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Sonic Attack on a Silent Vigil

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0 About Earshot

Founded by the artist and audio investigator Lawrence Abu Hamdan, Earshot emerged from years of pioneering work challenging how forensic audio is used and who it serves. Among Abu Hamdan's early contributions was the exposure of the unscientific use of accent tests in asylum tribunals in 2011. His landmark collaboration with Amnesty International in 2016 turned earwitness testimony from former detainees into an acoustic reconstruction of Syria's Saydnaya prison, making its atrocities visible to the world. His PhD traced the history of forensic audio, reimagining how sound could be used not as a tool of police departments and surveillance states, but as a means of empowerment for vulnerable communities often left unheard. From proving that an Israeli drone circled a group of seven journalists in southern Lebanon eleven times before being hit by artillery, to tracing the sonic fingerprint of environmental destruction in projects like Zifzafa, Earshot continues this mission, steering the future of this pioneering field.

In just 18 months of operation, Earshot's team of 4 has led over 40 investigations spanning continents, from India to the U.S. to Palestine, Syria, France, and the Congo. Earshot's investigations have been cited in over 30 major news outlets — including The New Yorker, Le Monde, Washington Post, and Al Jazeera — and have supported advocacy campaigns with Amnesty International, Human Rights Watch, Forbidden Stories, Global Rights Compliance (GRC), and B'Tselem.

Earshot's investigation into the killing of Hind Rajab and her family on 29 January 2024 – produced with Forensic Architecture for Al Jazeera's Fault Lines – corroborated the victims' final words, revealing that they were fired upon by tanks just 13 meters away. The investigation's findings were presented in the U.S. Congress and featured in The Night Won't End, which won the 2025 Peabody Award and the CIR Open-Source Film Award. Further investigations have helped journalists at the BBC, Channel 4, and Al Jazeera to authenticate audio and debunk disinformation, including deepfakes distributed via official channels. As a member of Witness Media Lab's Deepfakes Rapid Response Force, Earshot exposed an AI-generated audio hoax targeting opposition leaders in Maharashtra, India – highlighting the organisation's role in protecting democratic processes.

This report was authored by Earshot's founding director and principal investigator; its deputy director, Caline Matar; audio investigator, Fabio Cervi; and assistant audio investigator, Adnan Naqvi.

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1 Summary

"And then from that complete silence, I heard this sound." (Witness 05)

In the aftermath of the alleged sonic attack on protestors engaged in a silent vigil in Belgrade, Serbia, on 15 March 2025, Earshot has undertaken a comprehensive analysis of the audio content of 19 videos, conducted 15 in-depth Earwitness interviews with protestors positioned along Kralja Milana Boulevard, and aggregated more than 3,000 written statements from the vigil's attendees. The findings of this investigation concludes it is highly likely protestors were subjected to a targeted attack using a directional acoustic weapon and contradicts the claims made in a report by the Federal Security Service (FSB) of the Russian Federation and Serbian authorities that the 'disorders' began with 'devices' such as fireworks, and other implications that protestors' reactions were merely a response to a sound generated by the crowd.

This report will demonstrate that witnesses were all able to clearly recall, describe and distinguish the unfamiliar sound of the attack from other sounds in their environment (such as motorbikes, fireworks, whistles, drones, and stampeding feet). Moreover, of the 3,244 written statements that were reviewed and the 15 earwitnesses that were interviewed, the sound of the attack was described as something "they had never heard before" or could not liken to any one single sound source. Earshot was able to ascertain that the sound of the alleged attack was unfamiliar to the earwitnesses, both in terms of how it sounded like and the way in which the sound itself was physically experienced. This was evidenced by earwitnesses who frequently referred to the sound as felt "inside" or coming "through" them and a further 2,335 statements specifically underscoring a physical as well as auditory sensation. The substantial concordance among the numerous witness statements and earwitness testimonies that were reviewed and conducted by Earshot permitted the conclusion that it is highly likely the protestors have been subjected to an attack by a highly directional acoustic weapon.

All 15 of the earwitnesses Earshot interviewed consistently identified 3 sounds out of a library of more than 26 samples played. A further 1,907 written statements similarly described sounds as the 3 identified by earwitnesses. As a testament to this overwhelming consistency, Earshot was able to reconstruct an approximation of the sound of the weapon that was used and published it on its website and social media platforms.

The report concludes with an investigation into the possibility that the source of the attack was a Long-Range Acoustic Device (LRAD) and includes a detailed analysis of the 450XL model, which is known to be in the possession of the Serbian police and to be present that night. While the FSB report asserts that the crowd movement "is not possible with a brief use of a special device"[1], Earshot's findings demonstrate how this claim is demonstrably false when reviewing the capacities of the LRAD 450XL in its user manual. Earshot's investigation offers an explanation as to why the sound of the LRAD 450XL is not overtly captured on the videos documenting the event: the absence of the sound on recorded devices could indicate, rather than disqualify, the use of an LRAD given the unique and patented mechanisms by which it propagates sound from its speaker array.

1 CRTA, Translated Report of the Federal Security Service Regarding the Alleged Use of a Sonic Weapon at the Silent Vigil Protest in Belgrade (Belgrade: Centre for Research, Transparency and Accountability, 2025), 2: "During the operation, the disorders began with pyrotechnic and incendiary devices used in front of an ambulance."

2 Introduction

On the evening of 15 March 2025, a 15-minute silent vigil was held in Belgrade, Serbia. One minute of silence was dedicated to each of the 15 people who lost their lives in the collapse of the Novi Sad railway station canopy in November 2024. Between 275,000 and 325,000 people took part in this act of collective mourning[2], many of whom were gathered along the Kralja Milana Boulevard, a 20-metres-wide and 1.3-kilometres-long street. Earwitnesses described the experience of the vigil as being so quiet that you could "hear someone coughing 200 meters away", comparing it to a collective "state of meditation". Just as the vigil was coming to an end, the crowd suddenly parted to either side of the road, compelled to move by a sound they have consistently described as akin to an unidentifiable vehicle approaching them at high speed.

Earshot initiated its investigation by examining the recordings of the incident that had been posted online and sent directly by protestors. Following an initial assessment[3] of 12 videos, Earshot identified sounds consistent with non-lethal crowd dispersal technology in 4 out of the 12 recordings. The sound identified was consistent with the noise produced by a Vortex Ring Gun or a Vortex Cannon. Following this preliminary evaluation, which did not ascertain the provenance of the acoustic phenomenon under investigation, but which did offer a tentative hypothesis, further investigation was required. Earshot partnered with the Centre for Research, Transparency and Accountability (CRTA) to gather first hand witness accounts. 3,244 written statements were analysed and 15 in-depth earwitness interviews were conducted. The technique of earwitness interviewing, pioneered by Earshot's founder Lawrence Abu Hamdan, is a process of interviewing subjects that is tailored to understanding their sonic experiences and involves a specific line of questioning accompanied by the playback of audio stimuli and if required, immersing witnesses into acoustic environments. The 15 earwitnesses were positioned at various points along the boulevard, enabling a more comprehensive understanding of how the attack was experienced from different acoustic perspectives. Together with these interviews, a comparative analysis was performed with a further 3,244 written statements detailing the experience of the alleged attack.

