequent investigation and possible cover-up as potential violations of people's rights.

[3] Where 'witnessing' refers to a **sensory contact** with the incident or things related to it

Premise

As a human rights organisation, Forensic Architecture's work does not aim to provide legal evidence to the police or the courts, nor does it aim to establish who killed Halit Yozgat. It rather seeks to reveal potential problems in these state processes and to call for an open and impartial investigation of all aspects of this case, including the involvement and interrogation of the police and secret services.

Our investigation was entirely based on material in the public domain.

In 2015, many of the police records documenting this investigation were leaked by a website known as "NSU Leaks"[4] (fig. 2). The leak made public police reports, witness testimonies, computer and phone logs and crime scene photographs.

Amongst these files was a crucial piece of evidence: a police video showing Andreas Temme re-enacting his visit to the internet café, which sought to demonstrate that Temme had not been aware of the killing.

The investigation also benefited from written and oral testimonies leaked or published in the media as well as from Temme's and other witnesses' testimonies in the court in Munich, as transcribed by "NSU Watch"[5].

We also had conversations in early 2017 with Ismail Yozgat, Halit's father, who was also the first one to discover his son dead.

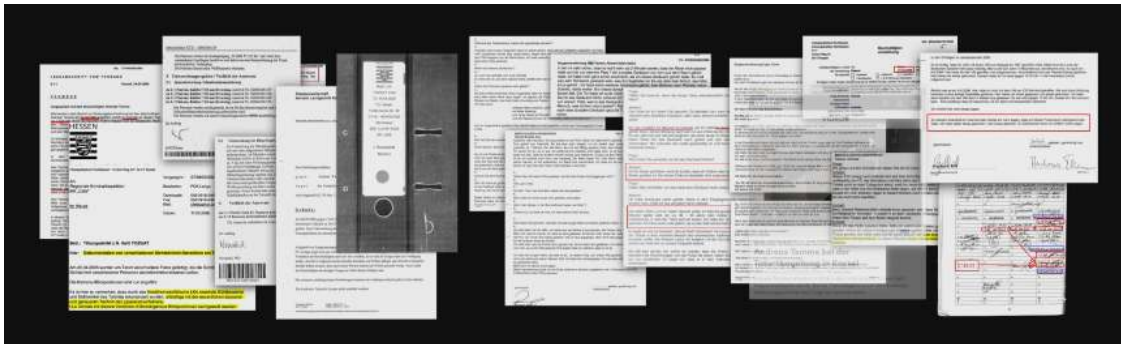

Fig. 2 – Leaked documents (NSU Leaks, 2015)

[4] NSU Leaks : https://sicherungsblog.wordpress.com/ accessed 28.06.2017
[5] NSU Watch: https://www.nsu-watch.info/ accessed 28.06.2017

Methodology

Model making

We constructed a virtual model of the internet café from leaked photographs of the crime scene, as well as open-source photographs taken at ground, aerial, and satellite levels.

We have modelled not only the size and shape of the shop, but also the material components that account for differing acoustic values given to various surfaces.

We then reduced the model into its most relevant elements, producing a digital model of the surfaces, partitions, furniture, and objects that would affect visual, acoustic, and olfactory modelling.

In addition to the virtual reconstruction, we built this partial model as a full scale mock-up at the House of World Cultures (HKW) in Berlin between 6-11 March 2017. The materials used in the construction of this model were specified by acoustic experts in order to ensure that, when tested, they would perform similarly to the original building materials of the café in Kassel.

Each experiment we subsequently undertook was conducted in both analogue and digital formats.

The final results of our report were achieved through the synthesis of physical and digital data in three separate and distinct ways:

- The results from the physical and digital models corroborated each other;
- The digital simulation was calibrated with measurements obtained within the physical model; and
- Some results were obtained from a combination of the two models.

Fig. 3 - Digital model matched to an onsite photograph from the evening of the murder

Timelines

That the murder happened in an internet café meant that all witnesses present at the time of the killing were connected to a time coded device, either a computer or a phone.

The leaked police investigation files included the phone and computer logins.

We worked from these files in order to locate each device both spatially in the model as well as temporally within a timeline we constructed. This formed the space-time matrix within which different possible events could take place.

The entire incident unfolded over 25 minutes. We charted these 25 minutes on a graph (fig. 4), plotting the start and end of each computer session or phone conversation in order to develop 'timecodes' for each activity.

Phone logs obtained by the police record the start time of each call within a minute and the end time of the call within a second.

Computer logs recorded by the police contain the start and end times of every session within one second.

This timeline allowed us to account for, and sometimes to correct, common problems with witness testimonies.

Witness testimony, especially when a traumatising event has taken place, is usually more precise in describing the order and sequence of events than it is in describing their duration. Consequently, events of this nature often seem to take longer or shorter than they did in real time.

Witnesses also tend to connect their memory of an event to what they were doing at the time. Therefore, although the precise timing of an event is not easy to define, witnesses can accurately report where they were, what they saw, and what they were doing (e.g. who they were calling) when they heard the sounds of the gunshots. Since all activities were registered on the computer and phone logs, we were able to anchor witness reports to the timecode of each activity.

This process enabled us to:

1. Position memory-based descriptions of events within clear time frames bracketed by the start or end of a call or computer login;
2. Corroborate and cross-reference the testimonies of different witnesses with each other; and
3. Plot several possible scenarios involving key characters, spaces, and objects across multiple timelines.

Using this data framework, we re-enacted different scenarios within the digital and physical models in order to determine their feasibility and plausibility.

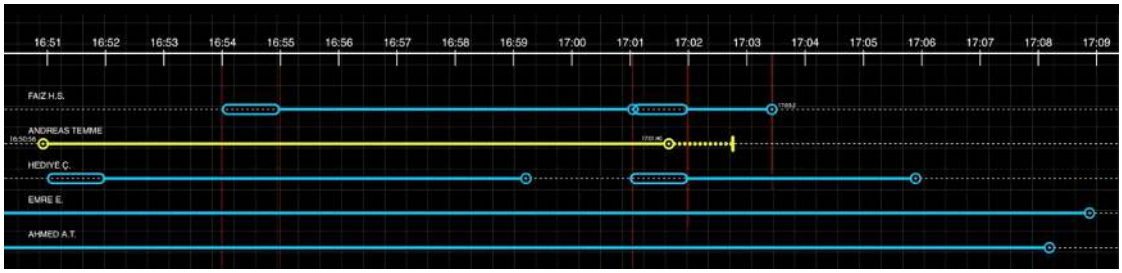

Fig. 4 – The computer logins and logouts of the witnesses inside the internet café

Expertise

In order to undertake some of the scientific experiments involved in this investigation, we collaborated with a number of external contractors, including:

1. **Anderson Acoustics**, a consultancy specialising in building, environmental and aviation acoustics. They advised us on the construction of the real scale model of the crime scene and undertook the measurements and digital simulations that determined the attenuation of sound through space.

2. **Armament Research Services (ARES)**, a highly specialised firearms consultancy. They undertook the weapons testing that captured the sound signature produced by the murder weapon.

3. **Dr. Salvator Navarro-Martinez**, Senior Lecturer at Imperial College, designed the algorithm that traced and visualised the movement of chemical particles in space. He undertook calculations and simulations that tracked the volume and latency of the smell cloud produced by the firing of the two gunshots.

Scenarios

Prelude

Examination of the computer logins revealed the following setup:

At approximately 16:30 on 6 April 2006, Halit Yozgat was sitting alone by the counter of the internet café.

The first to come into the internet café was 16-year-old Ahmed A.T., who saw Halit at the counter, paid him for half an hour internet access, and went to the back room where the computers are located. He sat at PC-7.

At 16:46:03", Ahmed A.T. logged in and started to play *Call of Duty*, a popular WWII-themed video game where players shoot Nazis.

The second to enter the shop was 14-year-old Emre E. He also paid Halit and went to the back room where he sat at PC-3.

At 16:48:58" Emre E. logged in. He had also come to the café to play *Call of Duty*.

The third person to walk in was Hediye C. and her three-year-old daughter. She sat in the telephone booth between the two rooms. She would make two calls that afternoon.

The last person to go to the back room and log into a computer was secret service agent Andreas Temme.

He said that he parked his car directly in front of the internet cafe, entered, saw Halit at the counter, and went directly to the back room. He sat at PC-2.

At 16:50:56" he logged in to the dating site i-LOVE[6].

His username, "wildman70", was what later revealed his presence in the internet cafe.

The last person to enter the shop was Faiz H.S. He was the last person to speak to Halit and was also the only person to have been in the room when the killing took place.

Faiz H.S. made two phone calls that afternoon. His first call started at 16:54, and his second finished at 17:03:26"

[6] iLove: https://www.ilove.de/ accessed 28.06.2017

When Faiz entered his phone booth Halit was alive, but when he exited **9:26 minutes** later Halit had been fatally shot.

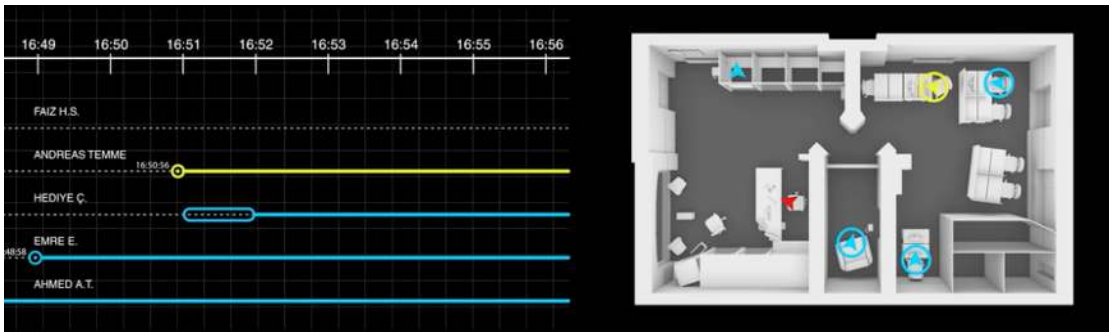

Fig. 5 – Computer and phone logins plotted in time and space

Shots

All witnesses present at the shop heard the gunshots, except for Temme who was the only one to have told the police that he did not notice anything unusual.

So where was Temme when the shots were fired?

His position in space can suggest the level of his involvement.

There are three possible scenarios to describe where Temme could have been at the moment of the killing:

Scenario 1: Temme left the shop;

Scenario 2: Temme was in the front part of the shop; or

Scenario 3: Temme was in the back room.

Scenario 1

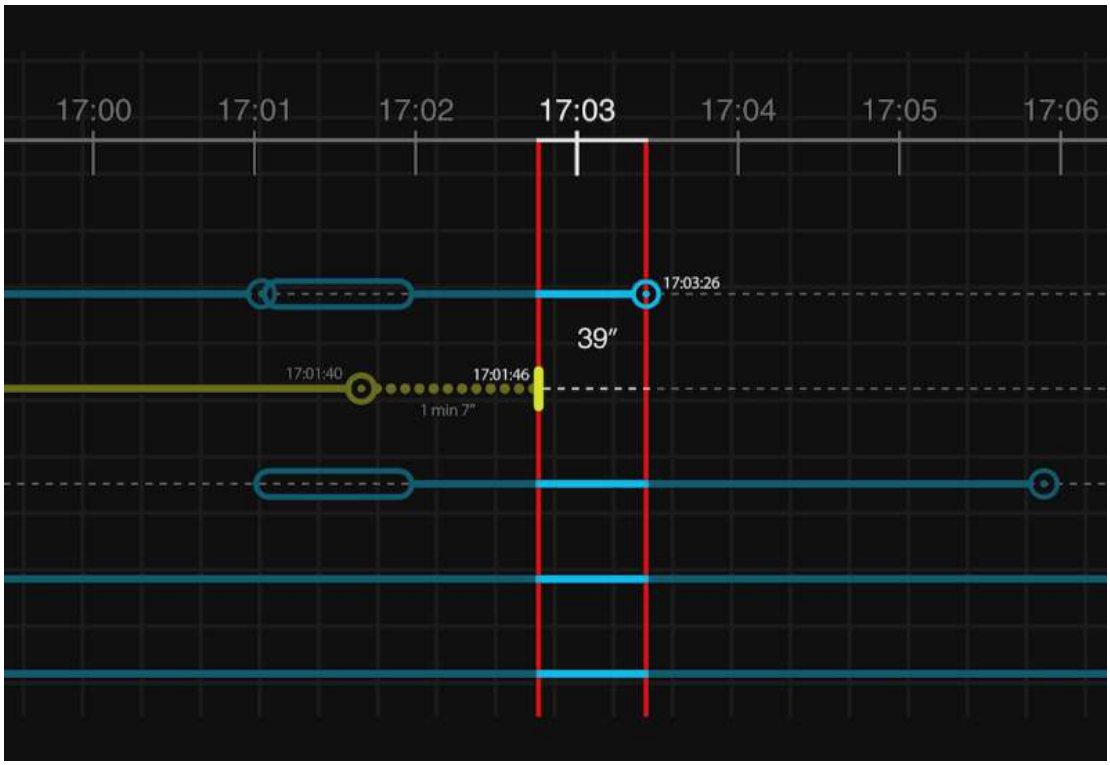

Fig. 6 - Scenario 1

Could the murder have happened after Temme had already left the internet café?

This scenario, referred to as the “41 seconds scenario”, was suggested by some in the German media[7] and the political sphere in Germany. According to this scenario, there were 41 seconds between the time Temme entered his car and drove off and the time Faiz H.S. exited his phone booth at the front of the shop.

We know that by the time Faiz H.S. exited his phone booth Halit Yozgat was already shot, as only a few minutes later Halit was discovered dead by his father, Ismail Yozgat.

In order to examine this scenario, we looked at the available time logs and found that (a) Temme logged out of PC2 at 17:01:40” and (b) according to his re-enactment, he took 1 minute and 7 seconds to look for Halit Yozgat, leave a coin of 50 cents on the counter, and exit the shop.

[7] http://www.sueddeutsche.de/politik/nsu-mord-die-pulverwolke-1.3452037?reduced=true accessed 28.06.2017

This leaves **39 seconds** (not 41) from the time Temme entered into his car (the last possible time that he would have a visual encounter with the shop) to the time Faiz H.S finished his call and exited his phone booth at 17:03:26".

In order to test this scenario, we undertook a number of re-enactments to check whether 39 seconds was long enough for this series of actions to take place in such a way that the different characters performing them could miss each other visually or physically.

These were four separate actions in this sequence:

1. Temme enters his car and drives off;
2. Halit Yozgat returns to the shop and sits at the counter;
3. The killer comes in, shoots twice, turns around and leaves; and
4. Faiz H.S. finishes his phone call and exits his booth.

Adding up these separate actions in a highly coordinated, controlled and directed experiment in which each action immediately follows the other amounts to **35 seconds**.

However, in a real-life situation there would need to be gaps between these actions for characters to miss each other. There would be only four seconds in total to spread between these actions for them to be performed without physical or visual encounter.

This fact makes Scenario 1 **very unlikely**.

Further reducing the possibility of Scenario 1 is the fact that Halit would have to be out of the shop when Temme was looking for him and back at his counter just before the murderer came in to shoot him. However, with five customers in the shop, it is unlikely that he would leave the internet café.

Furthermore, none of the witnesses in the shop reported seeing Halit leave and no other witnesses reported seeing him outside.

Taken in combination with the previous finding, this fact further diminishes the probability of Scenario 1, rendering it **extremely unlikely**.

However, the evidence that **forecloses** Scenario 1 altogether is the call logs of the other witnesses.

Hediye C. testified that she heard the sound of the gunshots after she started her second phone call, which began, according to the logs, between 17:01-17:02:

> *"The connection came immediately then. [...] I suddenly heard three sounds. Three times it went "tac, tac, tac", quickly, one after another. As if somebody was knocking against the wall of the room."*[8]

Faiz H.S. testified that he heard the shots towards the end of his first call:

> *"Approximately sometime during the first call, I heard something like a balloon exploding. I turned around, but I couldn't see, because of the picture on the glass door. I was busy entering the PIN from the MAXI card. I tried to look through the slot on the side [...]"* [9]

The act of inputting a PIN number for a phone call has a duration of approximately 18 seconds. This testimony therefore anchors the time of the gunshots to within a very specific time frame. Faiz H.S. heard the gunshots after his first call ended at 17:01:02" and before his second call went through, no later than 17:02.

Faiz H. S. was the only one to have seen the killer:

> *"For a short moment I noticed something, somebody going in or out [...]. I think the person went out [...] His face I couldn't see, he was looking towards the table. He was in a hurry."*[10]

These testimonies reduce the possible time of the murder to between 17:01:00 (the earliest moment Hediye C. could have started her second call) and 17:02:00 (the latest Faiz H.S. could have started his second call).

This evidence thus **completely discounts** Scenario 1, in which Temme had left the internet cafe by the time of the murder.

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[8] Police Questioning of Hediye Ç. on 7.4.2006, leaked on 11.6.2015, https://sicherungsblog.wordpress.com/2015/06/11/mord-kassel-eine-zeitleiste-mal-anders-teil-2/, accessed 25.5.2017

[9] Police Questioning of Faiz H. S. on April 2006, leaked: 11.6.2015, https://sicherungsblog.wordpress.com/2017/04/12/schlampige-ermittlungen-sind-die-regel-nicht-die-ausnahme/, accessed 25.5.2017

[10] Police Questioning of Faiz H. S. on April 2006, leaked: 11.6.2015, https://sicherungsblog.wordpress.com/2017/04/12/schlampige-ermittlungen-sind-die-regel-nicht-die-ausnahme/, accessed 25.5.2017

Fig. 7 - The position of Temme’s car according to his testimony

Scenario 2

Could Andreas Temme have been at the front of the shop at the time of the murder?

As mentioned above, Temme logged out at 17:01:40 and took 1 minute and 7 seconds to exit the internet café.

According to the testimony of Faiz H.S. and Hediye C., it is **possible** that the killing took place within the 20 seconds after Andreas Temme logged out.

This possibility is supported by the testimony of Ahmed A.T., who could see Temme from his seat.

Ahmed A.T. claims to have seen Temme coming in with a plastic bag:

> *"It was not fully packed, but something was in there, I believe it was rather heavy, pulling it down."*

The object in the bag may have been the gun.

Ahmed A.T. also claims to have heard the sounds of the shots after Andreas Temme left PC-2:

> *"I had been on the Internet for about 15 minutes when I suddenly heard a muffled sound. In my opinion it came from the direction of the entrance area. It was very loud and sounded as if something had fallen to the ground."*[11]

Ahmed A.T. later said:

> *"I am very sure that [the sound] was not more than 2 minutes after the man had passed me [...].*[12]

Twenty seconds after logging out, according to the timing of Temme's re-enactment, he would have still been at the front part of the shop. If the murder took place at that moment, he would have coincided with the killers.

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[11] Police Questioning of A. A.T. on 6.4.2006, leaked on 12.06.2015, https://sicherungsblog.wordpress.com/2015/06/12/mord-kassel-eine-zeitleiste-mal-anders-teil-3-die-kunden-vor-dem-mord/, accessed 25.5.2017

[12] Police Questioning of A. A.T. on 24.4.2006, leaked on 12.06.2015, https://sicherungsblog.wordpress.com/2015/06/12/mord-kassel-eine-zeitleiste-mal-anders-teil-3-die-kunden-vor-dem-mord/, accessed 25.5.2017

We have superimposed Temme's movements according to his own re-enactment onto the movements of the killer according to the timeline suggested by Scenario 2 and found that, in this sequence of events, Temme would have been in the same room at the same time as the killer at the moment the murder took place.

In this scenario, which the evidence does not exclude, Temme would either have been involved in the killing or colluded with the killer.

Scenario 3

Could the killing have taken place while Andreas Temme was still sitting logged in to PC-2?

This scenario agrees with the witness testimonies of Hediye C. and Faiz H.S. and is endorsed by the court in Munich.

However, Temme claims that he did not hear the shots, that he did not smell the distinct smell of gunpowder, and that he did not see Halit's body behind the counter when he left.

To test these claims, we undertook **three sensory tests** to determine whether the sound, smell, and sight of the murder could have been below the threshold of detectability.

Sound

The court at the NSU Trial in Munich accepted that Temme had been connected to PC-2 at the back room of the shop while the killing took place in the front room. Temme claimed that he did not hear the two gunshots that killed Halit.

To test whether Temme could have heard the gunshot from his position at PC-2, we first contracted weapon experts Armament Research Services (ARES), who went to Phoenix, Arizona in order to fire and record the sound of a Česká 83, the gun used in the murder, while using the same ammunition, 7.65mm Browning, and a sound suppressor.

ARES sourced a Česká CZ 83 pistol and recorded five shots. They have verified that its sound signature and audio level were similar to three other handguns of similar calibre. They tested a Beretta .32 pistol, a Bulgarian PM pistol and a Colt .32 pistol next to the CZ 83.

The weapons all generated equivalent A-weighted peak sound signatures, ranging from 157 to 158.5 dB(A)[13].

Out of those guns of the same calibre, the Colt 32 was threaded with both dry and wet sound suppressors to simulate the suppressor used in the crime scene (fig. 8).

Fig. 8 – Colt 32 with wet suppressor, ARES

[13] See ARES report, Appendix A

None of these shots were suppressed below 130dB(A). This figure agrees with a test undertaken in 2012 by the Federal Criminal police and reported by

de Welt[14]. The lawyers of the Yozgat family had asked the Federal Police for a demonstration of the sound level of a gunshot using a similar gun with a silencer; the sound was measured at 137.5 dB.

In order to test how the sound propagated throughout the space, we placed a high-decibel active loudspeaker at the position of the killer in our real scale installation in Berlin (fig. 9).

Together with acoustic experts from Anderson Acoustics, we played the recorded gunshots in the physical model and measured the sound levels.

Fig. 9 – Sound measurement, Anderson Acoustics in HKW, Berlin

[14] https://www.welt.de/politik/deutschland/article158248218/Hat-Temme-den-Schuss-in-Kassel-nicht-gehoert.html accessed 28.06.2017

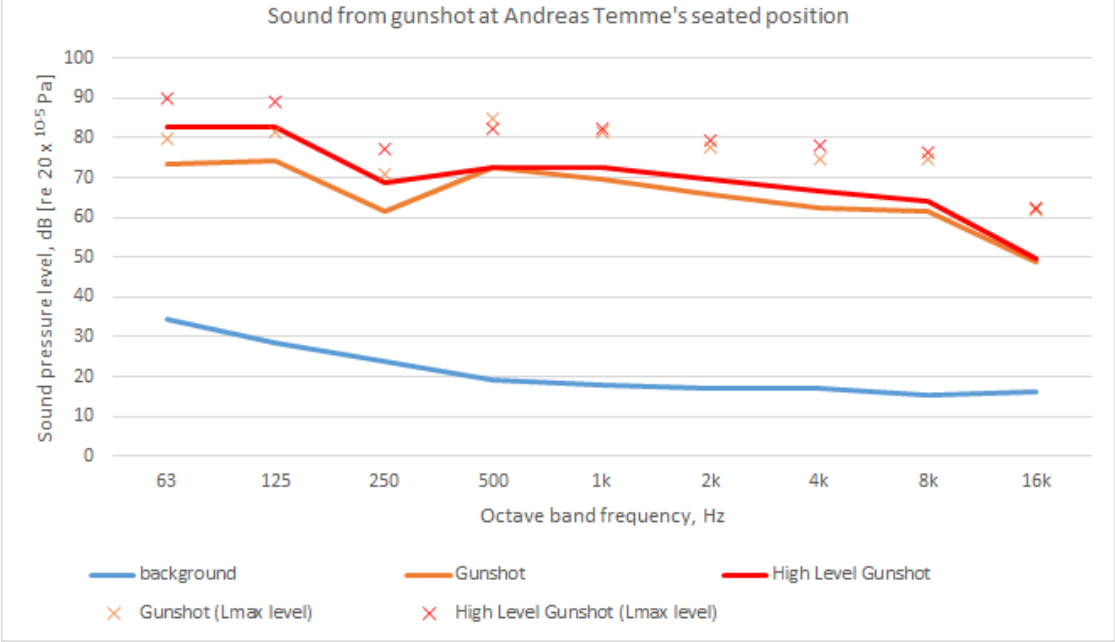


Fig. 10 – The sound levels measured at Temme's position by PC-2 (red and orange) when recreating the sound signature of a supressed gunshot of a Colt.32 at only 100dB, some 30dB lower than the expected sound level of the gunshot. The graph shows these results in relation to the measured background level of noise in the space (blue). The gunshot sound playback was observed to be clearly audible at Andreas Temme's position in the full scale mock-up of the shop.

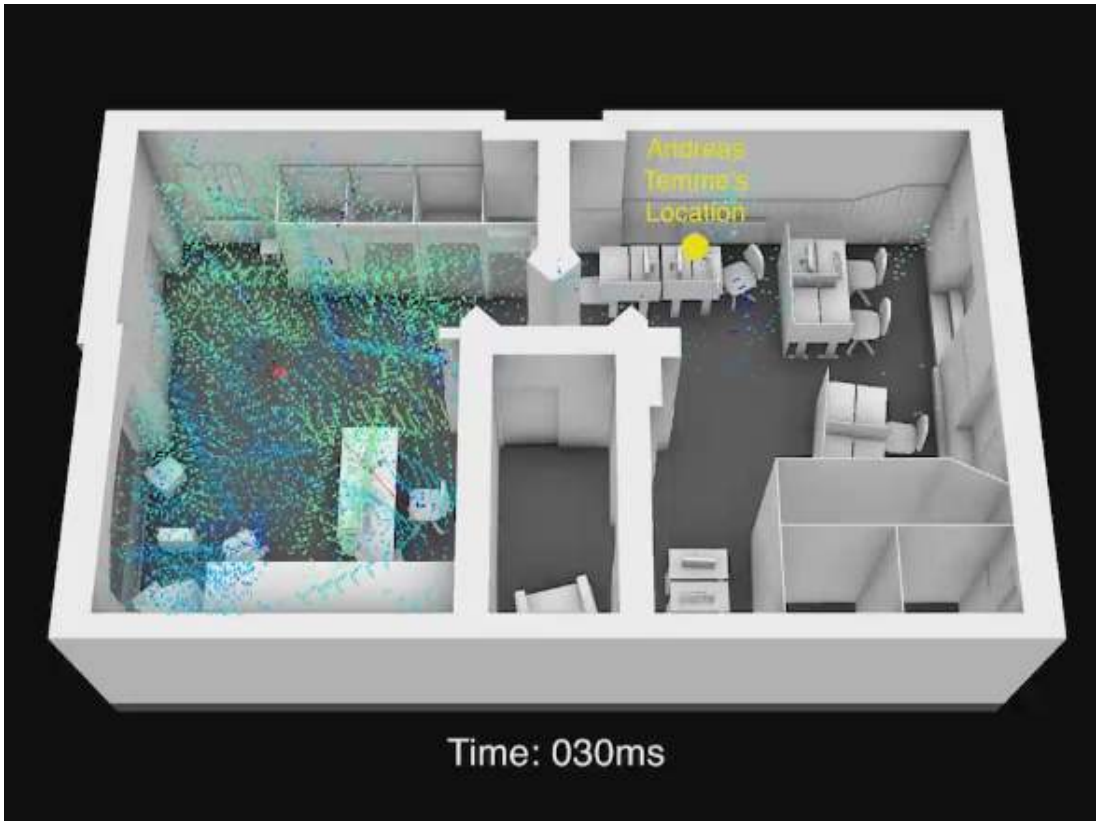


Fig. 11 – Sound simulation, Anderson Acoustics

In order to confirm that any additional sound paths present in the physical model would not significantly affect measured results and to corroborate our findings, we created computer simulations, using ray tracing digital techniques. (fig. 11).

We created two digital models. The first simulated the propagation of sound within a digital model of the internet café that was designed to mimic the exact dimensions and materials of the actual space.

In the second model, we recreated the physical setup of our real scale installation in Berlin and digitally reproduced the experiments we undertook there.

The comparison of the two models allowed us to corroborate our findings across techniques and provided a conversion rate between the physical and digital models.

Results

The data from both the physical and digital tests confirmed that the sound level at Temme's position at PC-2 was between 94 to 99 dB at maximum level[15].

This is 40 to 45 dB above the maximum ambient sound level that can be expected in such a space[16].

For one-eighth of a second the volume of the shot would be as loud as a jackhammer[17] and would have been clearly audible by Andreas Temme (fig. 12).