Based on these 15 earwitness testimonies, the methodology of which is detailed in Part 1, Earshot investigators concluded that all 15 earwitnesses had a shared experience of a sudden, unfamiliar, rapidly approaching sound, perceived as external to the crowd. This sound was associated with a profound sense of impending physical impact, as detailed in Part 2. The cross-corroborative accounts across earwitnesses and written statements pointed toward a sonic experience which differed from Earshot's initial findings on the use of a Vortex Cannon, namely in the machinic and vehicular descriptions. Such descriptions are inconsistent with the Vortex Cannon's analogue process of emitting sound through pressurised airflow. Furthermore, through the playback of audio samples, earwitnesses consistently and categorically ruled out the sound of the Vortex Cannon, which Earshot obtained from the open source. These findings led Earshot to pursue a different line of analysis on the possible source of the sonic attack[4].

Due to the consistency and specificity of earwitness accounts, Earshot investigators were able to simulate the described sound, a process documented in Part 3. The final section of this report, Part 4, examines the propagation characteristics of the LRAD 450XL — a device known to have been present on the night of the silent vigil and to have been in the possession of the Serbian police — and considers whether this device could plausibly have produced the sound heard by the earwitnesses that night.

2 BBC News, Government denies using "sound cannon" at Serbia protests, https://www.bbc.com/news/articles/cqjdpy8dyzzo, (Accessed June 3, 2025).

3 Earshot Investigations (@earshot.ngo), "On the 16th of March 2025, Earshot was contacted by activists in Serbia to investigate the potential use of sonic weapons by the government on a crowd of protestors as they were holding a silent vigil for the victims of the Novi Sad railway station canopy collapse." Instagram, June 3, 2025, https://www.instagram.com/p/DHTkhQpodxa/

4 Data was collected between March 16 and March 19, 2025, through a questionnaire by civil society organizations:Belgrade Centre for Human Rights, CRTA, FemPlatz, Civic Initiatives, A11 – Initiative for Economic and Social Rights, and Lawyers' Committee for Human Rights – YUCOM, with data processing by SHARE Foundation.

3 Part 1: Methodology of earwitness interviews

Earwitness testimony refers to the process of gathering and interpreting memory accounts based on sound rather than sight. In many investigative contexts, crimes are more often heard than seen, with auditory experiences sometimes serving as the sole evidence available. Despite this, conventional forensic methodologies tend to privilege visual over auditory information, leaving earwitness accounts undervalued and underutilised.

Earshot seeks to address this gap by developing tools and techniques specifically tailored to the auditory domain. Its approach centres on eliciting, reconstructing, and analysing sonic memories with scientific rigour and ethical consideration.

3.1 Methodological approach

Structured interviews are conducted with earwitnesses, using a multimodal approach that combines verbal enquiry with auditory stimuli. These stimuli may include synthesised tones, white noise, convolutional reverberation, digital acoustic modelling, and curated sound effects. This aids memory recall and provides earwitnesses with a perceptual vocabulary for experiences that are often difficult to articulate.

All sessions are carried out in a controlled and psychologically safe environment that emphasises care, consent, and sensitivity to trauma. This method is particularly effective in cases where individuals had only peripheral exposure to events (e.g., through walls, blindfolds, or other visual obstructions), or where specific sounds, voices or acoustic conditions play a defining role in how events were perceived.

3.2 Applications and precedent

This methodology has proven instrumental in investigations involving unlawful detention, abduction, and aerial attacks. Notably, it has been used to assess the acoustic signature of airstrikes, identifying jet and drone activity in conflict zones.

A notable example of this approach was the 2016 investigation into Saydnaya prison[5], led by Earshot's founding director, Dr Lawrence Abu Hamdan. Working alongside Forensic Architecture and Amnesty International, Dr. Abu Hamdan developed earwitness testimonies to map the conditions of incarceration under the Assad regime. This was one of the first public uses of earwitnessing as a primary forensic tool, setting a benchmark for future investigations. The liberation of the prison in December 2025 served to evaluate the effectiveness of the 2016 methods, as it was finally possible to see inside the prison and hear from many more survivors. Reviewing the 2016 model and witness descriptions alongside the photographs and testimonies that emerged after the prison's liberation revealed a striking resemblance, confirming the reconstruction process' accuracy.

3.3 Ethical considerations

Earshot adheres to strict ethical protocols to ensure the safety and autonomy of all participants. Informed consent is obtained prior to any interaction, with participants fully briefed on the purpose of the investigation, the nature of the sound-based methods used, and how their testimonies will be recorded, stored, and potentially utilised.

Given the often-traumatic contexts in which earwitness memories are formed, all interviews are conducted in trauma-informed settings, with psychological safety prioritised throughout. Participants retain the right to withdraw at any point without facing any consequences, and all data is handled with the utmost confidentiality, in line with international standards for human rights investigations and digital security.

5 Amnesty International (2016): Saydnaya – Inside a Syrian Torture Prison. In collaboration with Forensic Architecture. Available at: https://saydnaya.amnesty.org/ (Accessed June 3, 2025)

This commitment to ethical practice is essential not only to safeguarding participants, but also to ensuring the integrity and admissibility of the evidence collected through these methods.

3.4 Method of testimony collection: 15 interviews

In two separate 3-hour sessions, Earshot investigators interviewed 15 earwitnesses who were present during the alleged sonic attack on 15 March 2025. Initial introductions and video calls were conducted remotely using Microsoft Teams, and high-fidelity audio sharing was conducted using Cleanfeed. During the session, the earwitnesses' positions at the time of the silent vigil were geolocated and organised into three groups, A, B, and C, based on the proximity to Terazje Square, Kralja Milana Boulevard, and Slavja Square, respectively. For anonymity purposes, the earwitnesses are identified in this report by number (Witnesses 01-15) (see map below).