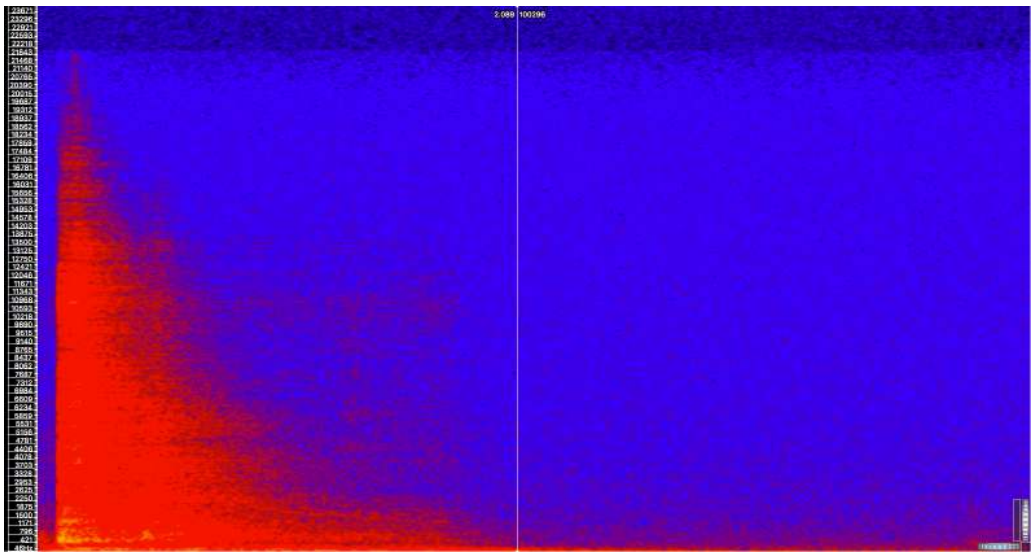


Fig. 12 – Spectrogram of gunshot recorded from from PC-2 in the real scale installation, Anderson Acoustics

[15] Audibility has been assessed using the $L_{Amax,F}$, metric that describes the A-weighted maximum sound pressure level measured in a 125-millisecond time period with the sound level meter set to 'fast' response. $L_{Amax,F}$ is typically used to assess the audibility of short-term, transient sound sources. Other metrics were also used across our experiments and were converted according to common practice. For more information see the report by Anderson Acoustics, Appendix B.

[16] The ambient sound levels in the internet cafe at the time of the event are not known. Reference has been made to the British Standard 8233:2014, which provides guidance on ambient noise level criteria.

[17] According to the BS 5228, a pneumatic drill breaking concrete or hard ground would produce a sound pressure level of 100 dB(A) on average at 3m.

Smell

Could Temme smell the residual gun powder from the shots as he exited the internet café?

A gun shot in an interior space leaves a sharp smell of burnt gunpowder. When questioned by the German Federal Police in 2012, Temme confirmed he was used to handling guns. Therefore, he could identify the distinct smell of gunpowder. Temme, however, claimed that he sensed no such smell when leaving.

According to witness testimonies, the gunshots were fired between 17:01 and 17:02. Therefore, it would be no longer than 40 seconds after the shots were fired when Andreas Temme logged out of PC-2 and walked into the front room, passing through a cloud of residual smell from spent gunpowder.

In order to determine whether or not Temme would have been able to perceive the smell of gunpowder, we simulated the dispersion of the gases produced by the fired CZ.83 gunshots within both the physical and digital models. Whether Temme would have been able to smell the residual gunpowder was determined by calculating the concentration of odorous chemical particles within this cloud. These particles originate from the gases discharged from the firearm and are the origin of the “gunpowder smell”

In the physical model, we used smoke dispersers to reproduce the volume of gases expected from such gunshots, following calculations by fluid dynamics specialist Dr. Salvador Navarro-Martinez.

In order to simulate the amount of gases produced by the shooting of a 7.65mm Browning bullet through a CZ.83 handgun using a silencer, we approximated the original composition of the gunpowder. According to the manufacturing company Sellier & Bellot, each 7.65 Browning bullet (32 Auto) contains 73 grains of gunpowder, which amounts to 4.73g[18]. Since the manufacturer will not disclose the original composition of the gunpowder[19], we calculated the volume of gases produced using several mixtures of Nitrocellulose and Nitroglycerine, the most common[20] smokeless powder. The volume of gases produced by 4.73g of active components is expected to be between 20.8 and 41.66 cc, which is equivalent to gases filling a vessel slightly bigger than a can of beer. This test was designed to visualise the dissipation and latency of smell within space.

[18] http://www.sellier-bellot.cz/en/product/pistol-and-revolver-ammunition/pistol-and-revolver-cartridges/products/detail/294/ accessed 03.07.2017

[19] Efforts have been made to obtain the original composition of the gunpowder from both the bullet manufacturer Sellier & Bellot and the gunpowder manufacturer Explosia. Both companies refused to provide such information.

[20] According to our firearms expert consultants

The digital simulation computed the space and time evolution of the concentration of chemical compounds released from the gunshots. The computer model uses Large Eddy Simulation techniques to account for the turbulence effects on particle dispersion. Particular attention was paid to the opening and closing of the door following the killer's exit from the café. The door opening creates a vortical motion that mixes the chemical particles and distributed them evenly in space. Buoyancy also creates vertical motion of the particles as smell tends to move upwards.

The smell intensity can be retrieved from the concentration by the use of the reference odor threshold[21] for different chemical elements. The most significant challenge in this experiment was predicting the original composition of the released gases, which depends on the gunpowder composition and the additives that are often used in such ammunition. The major gases released by the firearm are odorless: water, CO, CO_2, H_2 and N_2. However, additional odorous compounds are present: hydrogen cyanide, ammonia, methane products, benzene and various aromatic hydrocarbons. Following laboratory testing of similar ammunition[22], a conservative approach was taken in consideration of the composition of the major gases released from the original gunshot.

Results

Among the volatile odorous compounds, the simulation showed concentrations of ammonia higher than the threshold of common perceptibility. Gaseous ammonia seemed to be present in the resulting propellant gases of a variety of propellant powders[23].

The results showed that if the gunshots were fired up to 20 seconds before Temme logged out, then the smell of gunpowder would have been perceptible as Temme exited the room. If the gunshots were fired during the latter 20 seconds suggested in this scenario, then there is not yet enough information to establish whether or not Temme would have been able to perceive the smell. Obtaining conclusive results would depend on confirmation of the detailed gas composition released by the original ammunition of the firearm and would require further experimental data.

[21] G Leonardos *et al.*, J Air Pollution Control Assoc.,19:91-95(1969)
[22] J F Moxnes *et al.,* Propellants Explos. Pyrotech., 38, 255-260 (2013)
[23] Kirchner et al., Combustion Products of Propellants and Ammunition, Deeter and Gaydos Eds. (1993)

Furthermore, if the gun was fired through a plastic bag, it is expected that the bag would not hold more than 50% of the residual smell. A perceptible concentration of residual smell would therefore still have been reached.

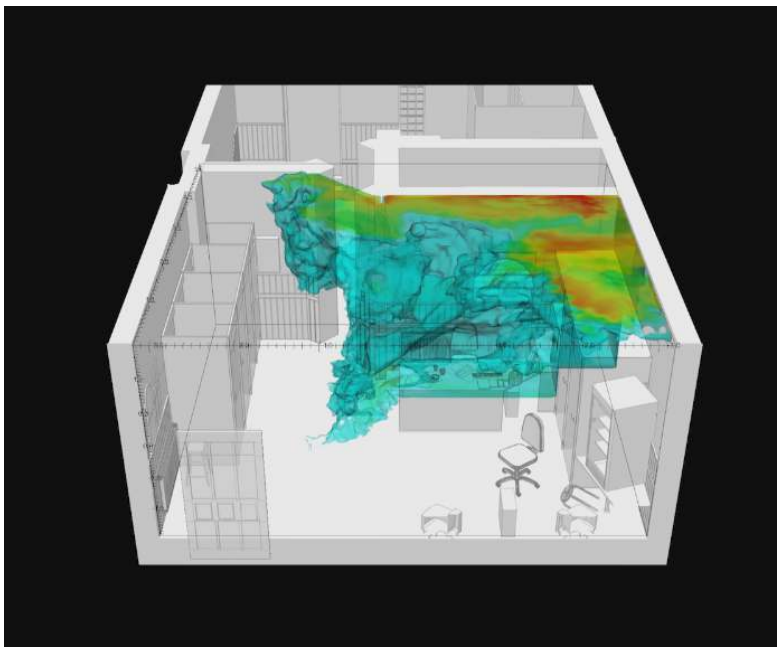


Fig. 13 - Simulation of the fluid dynamics of smell particles (Ammonia) within the front room, by Dr. Salvador Navarro-Martinez and Forensic Architecture

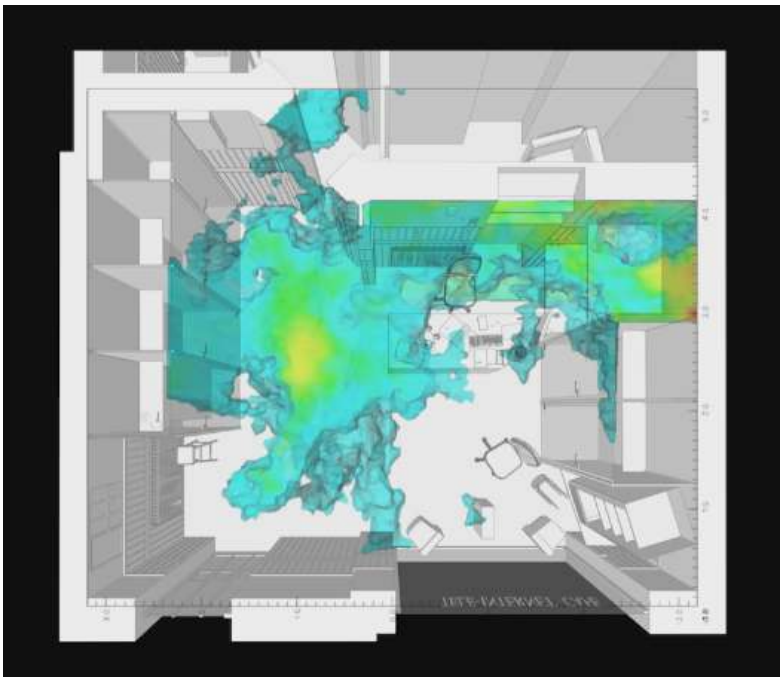


Fig. 14 – Simulation of the fluid dynamics of smell particles (Ammonia) within the front room, by Dr. Salvador Navarro-Martinez and Forensic Architecture

Vision

Could Temme see the body of Halit Yozgat as he exited the internet café?

The body of Halit Yozgat was first discovered by his father, İsmail Yozgat, when he returned to the shop a few minutes after the murder. İsmail described the body of Halit as lying face down behind the reception desk. He produced a number of sketches (including some at the request of Forensic Architecture) depicting the position of Halit's body. He also lay down on the floor and showed us exactly the position in which he found his son.

Temme testified that he did not see the body when leaning over the counter to place a coin before leaving the shop.

Temme performed a re-enactment at the request of the Hessen State Police to support his testimony. As previously mentioned, a video of this re-enactment was ultimately leaked and made public online.

Aided by motion detection software and analogue measures, we examined and modelled this re-enactment video in order to establish the precise positions and movements of Temme's body and especially of his head. We thus recreated Temme's moving field of vision.

We animated this moving field of vision digitally within a computer model (fig. 14) and repeated this test in the physical model with a camera (the experiment was performed with a Go-Pro and digital camera using a 30mm lens[24]) attached to the head of an actor[25] (fig. 15).

These experiments sought to establish whether, even by Temme's own account, witnessing would be possible.

We determined that, at the position described to us by İsmail Yozgat, the body would clearly lie within Temme's field of vision.

Subsequently, we also tested for other positions into which Halit could have fallen by attempting the fall ourselves within the real scale model. We found that at any position the body could have fallen, it would have been visible to Andreas Temme as he bent over the counter according to his re-enactment.

---

[24] A 30mm lens is slightly wider than the field of human vision, however the height of the lens was 42mm which approximately matches the 43mm height of human vision. All events recorded by both the GoPro and the 30mm camera happened in the centre of the field of vision, therefore the slight variations of the lenses did not affect the visibility of the subject at hand.

[25] Temme's height was referenced in court and transcribed by NSU Watch. Different figures have been mentioned, and vary from 1.86-1.96m. The actor performing the re-enactment within the mock-up of the shop had a height of 1.84. This meant that the camera that was mounted to his head was equivalent to the height of Temme's eyes.

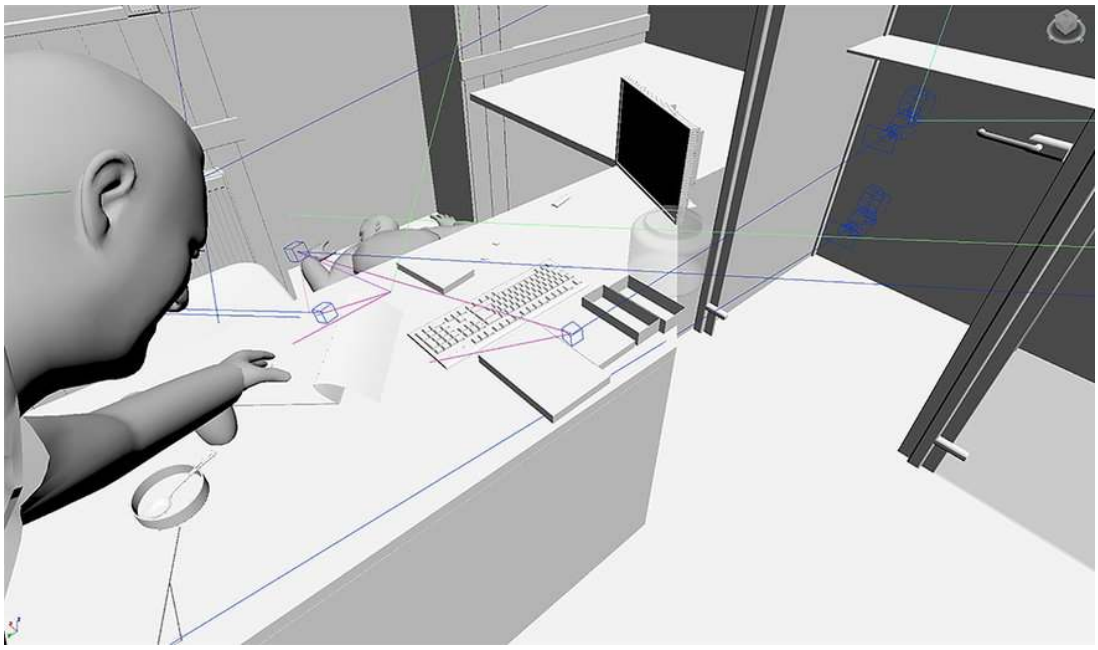


Fig. 15 – Computer simulation of Temme's field of vision and the extent to which Halit Yozgat's body (in the position described by İsmail Yozgat) would have been visible to Temme as he placed the coin on the table.

Fig. 16 – Physical re-enactment of Temme's field of vision and the extent to which Halit Yozgat's body (in the position described by İsmail Yozgat) would have been visible to Temme as he placed the coin on the table.