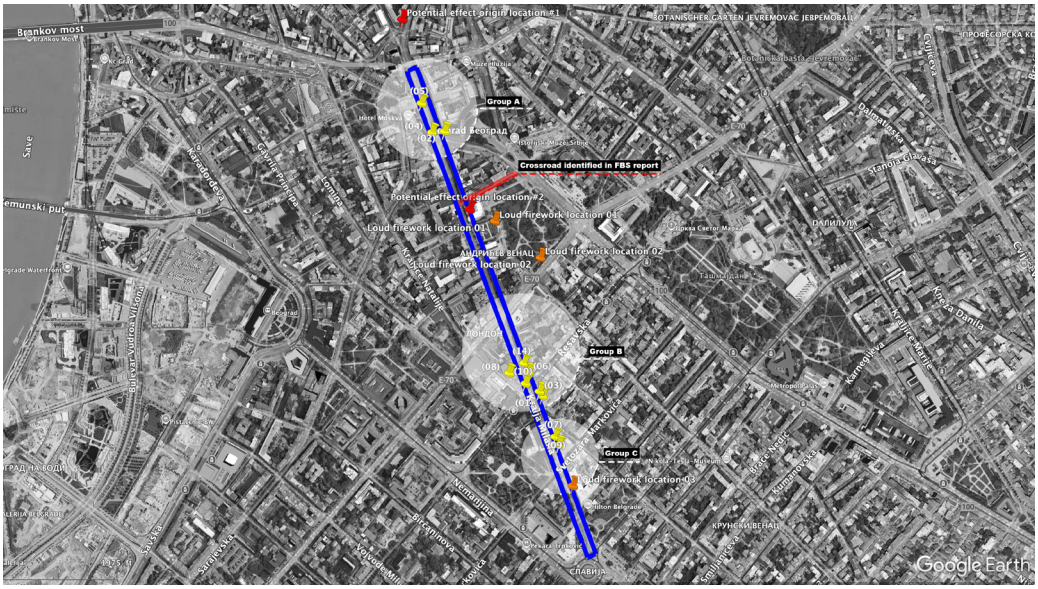

Figure 1: Map showing the three groups corresponding to the locations of the 15 earwitnesses during the silent vigil.

Each interview lasted 15-30 minutes and followed a semi-structured protocol derived from a prepared questionnaire. Investigators adapted their questioning in real time to preserve natural flow of the conversation while ensuring thematic consistency across testimonies. The objective was threefold:

1) to document their ability to analytically determine the sounds surrounding them during the silent vigil. The following questions illustrate the nature of the enquiries in one section of the interviews: "Could you describe the scene and context before you heard any alleged weapon or commotion? What could you hear around you, and what was the scene like before it started?"; "It would be helpful to establish the context, such as your position, where you were, and what you experienced during the silent vigil."; "Do you remember hearing anything unusual in the crowd during the silent vigil before the attack? Did you hear or see any unusual movements before?";

2) to capture detailed descriptions of the alleged sonic attack. For example, questions such as the following were asked during the interviews: "Could you describe the sound?;" "Had you ever heard anything like that before? Have you ever experienced something like that?;" "Where would you say the sound was coming from? Which direction? Was it passing at ground level or overhead?;" "Was the sound coming from behind you, as you can hear in your headphones now?";

3) to elicit additional sensory impressions that would be useful for reconstructing the event. This methodology was aided by a library of 26 sample recordings. The library was curated based on the descriptions of the sound of the attack mentioned in the 3,244 written statements. These sounds ranged from stampedes, jet engines, sirens,

sine sweeps, white noise, whistles, fireworks, and supersonic shockwaves. Each session included a lead interviewer and three assistants: one responsible for geolocation (Google Earth), one for playback and manipulation of pre-curated audio samples, and one for real-time spatialisation of those sound samples. This configuration ensured procedural consistency across the earwitness interviews.

The playback and manipulation of pre-curated audio samples involved the use of Digital Audio Workstation (DAW) software such as Reaper and Ableton. Real-time spatialisation of audio samples was achieved by using Ableton reverb and binaural plugins together with manually setting parameters over playback time. Additional synthetic and composite audio generation was done through Touchdesigner through the use of pure sine frequency and equalisation plugins.

4 Part 2: The silent vigil

> *"Nothing was happening. We were just standing. It was quiet because of the 15 minutes that we were giving for the people that are not with us anymore." (Witness 03)*

Backed by an authored report by the Federal Security Service (FSB), the Serbian authorities deny any attack on the silent vigil and claim that 'pyrotechnic and incendiary devices [fireworks]' were the catalyst to the disorder[6]. Earshot investigators sought to verify this claim. To this end, the first half of each earwitness interview was dedicated to understanding the earwitnesses' ability to discern the sounds they had heard during the silent vigil. Establishing the state of their acoustic analytical capacities before the incident was necessary to ascertain whether a sound such as a firework or other explainable acoustic stimulus could have caused the mass panic and sudden motion seen in the videos circulating online. Earshot began by asking each earwitness to describe all the sounds they remembered hearing during the silent vigil.

> *"Nothing special. Sounds, the sounds in the dead silence were only from drones. And eventually from some phones, notifications on phones." (Witness 13)*

> *"I could hear very distant, some sounds that were breaking the silence, but it was very far away, and you know, it was someone trying to provoke. And then someone shushing them. But it was completely unrelated to what happened. But it was like the only sound I could hear." (Witness 06)*

> *"Before the attack, it was all silent because I can hear someone cough maybe 200 metres away from me because it was so much silent. And then the attack itself." (Witness 08)*

These excerpts are indicative of the crowd's high attentiveness and responsiveness to the surroundings in the moments leading up to the sonic attack. Earwitnesses were able to remember with clarity the sonic constitution of the silent vigil, due to the fact that they were concerted in their efforts to remain silent. Interruptions of the silence were registered more acutely because of the collective intentionality to be silent. The demonstrated sensitivity to sound, for example through the ability to discern and recall a cough from approximately 200 metres, is indicative of the exceptional acoustic condition that these protestors collectively manifested.

From an analysis of 11 video recordings Earshot was able to derive an ambient noise level of approximately 50dB during the silent vigil. Testimonies mentioned hearing sounds such as coughs, phone notifications, drones, and popcorn machines, noting often how far away the sounds were from them. As sound decays 6dB every doubling of distance from its source[7], most of these sounds would have measured around the

6 CRTA, Translated Report of the Federal Security Service Regarding the Alleged Use of a Sonic Weapon at the Silent Vigil Protest in Belgrade (Belgrade: Centre for Research, Transparency and Accountability, 2025), 2: "During the operation, the disorders began with pyrotechnic and incendiary devices used in front of an ambulance."

7 David A. Bies and Colin H. Hansen, Engineering Noise Control: Theory and Practice, 4th ed. (London: Spon Press, 2009), 219.

same intensity if not lower than that of the general ambiance during the silent vigil: 35-45dB for a cough heard 200 metres away, ~50dB for a quadcopter (referred to as drone in the testimonies) flying 50 metres above ground level, ~40-60dB for a phone notification heard from a few metres away. It was further established that a significant proportion of the sounds in question were either faintly registered by the devices' microphones (e.g. coughs, drones, phone notifications) or were either too quiet or too distant from the locations of recording (e.g. popcorn machine). Though microphones can have a broader sensitivity to sound pressure and frequencies than the human ear, it is well established that the ear possesses a much more sophisticated auditory processing capability[8]. The findings from this chapter demonstrate that the crowd exhibited the capacity to both recall and discriminate a wide range of sounds at varying levels of intensity from the sonic attack. This indicates the necessity to incorporate earwitness testimonies in the analysis of the events leading to the attack and to exercise caution when relying solely on video recordings as evidence in determining the presence of sonic weaponry.

> *"Lawrence Abu Hamdan: OK. And do you feel that there, as the sound got louder, it was easier to disassociate that sound from the one that the people could have been making.*
> *Witness 07: Oh yeah, of course, of course, especially when it flew over us and that was when I was sure something happened."*

These findings were further substantiated by the exhaustive elimination of multiple audio samples of what the attack may have sounded like by the earwitnesses Earshot interviewed. Sounds of an explosive or ballistic nature, such as those generated by fireworks, were ruled out, as were the noises generated by a quadcopter flying overhead. Furthermore, large stampede noises created by layering footsteps and their reflections to form a mass of crowd-generated sound were not identified as resembling the sound of the attack. In fact, earwitnesses were able to clearly differentiate between stampede noises and the sound of the attack. The elimination of these sounds was significant in further solidifying the conclusion that the crowd was specifically subjected to a weapon that produced sonic effects, rather than being startled by a crowd-generated noise or otherwise explainable acoustic triggers. Taken together, these findings demonstrate therefore the acute analytical state of sonic attention exhibited by the earwitnesses, thereby challenging the FSB report's claim that the 'disorders began with pyrotechnic and incendiary devices [fireworks]'.

Subsequent to the initial elimination process, auditory stimuli in the form of sounds typically generated by weaponry that produce sonic effects were presented to the earwitnesses. These included sirens and sine sweeps, similar to the onboard sounds of sonic weapons such as the Long-Range Acoustic Devices (LRADs). These sounds were not identified by any of the 15 earwitnesses. The sound of a Vortex Cannon was also presented to the earwitnesses, which Earshot had identified in its initial assessment. This auditory stimulus was also universally rejected by them, except for one earwitness who noted a vaguely familiar sensation.

> *"You could hear the drones buzzing. So, so, so silent." (Witness 01)*

Together with 4 earwitnesses identifying sounds of drones flying overhead, 2 earwitnesses further identified the sounds of motorcycles in the distance. Testimonies of vehicular sounds are significant in that they demonstrate the earwitnesses' ability to distinguish between vehicular sounds and the vehicular quality of the sound of the attack later experienced.

> *"That was very quiet. I heard just drones recording above us and 1 motorcycle that tried to go over, but it stopped and [was turned off] in the middle of the street." (Witness 12)*

> *"I saw two drones above our heads. And then, uh, you can hear the whirr of the drone. And then they were, I think gone." (Witness 14)*

8 Lawrence E. Kinsler et al., Fundamentals of Acoustics, 4th ed. (Hoboken, NJ: John Wiley & Sons, 2000), 312.

4.1 An unfamiliar sound

> *"The sound was very strange and alien to me. I don't know if I can actually reproduce something like that." (Witness 11)*

Having established the earwitnesses' capacity to describe and identify the sounds around them during the silent vigil, the questioning moved on to the sound of the attack itself. 8 of the 15 earwitnesses explicitly stated that they had never experienced or heard "a sound like that" before. All 15 of the interviewed earwitnesses, as well as more than 60% of the written statements, used a combination of at least two sounds to describe what they had heard that night. This finding suggests that, in contrast to the noises described and identified by earwitnesses during the silent vigil, the sound of the attack was unanimously experienced as an unfamiliar auditory event.

> *"It's not normal situation that you feel on that place where you are. I mean you can, feel that when you're, when you go, when you are travelling or you're when you're on airport or something like that. But on the street in front of the hotel, during the silence, it's not normal sound to hear on that position. It is something that is frightening you." (Witness 02)*

> *"Yeah. I think it wasn't people because I felt something, like it's something that you don't see, but you feel it. And maybe I felt like, uh, it's going to like, take us from the ground and put us on the floor. I felt something like that. It's going to take me and I'm going to be on the floor, all of us." (Witness 03)*

4.2 Embodied sound

> *"It wasn't that much the sound. It was the feeling. The heart rates jumped up and me and people around me had this, you know, need to move away from the spot that we were in and this is it." (Witness 09)*

For many, the auditory experience was not simply the perception of sound; it was also accompanied by a strong physical sensation. In 2,335 of the written statements (72% in total) the sound was accompanied by such a sensation. 8 earwitnesses described it as a physical sensation akin to a force permeating or entering the body, prompting an instinctive reaction to move away from the centre of Kralja Milana boulevard. This auditory phenomenon, imperceptible yet potent, exhibited a unidirectional force that prompted the immediate movement to either side of the boulevard.

> *"It was not just what we heard, it was more the feeling that we felt, it was something that made us run away from there. So, this is what I experienced (…) This feeling that something is happening, and we don't know what is going on, it just made us run away. This feeling that I never felt before because I don't know what is going on." (Witness 08)*

> *"I felt like this sound was going through my body like I felt it in my bones, in my muscles. And throughout the head with the chills in my body as I felt the sound." (Witness 09)*

> *"It's like, it's coming towards me (…) and then it was in me. You know it's like that." (Witness 11)*

> *"But this sense was what I what I remember. So probably like my adrenaline jumped, but it wasn't like. I've been to a lot of demonstrations in the 90s. I ate tear gas and everything, and this was a little bit different. Because, like the stress was from the inside, not from something that I saw or that is going to happen, then we need to run left, run right, whatever. But this was from the inside. Maybe I'm not describing it well." (Witness 14)*

To replicate the intensity of this sonic experience is challenging with the use of only headphones and a remote connection to the witnesses. In order to approximate the sensation, Earshot investigators used very low frequency 20 Hz tones, played to 13 earwitnesses, to elicit a physical reaction. While less perceptible to the ear and close to the resonant frequency of a human skull, the 20Hz tone produces low-frequency pressure waves that resonate through the body, recreating an effect of physical vibration. All earwitnesses identified the effect of this sound as closely resembling the sensation they felt during the event, though many remarked that it was the feeling that was approximated by the sound but that the attack did not resemble the sub frequencies sound played.

"I don't remember that specific sound [20Hz], but the sensation and vibrations are similar to what I felt." (Witness 09)

This consistent response to a sonic stimulus that approximates the feeling of a sound as an internal sensation, provides an initial clue into the possibility of the use of a highly directional acoustic weapon. It is unique to such weaponry to channel intense sounds in narrow streams, causing a disorientating sensation that witnesses describe as moving "inside" or "through" them. This internal sensation described by earwitnesses is indicative of an anomalous acoustic event which was not only unidentifiable as a sound, but also propagated through the air in ways that sound typically does not. The experience was therefore highly unfamiliar both in its perceived appearance and as an acoustic experience in itself. In other words, earwitnesses described hearing an unfamiliar sound that also behaved in an acoustically idiosyncratic or anomalous way

4.3 A rapidly approaching, vehicle-like sound

"I thought that 200 bikers, people on the motorcycles are coming towards us. (…) My biggest impression is basically that feeling that, uh, that fear that some machine is going to get over" (Witness 02)

"And then I heard very weird sound like I was 100% sure that a vehicle is approaching (…) coming towards us." (Witness 06)

The sound was described as approaching the earwitnesses in a highly directional way from the northern end of Kralja Milana Boulevard, from the direction of Terazje Square – a detail emphasized by 11 out of the 15 earwitnesses, all of whom confirmed it originated from that same direction. 9 of the 15 earwitnesses explicitly reported how the sound advanced rapidly, approaching them in a vehicle-like manner. 1,907 of the written statements (59% in total) referred to the sound of the attack as having a machinic, vehicle-like quality.