Conclusion

We have determined that, if Temme was sitting at PC-2 when the murder took place as in Scenario 3 (the scenario endorsed by the court), he would have:

1. Heard the gunshots;
2. Seen the body of the deceased; and
3. Possibly smelled the residual gunpowder.

It is also possible that the murder happened when Andreas Temme was leaving the internet café, as in Scenario 2, in which case he would have colluded with the killers.

However, it is not possible that the murder happened while Temme had already left the internet café, as in Scenario 1.

These results establish that Temme's testimony is untruthful.

Forensic Architecture Team

Director: Eyal Weizman
Project & Research coordination: Christina Varvia
Research: Stefanos Levidis, Omar Ferwati, Eeva Sarlin, and Ortrun Bargholz
Filmmaking post-production: Simone Rowat
Animation: Yamen Albadin, Stefanos Levidis, and Nicholas Masterton
Filmmaking Berlin team: Khaled Abdulwahed, Cem Kaya, Vanina Vignal, Frank Bubenwer (sound), and Gozen Atila
Curation of Berlin installation: Cordula Hamschmidt
Actors: Stefanos Levidis, Fritz Laszlo Weber, Markus Mohr, Omar Ferwati, and Mathias Zeiske
Weapons testing: Armament Research Services (ARES)
Acoustic consultancy & simulation: Grant Waters / Anderson Acoustics
Olfactory experiment: Salvador Navarro-Martinez / Imperial College
Colour grading & syncing: Sebastian Bodirsky
Sound balancing: Mihai Meirosu / Nvision Audio
Advisors: Franc Camps-Febrer, Chris Cobb Smith, Lawrence Abu Hamdan, Mark Mastaglio, Jonathan Painter
Translation: Serdar Kazak, Basak Ertur, Norma Tiedemann, Ortrun Bargholz
Voiceover: Omar Ferwati, Ortrun Bargholz, Basak Ertur
Project assistance: Hana Rizvanolli, Sarah Nankivell, Christopher Hupe, and Veronika Gugel
Facilitators: Natascha Sadr Haghighian, Fritz Laszlo Weber and Ayşe Güleç, Cordula Hamschmidt

Commissioned by:

The People's Tribunal "Unravelling the NSU Complex"; Initiative 6 April; Haus Der Kulturen Der Welt (HKW); and documenta14

For further details, please contact:

Christina Varvia - xv@forensic-architecture.org
Eyal Weizman - ew@forensic-architecture.org

Forensic Architecture
Centre for Research Architecture
Department of Visual Cultures

Goldsmiths, University of London
8 Lewisham Way
London SE14 6NW
United Kingdom
T+44 (0) 20 7078 5387

www.forensic-architecture.org

Appendix A

Report: Sound Suppressor Testing

Prepared for Forensic Architecture by Armament Research Services (ARES)

Sound Suppressor Testing

Prepared for: Forensic Architecture

7 March 2017

Forensic Specialist: Aaron Brudenell

Items Tested:

Reference firearms (4):
Colt Model 1903, caliber .32 ACP, ~10.5 cm threaded barrel
Beretta Model 70, caliber .32 ACP, ~9 cm barrel
CZ Model 83,caliber .380 ACP, ~9.5 cm barrel
Bulgarian model PM, caliber .380 ACP, ~10.5 cm threaded barrel

Reference Ammunition (2):
S&B .32 ACP 73 grain FMJ
Geco .380 ACP 95 grain FMJ

Sound Suppressor (1):
GEMTECH model SOS-9 (9 mm)

Note: “Wet” testing conducted with the addition of ~5 cc H_2O to the rear chamber of the sound suppressor

Testing Equipment & Methodology:

Sound meter: Larson-Davis 800B, 1/4" microphone
5 shots each, 1 meter left of muzzle, ~1.6 meters AGL

Audio recorder: H4n, 96,000 Hz, 24 bit stereo
3 shots each, 5 meters left of muzzle, ~1.6 meters AGL

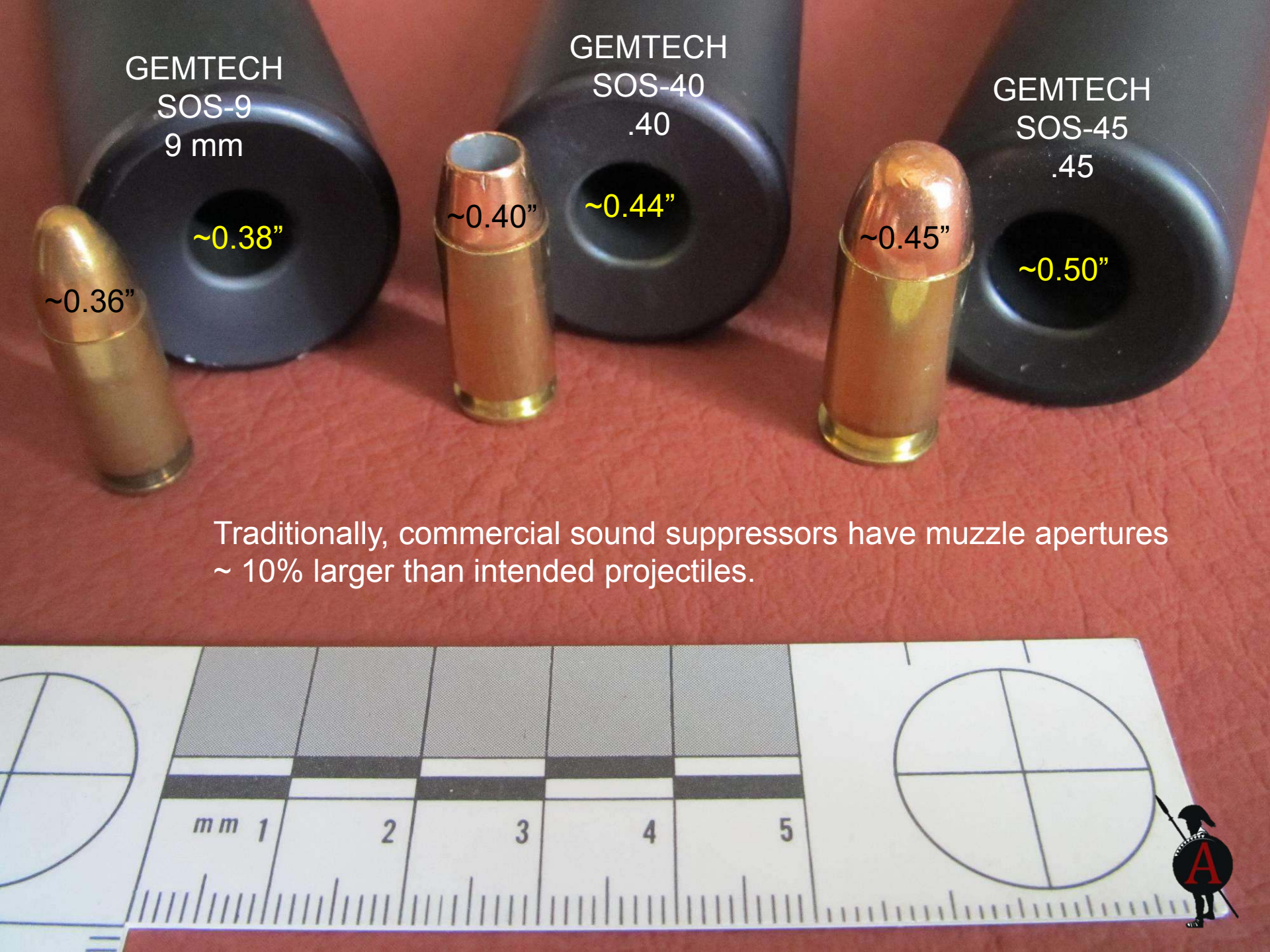
Meteorological Data:

Location: North Phoenix, Arizona, United States of America

Elevation: ~3060' (~ 930m) AMSL
Temperature: 61 (16 °C)

Humidity: 34% RH

Barometric pressure: 30.06 "Hg (1017.95 hPa)

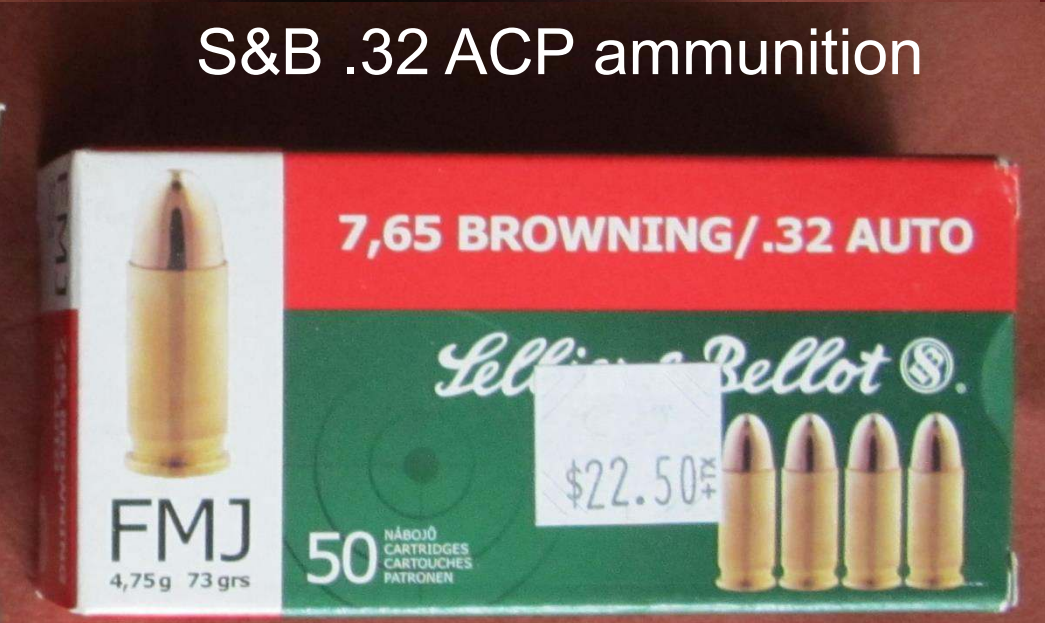

GEMTECH
SOS-9
9 mm
~0.38”
~0.36”
GEMTECH
SOS-40
.40
~0.40”
~0.44”
GEMTECH
SOS-45
.45
~0.45”
~0.50”
Traditionally, commercial sound suppressors have muzzle apertures
~ 10% larger than intended projectiles.
mm 1 2 3 4 5

Firearms and sound suppressor used for testing including and replacement .32 ACP barrel for Colt pistol:

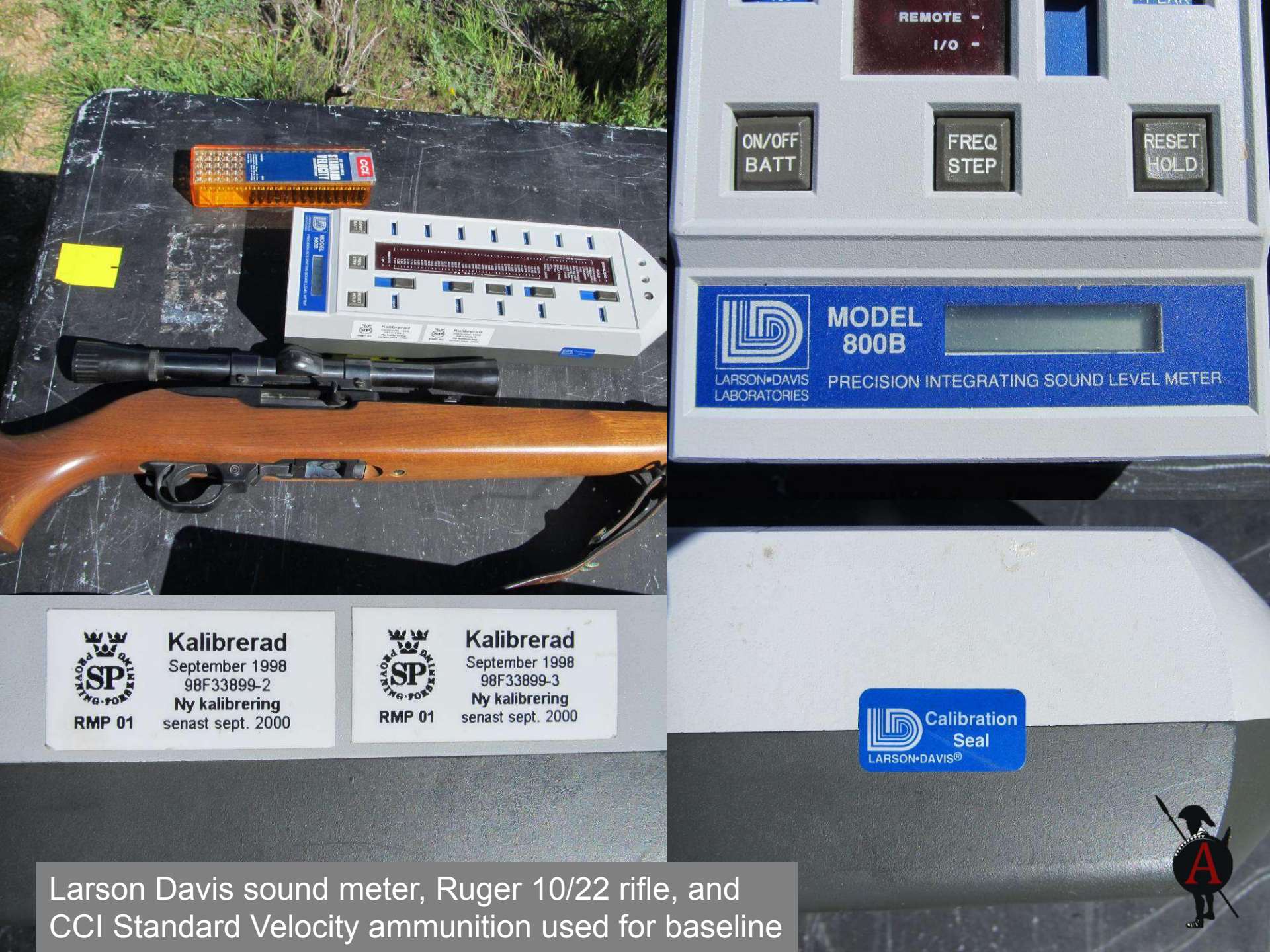
Colt pistol, threaded barrel, and Gemtech model SOS-9 sound suppressor used to produce reduced sound signatures.

Barrel length, calibre, and action type (hammer fired, blowback) are similar to CZ 83 pistol described in background material

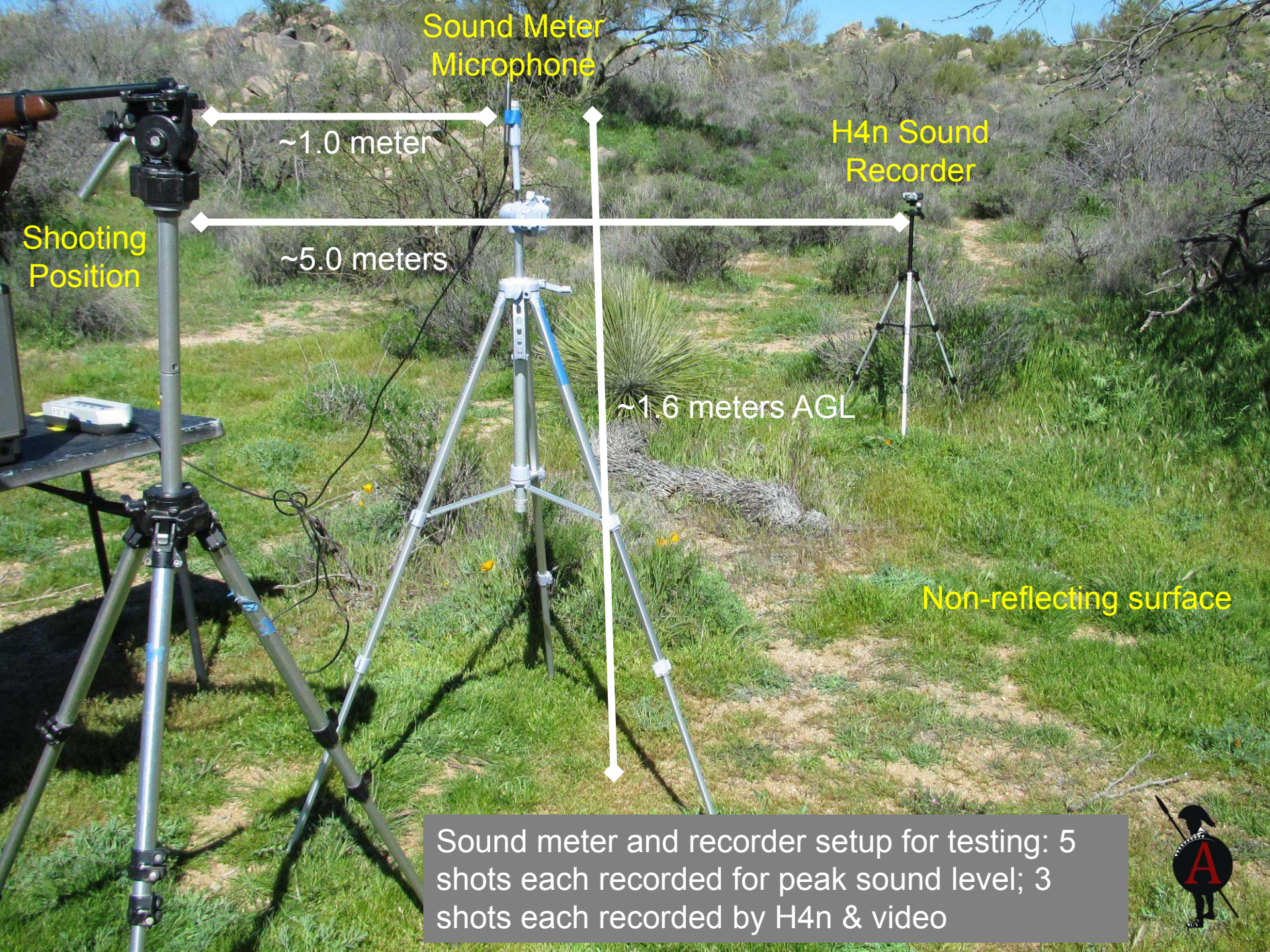
S&B .32 ACP ammunition



Geco .380 ACP ammunition

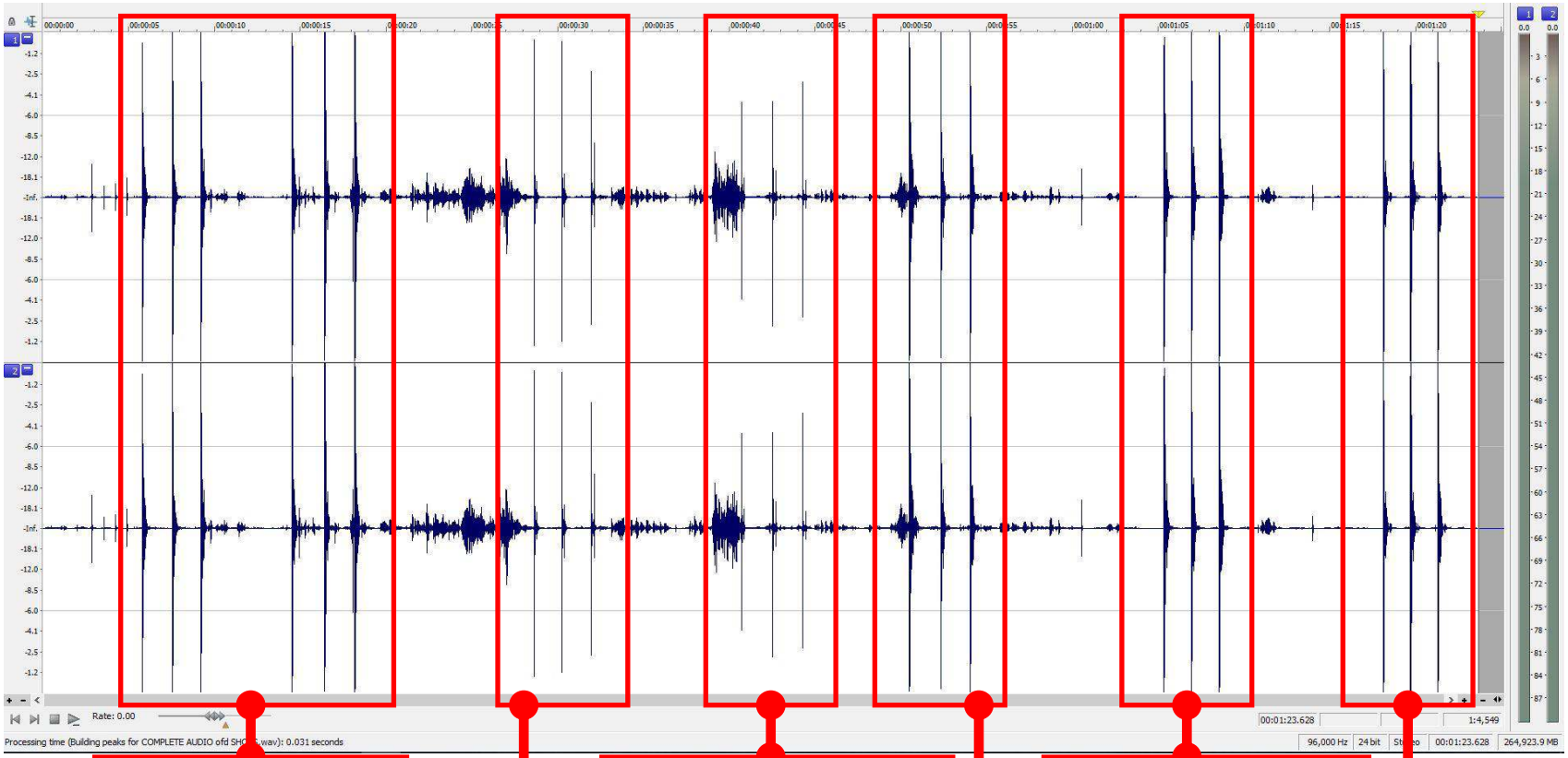


Larson Davis sound meter, Ruger 10/22 rifle, and CCI Standard Velocity ammunition used for baseline



Sound meter and recorder setup for testing: 5 shots each recorded for peak sound level; 3 shots each recorded by H4n & video

Sound Forge display of shots recorded by H4n sound recorder (stereo)



Colt .32 ACP
(unsuppressed)
~157 decibels

Colt .32 ACP
(suppressed, dry)
~142 decibels

Colt .32 ACP
(suppressed, wet)
~131 decibels

Beretta .32 ACP
(unsuppressed)
~158 decibels

CZ 83 .380 ACP
(unsuppressed)
~158 decibels

PM .380 ACP
(unsuppressed)
~158 decibels

Peak Sound Data (dB)

Firearm	Average	shot 1	shot 2	shot 3	shot 4	shot 5
Colt .32 pistol (unsuppressed):	157.46	157.8	157	157.5	157.5	157.5
Colt .32 pistol (dry suppressor):	142.2	140.9	143	142	144.8	140.3
Colt .32 pistol (wet suppressor):	130.66	130.4	130.8	130.8	131.3	130
Beretta .32 pistol:	157.82	158	157.9	157.8	157.5	157.9
CZ 83 pistol:	158.26	158	158.4	158.3	158.1	158.5
Bulgarian PM pistol:	158.18	158.1	158.1	157.8	158.6	158.3
Pre-test std. .22 LR Std. Vel.	*139.3*	*139.6*	*139.3*	*139*		
Post-test std. .22 LR Std. Vel.	*138.22*	*138.4*	*138*	*138.4*	*138.3*	*138*

Summary:

1. Peak sound signatures measured and recorded for the unsuppressed pistols listed above bearing similar barrel lengths were all comparable to each other regardless of model or caliber.

2. Peak sound signatures measured and recorded for the suppressed Colt .32 ACP pistol were reduced by approximately 15 decibels. The addition of ~5 cc H_2O further reduced the report of the same firearm and ammunition combination by approximately an additional 11 decibels.

Note: *Sound level measurements of the PM .380 fitted with a suppressor (not included in dataset) averaged within 1 dB of the Colt .32 ACP data. The over-calibre 9 × 19 mm silencer produced similar sound reduction with the .380 ACP and .32 ACP ammunition.*

Six (6) video and six (6) audio files accompany this report.

Armament Research Services (ARES)
www.armamentresearch.com
Office: +61 8 6365 4401

Appendix B

Report: Acoustic Investigation

Prepared for Forensic Architecture by Anderson Acoustics

ACOUSTIC INVESTIGATION

KASSEL 6.APRIL.2006: A COUNTER INVESTIGATION INTO THE MURDER OF HALIT YOZGAT

FORENSIC ARCHITECTURE

JULY 2017

ACOUSTIC INVESTIGATION
KASSEL 6.APRIL.2006: A COUNTER INVESTIGATION INTO THE MURDER OF HALIT YOZGAT

Our Ref: 3241_001r_3-0_gw.docx

Client: **Forensic Architecture**
Goldsmiths University

Report by: **Anderson Acoustics Limited**
3 Trafalgar Mews
15-16 Trafalgar Street
Brighton
East Sussex BN1 4EZ

www.andersonacoustics.co.uk
T: 01273 696887

Date: **20 July 2017**

Project No: **3241**
Status: **Issue**

Author	**Grant Waters BSc (Hons) AMIOA** **Consultant** **Anderson Acoustics**		**20 July 2017**
Reviewed	**Joe Baggaley** **Principal Consultant** **MSc BSc (Hons MIOA**		**20 July 2017**
Approved	**Joe Baggaley** **Principal Consultant** **MSc BSc (Hons MIOA**		**20 July 2017**

REVISION HISTORY

Version	Comments	Changes made by	Approved by
1.0	First issued version	GW	JB
2.0	Revised issue version	GW	JB
3.0	Further revised issue version	GW	JB

CONTENTS

1 INTRODUCTION

Anderson Acoustics Ltd was commissioned by Forensic Architecture in January 2017 to undertake an acoustic investigation into the audibility of the gunshot that killed Halit Yozgat specifically from the perspective of witness Andreas Temme's seated position.

The murder took place in an Internet Café owned by Halit's father in Kassel, Germany on the 6th April 2006 and was later attributed to a neo-Nazi group referred to as the National Socialist Underground (NSU).

Andreas Temme denied being a witness to the incident at the NSU trial in Munich. The court found that Andreas Temme was present at the back room of the Internet café at the time of the murder and that from his position it was possible not to have witnessed the killing.

Forensic Architecture have been commissioned by the organisers of the People's Tribunal 'Unravelling the NSU Complex' to investigate the validity of this statement. The specific question for this acoustic investigation is:

> *"Could Andreas Temme have heard the gunshots from his position in the back room of the Internet Café?"*

In order to investigate the audibility of the murder at the witness position, both computer modelling techniques and measurements within a life-sized model have been undertaken, as well as measurements of the sound levels produced with comparable firearms.

The results are presented in a direct and visual manner in order to aid understanding. Where any conclusions are dependent on assumptions these are clearly stated.

Noise units, acoustic terminology and environmental noise criteria relevant to the assessment have been presented and briefly discussed in Section 2 of this report.

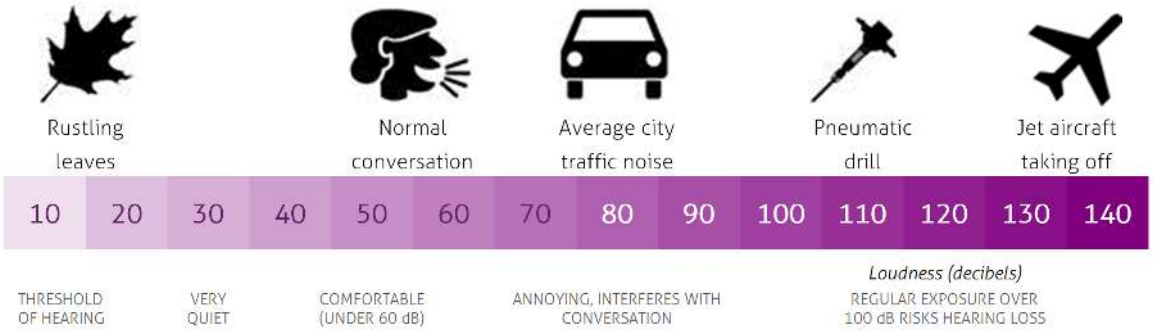
2 NOISE UNITS

There is a million to one ratio between the threshold of hearing and the highest tolerable sound pressure. Noise is therefore measured using a logarithmic scale, to account for this wide range, called the decibel (dB). Noise is defined as unwanted sound and the range of audible sound varies from around 0 dB to 140 dB.

The human ear is capable of detecting sound over a range of frequencies from around 20 Hz to 20 kHz, however its response varies depending on the frequency and is most sensitive to sounds in the mid frequency range of 1 kHz to 5 kHz. Instrumentation used to measure noise is therefore weighted across the frequency bands to represent the sensitivity of the ear. This is called 'A weighting' and is represented as dB(A).

It is generally accepted that under normal conditions humans are capable of detecting changes in steady noise levels of 3 dB, whilst a change of 10 dB is perceived as a doubling or halving of the noise level. An indication of the range of noise levels commonly found in the environment is given below.