"A sound I never heard before. It was a mixture of like a herd of horses coming towards me, but also with something mechanical, not as a car but something bigger and louder coming towards me. So, something in between." (Witness 05)

"I could hear the sound when, like, you know, when you start the engine, and you hit the gas pedal hard and that sound I could hear, that sound like approaching and becoming more distant. That is why I was 100% sure that some things ran through the crowd." (Witness 06)

"Maybe 10 seconds before this strong sound was heard, I actually heard this electric buzzing sound like electric car or something like that going for 10 seconds. Something like that." (Witness 10)

"It was just a roaring sound of like a jet engine or something like that. It just went through the crowd." (Witness 07)

"It was complete silence (…) then I heard this loud sound that it was like breaking the sound barrier and it was a strong sound." (Witness 09)

7 out of 8 earwitnesses who were played a jet engine sample recognised it as being similar in intensity and sonic profile to what they remembered. The comparison was rarely based on one sound sample alone. Instead, they responded to how the sample mimicked the perceived movement of the original event: advancing from a distance and growing in strength to occupy the vertical or overhead space. This corroborates numerous accounts of a fast-approaching directional force that bore a resemblance to an aircraft or high-speed mechanical propulsion at proximity.

"Lawrence Abu Hamdan: So, we're going to play a couple of sounds and see if they were present.
Witness 08: Yes, yes, yes, yes.
Lawrence Abu Hamdan: Like this, huh? Something like that. I see. And you felt it, like coming closer. Closer.
Witness 08: Yes, coming closer in high speed."

4.4 The fear

"You know how, but and it was so unreal, and you cannot explain it to your brain that you hear the car coming, but you cannot see" (Witness 01)

Of the 15 earwitnesses interviewed, 11 mentioned this feeling of something coming towards them, rapidly approaching, prompting them to react. Even though all of them were able to identify the place from which the sound emanated, they were unable to locate a visible source of the sound. This fact was explicitly stated by 8 of the earwitnesses. This absence of a visible source of sound that caused such an intense physical experience contributed to a pervasive sense of fear and disorientation.

"Well, just the shock of it, it was, I don't know, we've, as I said, we've been to a lot of protest and every time when it's the end of the silence, you get this release because everyone starts making noise again and we, everyone knows what it means. Everyone knows why we are there. So, we were just waiting for that to happen and instead of that we got something that we didn't know what it was. So, it was a shock, and I don't know, just the panic, the panic of people stood in my mind the most. And that's the only thing that I have. Now we are two weeks removed from that. Bit more so just that sound of panic and just people. Just falling over, each other, running away from nothing, basically, that was my recap of the event." (Witness 07)

In contrast to the FSB report, which claimed that the crowd exhibited no signs of acute distress[9], 5 of the earwitnesses explicitly described a clear and immediate sense of an imminent threat. This perceived threat did not stem from the intensity of the sound, but rather from its unfamiliar acoustic profile, marked directionality and lack of identifiable source. Earwitnesses consistently reported a sense that something was approaching rapidly at high speed, suggestive of an impending projectile or vehicle impact, creating a state of anticipatory fear. 393 (12% in total) of the written statements pointed to a clear sensation of fear and distress, including discomfort, unease, uncertainty and a sense of impending danger. Although no physical impact occurred, the convergence of testimonies describing this anticipatory response suggests that the sound was collectively and coherently interpreted as a threat.

"And then uh. Something like anxiety or fear. (…) I was so afraid of what happened to my kids." (Witness 01)

"So, the intensity is what stuck with me and the moment I felt it, it was like I felt it in my chest. Then the heart started pumping. And then and like, a panic (…) I felt anxiety in my chest" (Witness 04)

9 CRTA, Translated Report of the Federal Security Service Regarding the Alleged Use of a Sonic Weapon at the Silent Vigil Protest in Belgrade (Belgrade: Centre for Research, Transparency and Accountability, 2025), 2: "During the operation, the disorders began with pyrotechnic and incendiary devices used in front of an ambulance."

"Mostly it was something that caused strong fear in me, like something I had to explain for." (Witness 06)

"Just after the sound, I rushed down the street. You know, I saw people running. I saw people, you know, looking for other people (...). I Started running, you know, and jumping over people because people fell on the ground." (Witness 11)

For some, this sound also appeared to trigger associative responses linked to past experiences of conflict. 2 earwitnesses explicitly referenced memories of wartime environments, noting similarities between the sound they heard and those associated with NATO's aerial bombardments of Belgrade in 1999. In these instances, the sound functioned as an acoustic analogue to prior traumatic events. Even in the absence of physical harm, it generated a conditioned fear response, evidencing how, in this context, sound operated as a psychological weapon by activating latent or inherited memories of violence.

"And then uh. Something like anxiety or fear. I thought of NATO bombing. (...) That fear and discomfort that I felt in my body, not the sounds. Because those rackets and everything you couldn't hear it, you couldn't see it. You couldn't see when the bomb [hit], [it] felt like bombing." (Witness 01)

"I remember the similar sound when it was bombing of Serbia and I was in my hometown and one of these bombs went straight above my head (...) Or just because of the memory of the attack, it's uncomfortable. The memory of the bombing of Serbia, which what made it uncomfortable. (Witness 08)

The consistency of these testimonies when describing both the silent vigil and the sonic attack enabled Earshot investigators to categorise the sound heard by these earwitnesses according to four characteristics: highly directional sound, engine-like sound, embodied sound, and perceptually ambiguous sound. These characteristics would later be used to reconstruct the sound that the interviewed earwitnesses heard that night.

5 Part 3: Reconstructing the sound of the sonic weapon

Drawing on 15 earwitness interviews and comparisons with 3,244 written statements, Earshot investigators reconstructed the sound of the attack using a process combining verbal description, sonic emulation, and sample recognition (see Part 1 for methodology). What emerged was a composite sound shaped by the four recurring characteristics of the sound identified in Part 2: vehicle-like sound, highly directional sound, embodied sound, and perceptually ambiguous sound. The importance of this exercise in sonic reproduction resides in substantiating a mass auditory experience shared by thousands. The ability to reproduce the sound is a testament to the striking consistency between the interviewed earwitnesses, and the 3,244 written statements gathered by CRTA and other civil society organisations.