Figure 2.1: Typical noise levels



A number of different indices are used to describe the fluctuations in noise level over certain time periods. The main indices include:

$L_{A90,T}$ This is the noise level exceeded for 90% of the measurement period and provides a measurement of the quieter 'lull' periods in between noise events. It is often referred to as the background noise level.

$L_{Aeq,T}$ This is the "equivalent continuous A weighted sound pressure level" and is the level of a notional steady sound which has the same acoustic energy as the fluctuating sound over a specified time period. It is often used for measuring all sources of noise in the environment, which can be referred to as the ambient noise.

$L_{Amax,F}$ This is the maximum sound pressure level measured in a 125-millisecond time period with the sound level meter set to 'fast' response.

L_{Apeak} This is the maximum sound pressure level measured with no time weighting applied.

Reference is often made to acoustic measurements being undertaken in 'free-field' or 'façade' locations. Free-field measurements represent a location away from vertical reflecting surfaces, normally by at least 3.5 metres. A façade measurement is undertaken, or calculated to a position 1 metre from an external façade and a correction of up to 3 dB can be applied to account for the sound reflected from the façade. This latter position is often used when assessing the impact of external noise affecting residents inside properties.

3 INTERNET CAFÉ ARRANGEMENT

It is understood that the murder took place in the front room of the Kassel Internet Café and that the witness (Andreas Temme) was seated in the rear room, which is connected by an open corridor. The position of the gun and the witness (Andreas Temme) is shown on the plan of the café in Figure 3.1.

It can be seen that there is no direct line of sight between gun position and the witness position. However, it should be noted that there is an open pathway between the front and the rear spaces of the Internet Café.

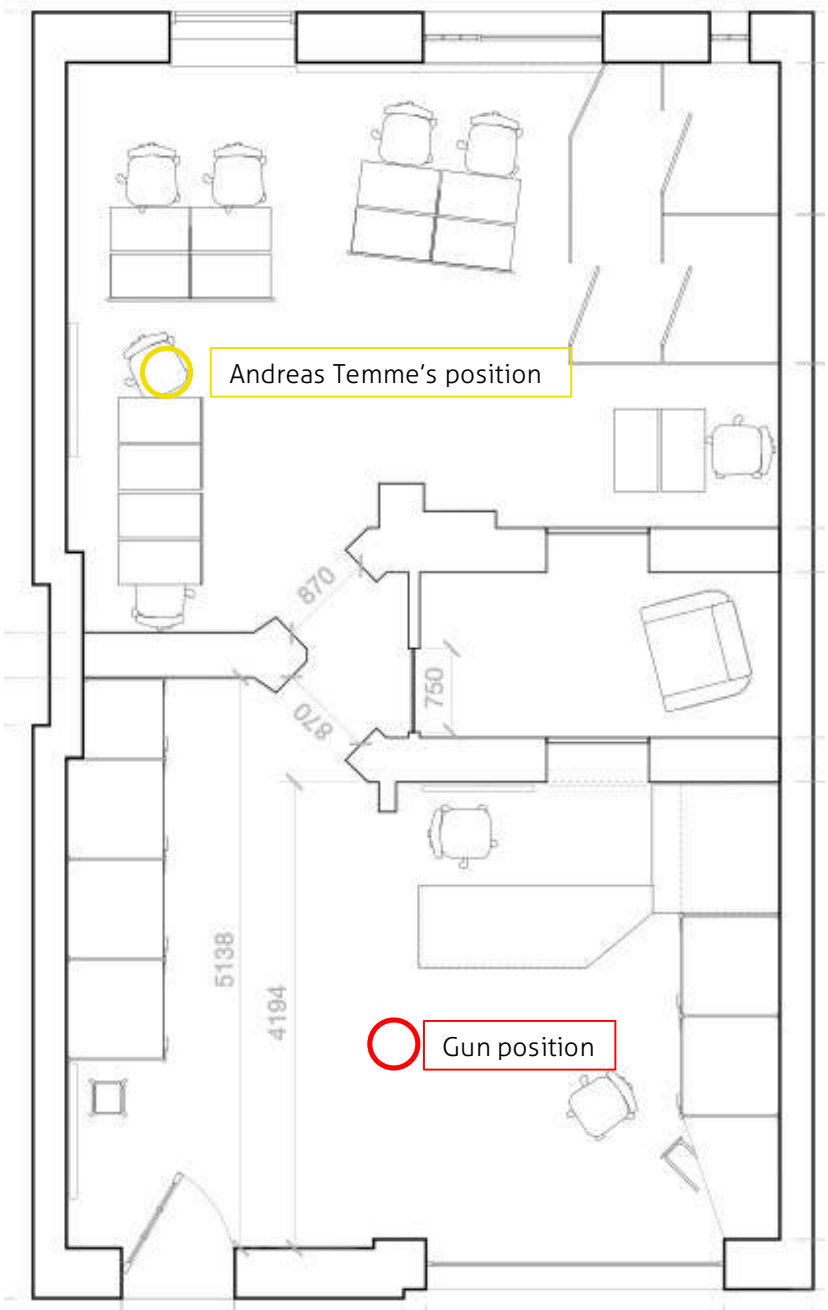


Figure 3.1: Plan of Life-size Internet Café model with location of gun position and Andreas Temme's seated position.

4 METHODOLOGY

In order to investigate the audibility of the gunshots at the witness position both physical scale model re-enactment measurements and a computer model validation process has been undertaken.

The question of the audibility of a sound is complex and is dependent on a number of factors including, the background and ambient sound level in the space at the time of the murder, the hearing capability of the witness, the activity that the witness was undertaking and their cognitive state. This list is by no means exhaustive.

The main objective of the investigation was to understand the level of sound attenuation due to distance, screening and room effects from the position of the gun to the position of the witness (Andreas Temme). Understanding this difference level as well as the original (or comparable) firearm sound, will enable a conclusion to the sound level at Andreas Temme's seated position.

For the purpose of this investigation, the audibility of the gunshot sound is to be evaluated using only relative decibel values. This will compare the predicted gunshot sound level at the witness' position with a range of typical ambient and background sound levels expected in an Internet Café.

This investigation does not account for the specific hearing or cognitive abilities of the witness.

It was not possible to undertake acoustic testing in the actual Internet Café space. Therefore, in order to predict the sound level at the witness' position a computer model has been created using CATT Acoustic modelling software and has been verified with real-world measurements conducted in a life-size physical model.

A four-stage validation process has been carried out that included:

- Conducting acoustic measurements of the re-enactment of the gunshot sound in the life-size model;
- Re-constructing the life-size model scenario as an acoustic computer model in order to 'ground truth' the computer modelling process;
- Constructing an acoustic computer model of the actual Kassel Internet Café space to confirm the level difference between the gunshot position and Andreas Temme's. Using this confirmation and firearm testing data, quantify the sound level at Andreas Temme's position;
- Assessment of audibility of the gunshot sound event level in relation to ambient sound levels.

4.1 Sound parameters

The sound parameters used throughout the investigation are all A-weighted Sound Pressure Levels (dB(A)) and differ only in time weighting. They include:

- L_{APeak} – The maximum sound pressure level measured with no time weighting applied;
- L_{Amax} – The maximum sound pressure level measured over a time period of 125 ms.;
- $L_{Aeq,T}$ – The sound pressure level measured over the total time period of the sound event.

The parameters are not interchangeable unless simultaneous measurements are conducted and the relative difference is understood.

Typically, L_{Apeak} is used to measure highly transient sounds, such as firearms, in order to assess potential for hearing damage and is not generally used to assess audibility, where maximum levels that occur for less than 100 ms are perceived to be less loud than those of longer than 100 ms (denoting the time constant of the human ear).[1]

Life-size model measurements and results are presented in L_{Amax}, where it demonstrates that the sound event level occurs for longer than 100 ms and is therefore of greater duration than the time constant of the human hear. This allows the sound level to be directly compared to background and ambient sound levels.

Ambient sound levels are presented in terms of $L_{Aeq,T}$, where the *T* denotes the time of the event or activity to obtain a steady state level.

4.2 Ambient sound levels

The ambient sound levels in the Kassel Internet Café at the time of the event are not known.

Reference has been made to the British Standard 8233:2014 that provides guidance on ambient noise level criteria based on room type. Some relevant room type criteria has been reproduced in Table 4.1.

Table 4.1: Ambient sound level criteria for unoccupied rooms based on use as per BS 8233:2014.

Activity/Room type	Design range, dB $L_{Aeq,T}$
Cafeteria	50 - 55
Restaurant	40 – 55
Open plan office	45 - 50
Library	40 – 50
Training room	35 - 45

The above levels are when unoccupied and are design ranges only. It is the assumption of this audibility assessment that only minimal speech conversation was present and that no amplified music was being played in the witness' location at the time of the murder.

For the audibility assessment, the value of maximum level of 55 dB $L_{Aeq,T}$ will be used as the ambient sound level in the space at the time of the event.

4.3 Established sound parameter relationships

Where there are varied sound parameters used throughout the investigation, the final result has been derived from understanding the relationship between these parameters. As mentioned previously, these relationships are wholly dependent on the type of sound in question and therefore only firearm measurements (including measurements conducted at the life-size model setup).

The relationship derived and used within the final calculations are shown below:

- L_{Apeak} to $L_{Aeq,T}$ – A difference of -24 to -28 dB (based on 0.40 calibre handgun)[2]
- $L_{Aeq,T}$ to L_{Amax} – A difference of +12.08 to +12.86 dB (based on life-size physical model measurements at both 1 m from source and at Andreas Temme's position, see section 5.2.3).

5 ANALYSIS

5.1 Firearm sound level validation

Measurements were undertaken of various firearms that are considered comparable with the gun used to carry out the murder. These were undertaken by Armament Research Services (ARES) under free-field conditions.

ARES sourced a Ceská CZ 83 pistol and verified that the sound signature is similar to another handgun of similar calibre – a Colt .32 pistol. Measurements of the Colt .32 pistol were carried out with both a wet and dry suppresser attachment. It is understood that the pistol with a suppressor was used to carry out the murder.

Average measurements results are presented in A-weighted L_{peak} sound pressure level and are shown for both without suppression and with suppression (wet and dry). Audio recordings were also captured.

Table 5.1: Minimum measured peak sound pressure level for comparative firearm with and without suppression.

Firearm	Minimum peak sound pressure level, dB L_{Apeak} (5 shots per setup)
Colt .32 pistol (no suppression)	157.0
Colt .32 pistol (dry suppression)	140.3
Colt .32 pistol (wet suppression)	**130.0**

As a worst case the lowest result, 130.0 dB L_{Apeak} when using a wet suppressor, will be referenced in the following sections of this report when referring to the known sound level of the firearm.

5.2 Life-size model acoustic measurement

A life-sized model of the Kassel Internet Café was constructed at the House of World Cultures in Berlin, Germany.

5.2.1 Design and construction

Due to constraints, the model used lightweight materials and constructions and was not fully enclosed in order to enable other investigations such as visual and smell, as well as to allow the documentation of the experiment.

During the design and construction process, Anderson Acoustics provided advice informing how to replicate similar acoustic conditions to that of the Kassel Internet Café with lightweight building materials and partially open facades.

Key sound transmission and reflection paths were identified in a computer model of the Kassel Internet Café space. This enabled the placement of reflecting surfaces at key locations around the source and receiver locations to best replicate the conditions in the Internet Café at the time of the event.

Additionally, separating constructions were specified for their sound reduction performance to suppress the transfer of sound via the elements to less than 10 dB than the initial sound transmission open path. This ensured that the level of sound contribution from sound transmission via the partitions does not significantly affect the sound level result at the witness' position.

Based on the same principle, the modelling was able to confirm that more indirect sound paths were of minimal contribution to the sound level at the witness' position.

5.2.2 Re-enactment measurements

Acoustic measurements were conducted in the life-sized model to quantify the sound level reduction from source position (position of firearm) and witness position.

The sound source used an audio sample of the gunshot measurements conducted by ARES and was generated by an active loudspeaker at 1.5 m centre height. The maximum output level for the mixer and the active loudspeaker was chosen, ensuring that distortion of the audio signal was not present.

The initial measurement was conducted at a distance of 1 m from the centre of the loudspeaker at a horizontal angle of approximately 45° from the forward-facing position. A measurement was conducted at the desk position understood to be that of Andreas Temme at 1.2 m height. An additional audio recording was taken at the position of the witness. Three repetitions of the gunshot sounding were measured.

5.2.3 Results

The measurement results are displayed in Table 5.2, including the level difference between the source level (at 1m) and the sound level at the witness' position. Frequency octave band levels were also measured and are displayed in Figure 5.1.

Table 5.2: Life-size model measurement results.

Position	Average event sound pressure level, dB $L_{Aeq,T}$	Maximum event sound pressure level, dB $L_{Amax,F}$
1 m (45° offset) from loudspeaker	90.5	103.3
Andreas Temme's position	74.3	86.4
Level difference (source-receiver)	**16.2**	**16.9**

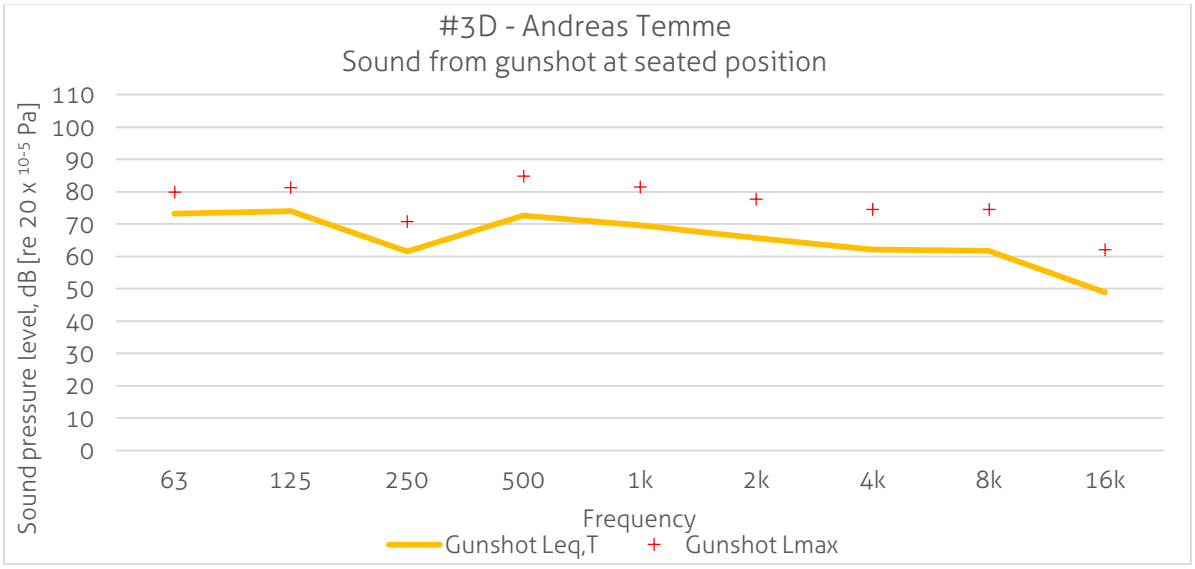


Figure 5.1: Measured sound pressure level per octave frequency band at Andreas Temme's position due to the re-enacted gunshot sound.