As stated in Part 2 of this report, the process of earwitness interviewing enabled the exhaustive elimination of several potential sound sources associated to the attack. The responses of the earwitnesses to the sounds presented to them were instrumental in identifying three sounds in Earshot's sample library that most closely resembled the one heard by the earwitnesses that night. The following three sounds were identified by all participants as consistent with the auditory experience described:

1. A very low 20 HZ frequency, close to the resonant frequency of the human skull. This sound was played to the earwitnesses on the understanding that it aimed to recreate the physical experience of the sound rather than its audible qualities.

2. Jet engine noises recorded at source – characterised by a continuous broadband noise – with the sound of an accelerating combustion engine. This

sound was first verbally identified by multiple earwitnesses as a core quality of the sonic experience and was later recognised sonically when played back to them without knowing what they were listening to.

3. White noise: characterised by equal intensity across all audible frequencies. This sound was widely identified as similar to that heard during the incident, particularly by earwitnesses located at the intersection of Kralja Milana Boulevard and Resavska Street as well as further south along the Kralja Milana Boulevard.

Though these three sounds were consistently identified in the earwitnesses' testimonies, none of these sounds individually accurately represented what was heard. However, by layering these samples and applying spatialised sound effects that related to the four characteristics of the sound, Earshot investigators were able to create a plausible acoustic reconstruction of the sound heard by the interviewed earwitnesses. The process is presented below.

Engine-like sound
Earwitnesses consistently referred to sensations of air pressure and engine-like sounds, using terms such as "air," "woosh," "jet," and "not a motor starting but more a motor in motion." (Witness 01). These descriptors point to the presence of a broad-spectrum frequency sound, like white-noise.

Highly directional sound
As demonstrated in Part 2, witnesses describe the sound as, "something coming towards me" (Witness 05). To reconstruct this movement, the amplitude of bandpass-filtered white noise was designed to rise logarithmically.

Embodied sound
Witnesses frequently described the sound as something "going through the people" (Witness 10). To simulate embodiment, spatialisation plugins that model the movement of sound around the listeners headspace were used. These increase the perceived spatial spread of the sound as it approaches the listener.

Perceptually ambiguous sound
Earwitnesses consistently describe the sound as evoking the texture of a jet or an engine whilst also being unlike anything they have heard before. To explore this perceptual ambiguity, a broadband frequency sound was shaped using multi-band dynamics - a sound design technique that allows frequency bands to respond independently over time. Dynamic movement in the high frequencies produces the sensation of a highly directional sound that is mechanical yet unidentifiable.

This reconstruction does not aim to replicate the original sound at its source, but rather to produce a composite that draws from the timbral qualities and perceptual impressions of spatial movement described by earwitnesses. Despite the denials by Serbian authorities of the use of a sonic weapon, and the inability of Earshot to identify verifiable traces of it in available recordings (the reasons for which are addressed in Part 4 of the report), the cross-corroborative accounts provided by thousands of individuals form a substantial evidentiary basis. The reconstruction serves as an approximation of how earwitnesses described hearing this sound, based on consistent and repeated accounts, and counters ongoing efforts to negate the protesters' accounts of that night.

6 Part 4: Could the Long-Range Acoustic Device (LRAD) be responsible for this attack?

On 19 March 2025, Marinika Tepc, a member of the Serbian parliament, presented the Serbian public with an official document clearly showing the Serbian Ministry of Internal Affairs requesting the procurement of seven 450XL LRADs and nine 100X LRADs[10]. Ahead of the press conference at which she made the documents public, Tepic posted an image on X captioned "On the right - a gathering of students and citizens. Left - POLICE HOLDING A SOUND CANNON on a jeep near the National Assembly of the State of Serbia."[11]

Figure 2: Image shared by Serbian member of Parliament Marinika Tepic highlighting Serbian police next to protestors with what appears to be a LRAD 450XL.[12]

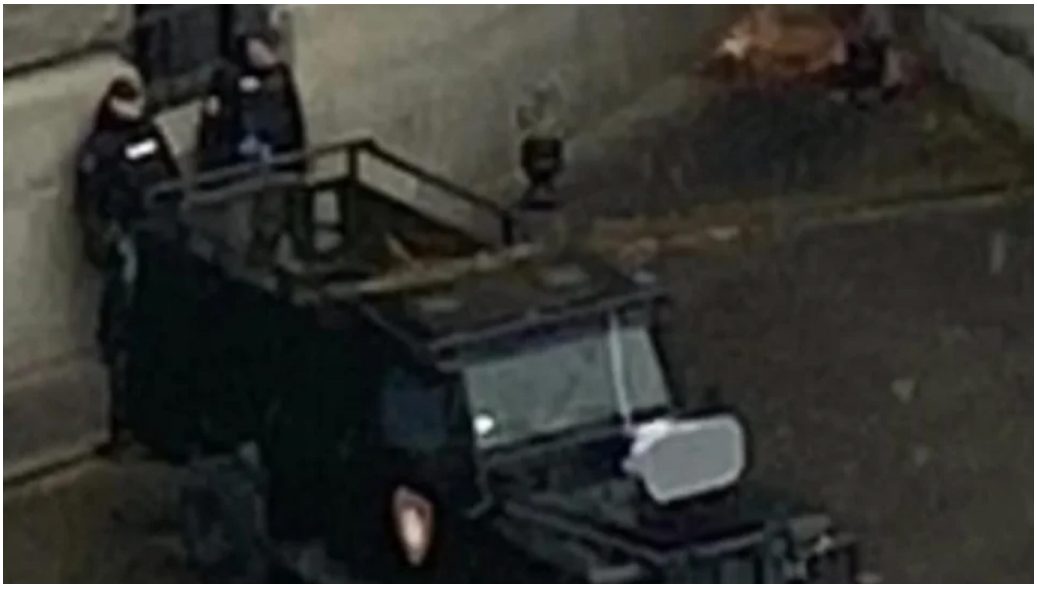

Figure 3: Image shared in Marinika Tepic's tweet zooming in on the vehicle showing what appears to be an LRAD 450XL.[13]

10 N. V. O., "Tepic: Internal Affairs Ministry Acquired Seven LRAD 450XL Devices," N1 Info, March 19, 2025, https://n1info.rs/english/news/tepic-internal-affairs-ministry-acquired-seven-lrad-450xl-devices/. (Accessed on June 3, 2025)

11 Tepic, Marinika (@MarinikaTepic). "Tepic: Internal Affairs Ministry Acquired Seven LRAD 450XL Devices." X (formerly Twitter), March 19, 2025. https://x.com/MarinikaTepic/status/1902285248492154901.(Accessed on June 3, 2025)

12 idem

13 Idem

Figure 4: LRAD 450XL, Product Specifications, Dash Mount Control Module (MP3 Player) visible.[14]

An anonymous member of the Gendarmerie corroborated the legitimacy of the image that Tepic shares telling Danas, a daily newspaper published in Belgrade, that "The device was mounted on the hood of our vehicle "Defender", which we colloquially call "Indian". It is a defender that does not have a roof. Next to him was the "operator" who was in charge of handling this device. Apart from this vehicle, the same vehicle with the same device was parked to the left of it. [He further says], it was explained to us that this device will be activated if there is a need, as well as how to behave if there is an activation". The gendarme also disclosed that "there were several of these devices deployed, and they were distributed across different locations."[15]

In light of this proof of purchase and presence on site, as well as the intention to use the LRAD 450XL, this final chapter will investigate whether the acoustic nature of this specific LRAD weapon matches the testimonies of the 15 earwitnesses.