The results predicted that a level difference between the gunshot position and Andreas Temme's position was between 16-17 dB. The measurements also indicate a difference between $L_{Aeq,T}$ and $L_{Amax,F}$ of 12.08-12.86 dB, which has been reference later on in this document to predict the final sound pressure level (see section 4.3). This range has been derived by the difference between $L_{Aeq,T}$ and L_{Amax} for both the measurements at 1m from gunshot position and at Andreas Temme's seated position.

It is noted that sound levels were not able to be produced to the level that would be representative of the ARES measurement results. This was due to the physical limitation of the mixer/active sound system setup.

For visual purposes, the audio sample recorded at Andreas Temme's position has been visualised to show frequency response over time and is compared to the original sound signature recorded of the Colt .32 pistol with wet suppression by ARES, as shown in Figures 5.2 and 5.3.

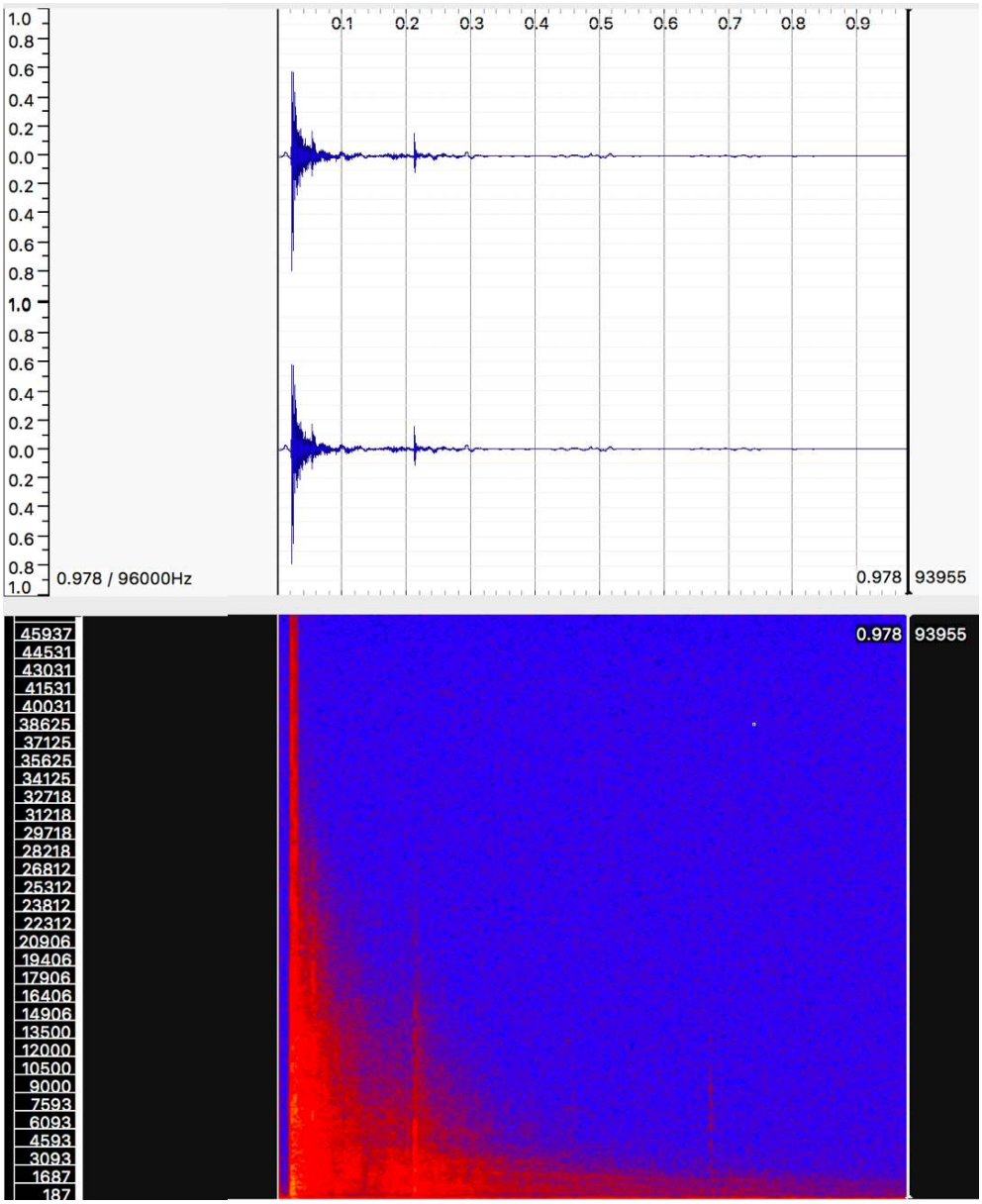


Figure 5.2: Audio frequency graphical representation over time of free-field Colt .32 with Wet Suppressor Recorded by ARES.

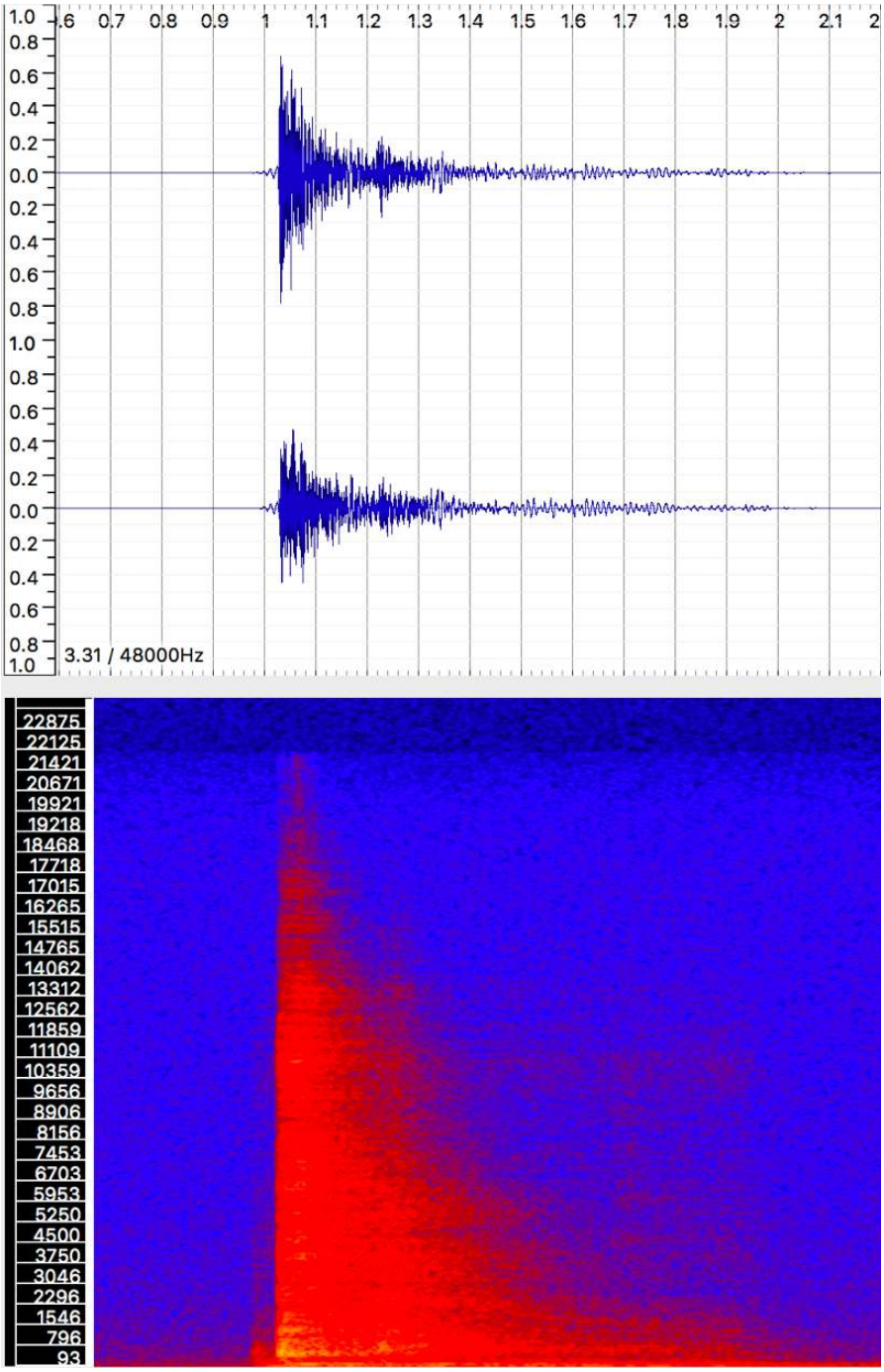


Figure 5.3: Audio frequency graphical representation over time as recorded at Andreas Temme's position in the life-size model in Berlin in March 2017. It should be noted that reflections from room surfaces increase the duration and level of the firearm sound.

5.3 Computer modelling

Acoustic computer modelling techniques were utilised using CATT Acoustic computer modelling software.

Generally, where exact constructions were not known, absorption coefficients for solid blockwork were applied.

One limitation of the acoustic software is that input levels are not able to be above 100 dB at certain frequencies. Measured $L_{Aeq,T}$ levels were input into the computer models and were subsequently corrected based on $L_{Aeq,T}$ / L_{Amax} relationships derived from measurement results.

5.3.1 Life-size model simulation

A computer model of the life-size physical model was constructed in order to re-create the scenarios measured and to confirm computer modelling techniques. The setup was modelled as per the real-world situation, where the space was within a seminar room of larger volume.

Using the life-sized model measurements results, the sound source level in the computer acoustic model was calibrated to achieve equivalent sound pressure level (dB $L_{Aeq,T}$) at 1 m distance. The input value for this source will subsequently be input into the actual Kassel Internet Café acoustic model to ground truth the life-size setup in Berlin.

The result was then predicted at the position of Andreas Temme's position and the difference between source (at 1m) and the receiver position was compared to the life-size model results. The results are shown in Table 5.3.

Table 5.3: Computer model results of life-size model simulation.

Position	Event sound pressure level, dB(A)
1 m (45° offset) from loudspeaker	90.3
Andreas Temme's position	74.3
Level difference (source-receiver)	**16.0**

The prediction of sound spread from the gunshot position is shown in Figure 5.2.

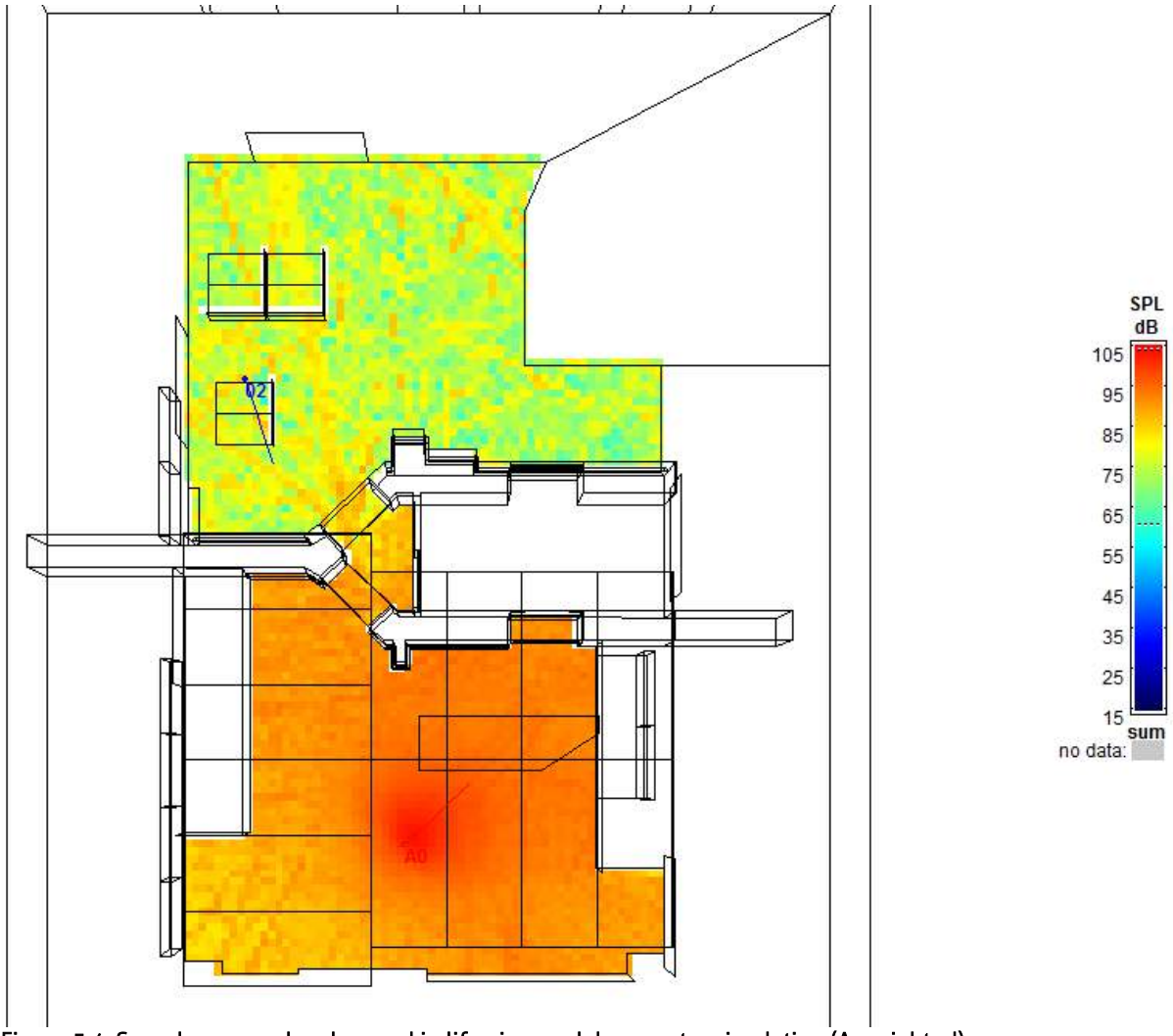


Figure 5.4: Sound pressure level spread in life-size model computer simulation (A-weighted).