6.1 LRAD overview

The LRAD is a highly directional sonic weapon that can transmit voice commands or sounds with high clarity and at volumes of up to 145 dB over long distances. The LRAD 450XL speaker comprises an acoustic array that produces a distinct emission pattern, unlike the typically omnidirectional manner in which sound spreads in standard acoustic conditions. This unique emission pattern is directly related to the phase inversion produced by the array structure present in the LRAD 450XL. Sound travels from the LRAD 450XL in a 30° cone and can remain intelligible for up to 1.7 kilometres (1700 metres).[16] Given its MP3 storage system, which enables playback of any uploaded sound, an LRAD operator could successfully recreate the experiences described by earwitnesses through playback of readily available broad-frequency-spectrum sounds, such as white noise or widely available sound effects of vehicular acceleration.

With the capacity to maintain volumes of over 80dB over a 1700 metres propagation length, such a sound could have been continually audible along the entire length of Kralja Milana Boulevard, where the protesters were gathered that night. This contradicts the claims made in the FSB report on the incident, which states that "Crowd movement was tracked at a fixed range (at about 600 meters) from the

14 Genasys Inc., LRAD 450XL Equipment Manual, Part No. 112343-00 Rev. E (San Diego, CA: Genasys Inc., January 2021

15 Ugljesa Bokic, "Zandarm tvrdi za Danas: Vise 'zvucnih topova' bilo rasporedeno u subotu na protestu," Danas, March 19, 2025, https://www.danas.rs/vesti/drustvo/zandarm-tvrdi-danas-vise-zvucnih-topova-bilo-rasporedjeno-u-subotu-na-protestu/. (Accessed June 3, 2025)

16 Genasys Inc., LRAD 450XL Equipment Manual, Part No. 112343-00 Rev. E (San Diego, CA: Genasys Inc., January 2021).

epicentre. This effect can only be achieved through coordination by organizers within a crowd and is not possible with a brief use of a special device."[17] The claim that this cannot be achieved by a special device, but only 'through coordination by organisers', is demonstrably false when reviewing the capacities of the LRAD 450XL in its user manual. This data demonstrates not only that the LRAD 450XL can be audible well above the 600 m defined in the FSB report, but also that it would be an effective tool for dispersing crowds extending over 1 kilometre, the length of Kralja Milana Boulevard.

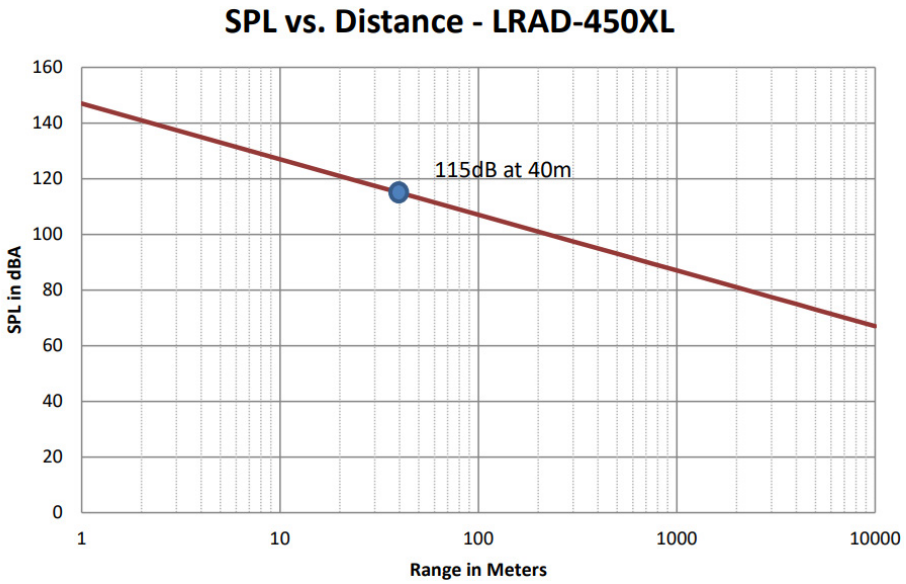

Figure 5: LRAD 450XL technical specification showing a capacity to maintain a volume of 80dB and above for up to 1.7 kilometers.[18]

6.2 Why is the sound of the attack not heard clearly on the recordings?

Although Earshot could not find any sound typically associated with the LRAD 450XL in the video recordings, an unidentifiable, non-human sound (not generated by voices or crowds) is heard faintly just before the crowds split. This sound matches some of the descriptions provided by earwitnesses.

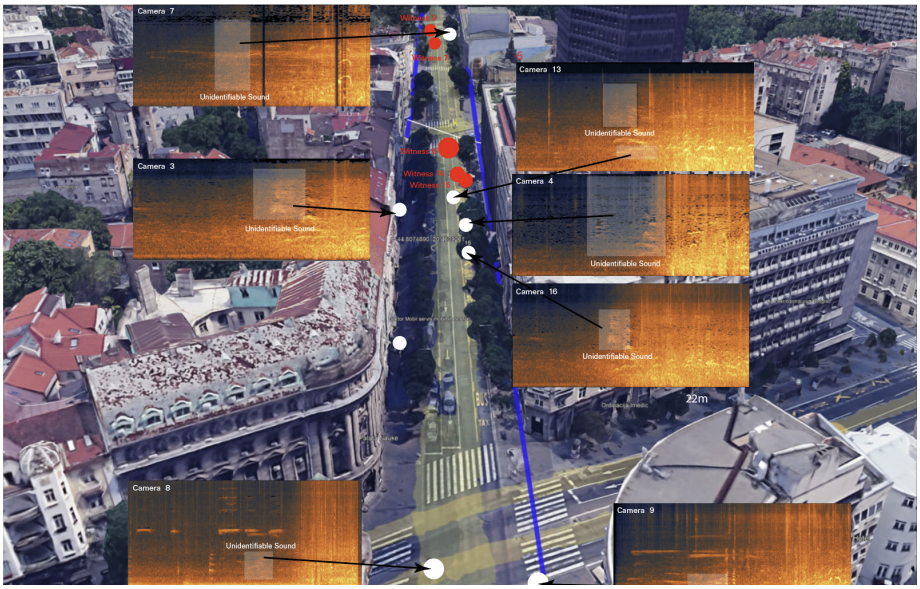

Figure 6: Sounds identified by Earshot investigators that are not made by the crowd or human voice.