It is shown that the absolute sound level predicted and the level difference between source and witness position in the computer simulation model are within 0.1 dB. This confirms the validity of the computer simulation method.

5.3.2 Actual Kassel Internet Café model simulation

Following the life-size model simulation, the derived model sound source levels were input into a model of the actual Kassel Internet Café space. Surface treatments were understood to be generally hard and reflective.

Sound level predictions were undertaken at the position of Andrea Temme and the difference between source (at 1m) and the receiver position was observed. Results are shown in Table 5.4.

Table 5.4: Computer model results of the Kassel Internet Café model simulation.

Position	Event sound pressure level, dB(A)
1 m (45° offset) from loudspeaker	94.1
Andreas Temme's position	77.1
Level difference (source-receiver)	**17.0**

The prediction of sound spread from the gunshot position is shown in Figure 5.3.

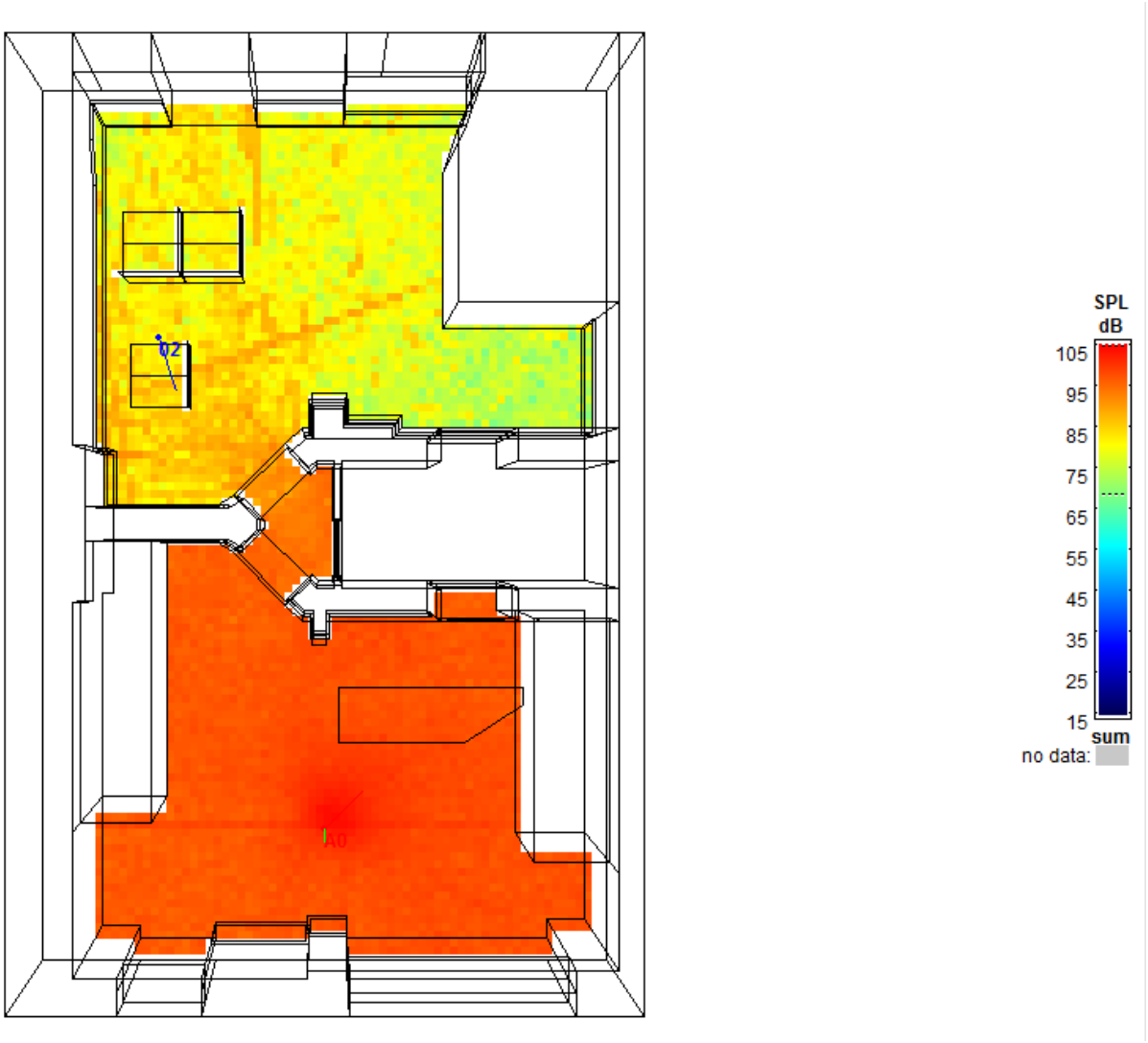


Figure 5.5: Sound pressure level spread in the Kassel Internet Café model computer simulation (A-weighted).

It is noted that the overall sound level both at 1 m from the source and at Andreas Temme's position is of higher level than in the life-size models. This is expected and is due to the smaller volume and the presence of increased hard, reflective surface finishes.

6 RESULTS

6.1 Acoustic modelling 'ground truth'

It has been confirmed from both physical and computer acoustic modelling analysis that the sound level difference between the position of the gunshot and Andreas Temme's position is between 16-17 dB.

As it was not possible to re-enact sound pressure levels representative of the firearm, due to the high amplitude, conversions have been made from the input value to the computer model (free-field sound pressure levels at 1m) to Andreas Temme's seated position. These are shown in Table 6.1.

Table 6.1: Modelling results and level differences used to derive a conversion from ARES free-field measurement data to Andreas Temme's seating position in the Kassel Internet Café.

Descriptor	dB(A)	Difference	Comments
Input value into Actual Kassel Internet Café model	96.93	-	Overall input value to Catt Acoustic model. Requests 'SPL at 1 m'
Output sound pressure level at 1m from firearm position	94.07	-2.93	Difference between input value and output at 1m in model.
Output sound pressure level at AT's position	77.08	-16.99	Difference between output SPL at 1m and at AT position
Total difference	**-**	**-19.85**	**Difference between free-field input at 1m to AT position**

The peak sound pressure level from the Colt .32 with a wet suppressor was measured (by ARES) to be 130.00 dB L_{Apeak}. Where the total difference conversion (as shown in Table 6.1) is applied this results in a peak sound pressure level predicted at Andreas Temme's position of 110.15 dB L_{Apeak}.

Using the established measure conversions shown in Section 4.3, this results in the following sound levels at Andreas Temme's position from a firearm being shot at the proposed position of the gunman.

Table 6.2: Predicted sound pressure level (various parameters) at Andreas Temme's position due to a suppressed firearm being triggered at the proposed perpetrator location (to zero decimal places).

Descriptor	dB L_{Apeak}	dB $L_{Aeq,T}$	dB $L_{Amax,F}$
Input value into Actual Kassel Internet Café model	110	82 – 86	94 – 99

It is concluded that the predicted maximum sound pressure level at Andreas Temme's positions due to a suppressed hand firearm being triggered at the proposed gunman position is between 94 to 99 dB $L_{Amax,F}$.

6.2 Audibility of gunshot sound level at Andreas Temme's position

Based on the assumed ambient sound level in the Internet Café being in the order of 55 dB $L_{Aeq,T}$, the predicted sound pressure of the gunshot at Andreas Temme's position is 39 dB higher than the typical sound conditions in the space when the maximum sound pressure level is referenced (94 dB L_{Amax} – 55 dB $L_{Aeq,T}$).

The spectral difference between the predicted gunshot maximum sound pressure level and assumed ambient sound levels in the Internet Café are shown in Figure 6.1. Spectral levels have been taken from measured playback of the Colt .32 hand firearm with a wet suppressor in the Berlin physical

model at Andreas Temme's position and corrected to represent the final predicted maximum sound event level value.

The difference between maximum sound pressure level from the gunshot and expected ambient sound levels at individual octave bands is 35 dB on average. Differences for each octave bands are shown in Figure 6.1.

Generally, it is considered that a sound level of equivalent sound pressure level to the ambient or background sound level will be audible, and cause an increase in overall sound level of 3 dB. It is further noted that where a primary sound level is more than 10 dB higher than another sound, the primary will be the dominant sound source.

The predicted sound level is significantly higher than the expected ambient sound level in the Internet Café and therefore should be considered audible at the witness' (Andreas Temme's) position. A single correction factor has been applied to derive the spectral maximum sound pressure level result.

It should be reiterated that this assessment does not take in to account the hearing or cognitive capabilities of the witness in question and conclusions are purely derived from relative sound pressure level comparisons.

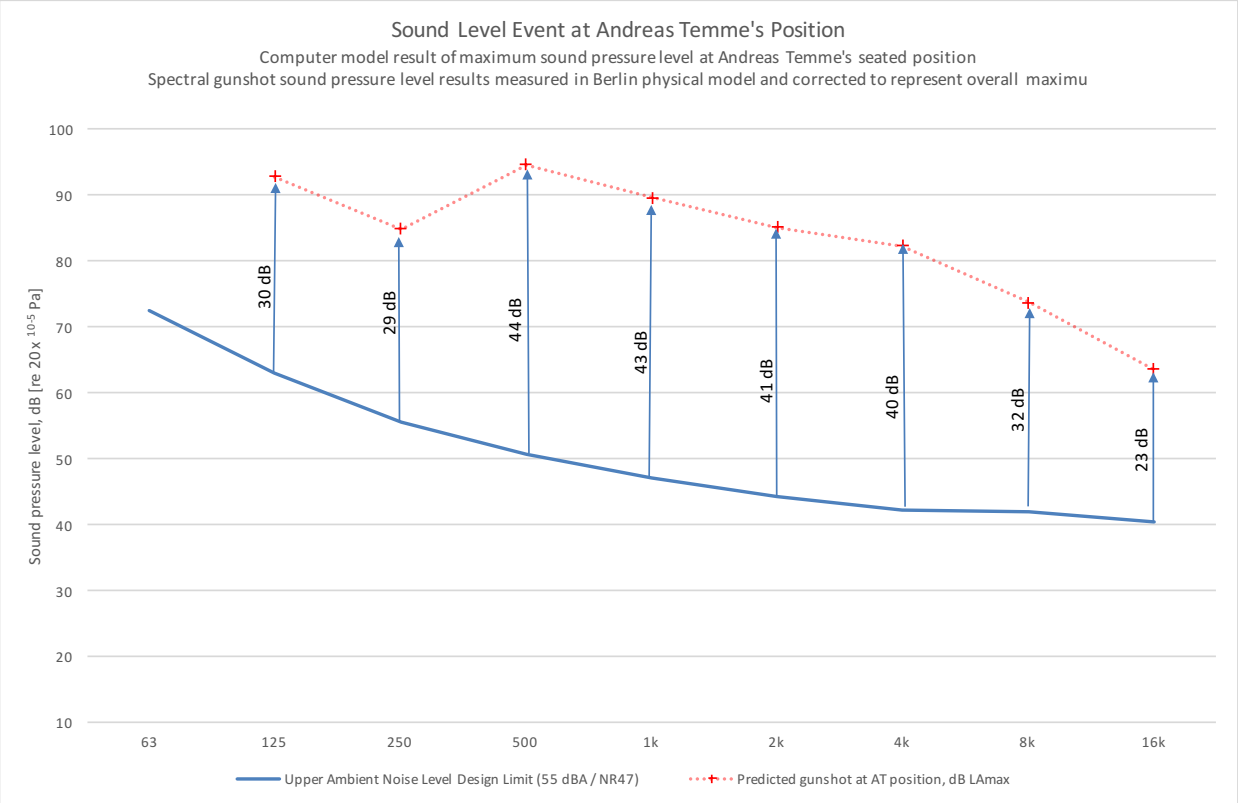


Figure 6.1: Computer model result of maximum sound pressure level at Andreas Temme's position and difference in level between the upper internal ambient noise level design range. Overall A-weighted maximum sound level of 94 dB $L_{Amax,F}$.

7 CONCLUSIONS

Anderson Acoustics Ltd was commissioned by Forensic Architecture in January 2017 to undertake an acoustic investigation into the audibility of the gunshot that killed Halit Yozgat, in a Kassel Internet Café in April 2006, specifically from the perspective of witness Andreas Temme's seated position.

In order to investigate the audibility of the murder at the witness position, both computer modelling techniques and measurements within a life-sized model have been undertaken, as well as measurements of the sound levels produced with comparable firearms.

Sound measurements of comparable firearms with suppressors were completed by others in March 2017. For all comparable firearms tested, the lowest level measured was 130.0 dB L_{Apeak}. No other parameters were recorded.

A life-sized model of the Kassel Internet Café was constructed at the House of World Cultures in Berlin, Germany and specified for acoustic performance to best replicate the Kassel Internet Café. A gunshot audio sample was played at the position of the gunshot at a sound pressure level of 103.3 dB L_{Amax} and the resulting sound pressure level at Andreas Temme's position was 86.4 dB L_{Amax}. Limitations of the sound system meant that the sound level at 1 m representative of the firearms testing was not able to be reproduced due to the high amplitude. The measured sound level difference between position of the gunshot and Andeas Temme's seated position was 16-17 dB.

Two computer models were created, the first to validate the computer simulation techniques by confirming the measurements completed in the life-sized model, and secondly to predict the propagation of sound in the Actual Kassel Internet Café.

The computer model of the life-size model confirmed the measurements conducted in Berlin within 0.1 dB. This validates the computer modelling techniques used.

The computer model of the Actual Internet Café predicted a total sound level difference from the position of the gunshot to Andreas Temme's position of -17 dB. An additional correction was predicted to translate free-field input data to within a room.

Following the results of the physical and computer model, where a gunshot of 130.0 dB L_{Apeak} was sounded at the proposed position of the gunman in the Kassel Internet Café front room, it is predicted that a sound pressure event level of between 82 – 86 dB $L_{Aeq,T}$ and 94 – 99 dB $L_{Amax,F}$ was present at the position of Andreas Temme in the rear room of the same Internet Café.

Based on the ambient sound level in the Internet Café being in the order of 55 dB $L_{Aeq,T}$, the predicted sound pressure of the gunshot at Andreas Temme's position is 39 dB higher than the typical sound conditions in the space when the A-weighted maximum sound pressure level is referenced. On average, spectral maximum sound pressure levels due to the sounded gunshot, were 35 dB higher than expected ambient sound level criteria.

The predicted sound level at Andreas Temme's position due to the gunshot is significantly higher than the expected ambient sound level in the Internet Café and therefore should be considered audible at the witness' (Andreas Temme's) position.

8 REFERENCES

1 Everest, F., Pohlmann, K., Master Handbook of Acoustics, *Fifth Edition*, 2009.

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3 British Standard 8233:2014: Guidance on Sound Insulation and Noise Reduction for Buildings