17 CRTA, Translated Report of the Federal Security Service Regarding the Alleged Use of a Sonic Weapon at the Silent Vigil Protest in Belgrade (Belgrade: Centre for Research, Transparency and Accountability, 2025), 2

18 Genasys Inc., LRAD 450XL Equipment Manual, Part No. 112343-00 Rev. E (San Diego, CA: Genasys Inc., January 2021).

Earshot cannot confirm that these are artefacts of a sonic weapon. As discussed in Part 2, the sophisticated processing capability of the human ear often allows the ear to identify and focus on sounds or sonic queues that can evade audio recordings, especially in the context of sounds masked by ambient noise. An analysis into the LRAD 450XL's technical specification shows that the absence of a verifiable LRAD sound does not indicate the absence of this weapon. Rather, sonic activity indistinguishable or barely distinguishable from the background noise of the recording could indicate the presence of an LRAD, given the unique and patented mechanisms by which it propagates sound from its speaker array.

These mechanisms of sound propagation are characterised by two distinct rates of sound decay along a longitudinal axis (parallel to the LRAD's direction of sound propagation) and latitudinal axis (perpendicular to the direction of sound propagation). In the case of the longitudinal axis, sound decays by 6dB with every doubling of distance, as is common with all sound dissipation (figure 7). Conversely sound decay along the latitudinal axis is specific to the patented mechanism of the LRAD 450XL, where a decay of 20dB is observed at the edge of a 30° 'front beam' operation zone (figure 8).

Table 1: Acoustic Exposure Limits

Max Sound Level (dBSPL)	Time limit (minutes)	Distance (meters)	Max Sound Level (dBSPL)	Time limit (minutes)	Distance (meters)	Max Sound Level (dBSPL)	Time limit (minutes)	Distance (meters)
<80	no limit		92	95	562	105	4.7	126
80	1440	2239	93	76	501	106	3.8	112
81	1210	1995	94	60	447	107	3	100
82	960	1778	95	48	398	108	2.4	89
83	762	1585	96	38	355	109	1.9	79
84	605	1413	97	30	316	110	1.5	71
85	480	1259	98	24	282	111	1.2	63
86	381	1122	99	19	251	112	0.9	56
87	302	1000	100	15	224	113	0.7	50
88	240	891	101	12	200	114	0.6	45
89	190	794	102	9.5	178	115	0.5	40
90	151	708	103	7.5	158	>115	forbidden	40
91	120	631	104	6.0	141			

Figure 7: LRAD 450XL technical specification showing a central axis volume attenuation of 6dB for every doubling of distance.[19]

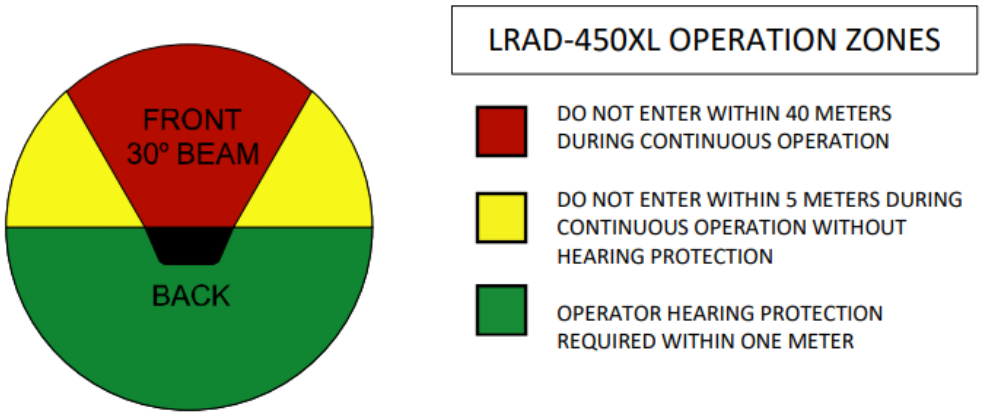

Figure 8: LRAD 450XL technical specification showing a 30° cone of acoustic propagation with a zone of decay beyond its edges.[20]

Using these two axes and their distinct rates of sound decay, Earshot simulated the perceived loudness of the LRAD 450XL to demonstrate the dramatic drop in intensity

19 Genasys Inc., LRAD 450XL Equipment Manual, Part No. 112343-00 Rev. E (San Diego, CA: Genasys Inc., January 2021).
20 Idem

depending on the listener's position in the 30° 'front beam' operation zone. For example, given a source volume of 145 dB, a listener positioned directly in line with the front beam 160m away from the source would perceive a sound with an intensity of 103 dB, as loud as a chainsaw. However, if the listener were to move such that they were positioned just 12° off the central axis of the front beam, still 160m away from the LRAD, the latitudinal sound decay of 20dB for every doubling of distance would reduce the perceived intensity down to 75dB, as loud as vacuum cleaner. If the listener were to move further to 18 degrees off the central axis just outside the 30° 'front beam', the perceived intensity would drop further to 60 dB, as loud as a normal conversation.

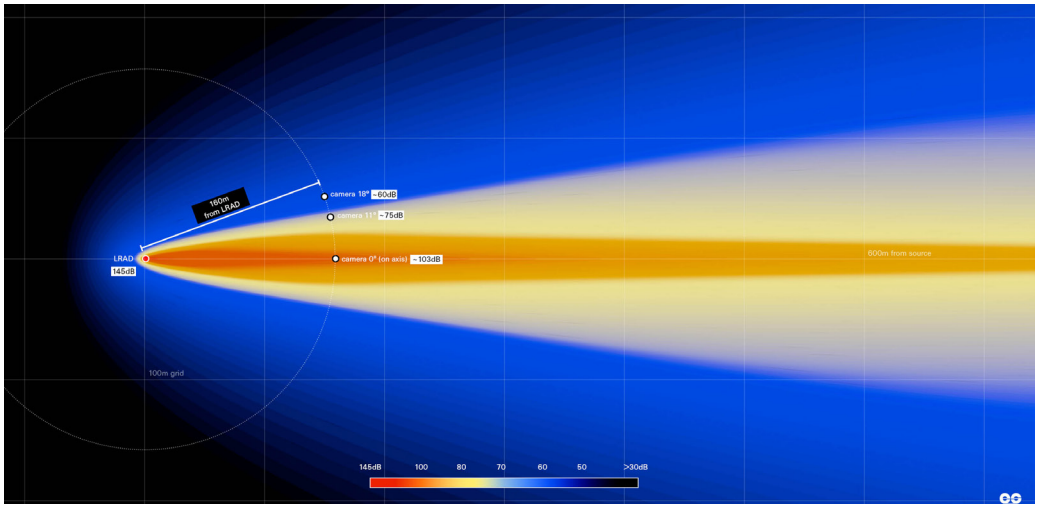

Figure 9: Aerial diagrammatic view of sound propagation of LRAD 450XL according to its user manual. The diagram illustrates three cameras positioned at 0°, 12°, and 18° off the central axis of the LRAD 450XL's 'front beam' operation zone, at 160 metres from the source.

These simulations illustrate how small changes in the angular position of a listener to the central axis of the LRAD produces significant reductions in perceived intensity. However, these calculations are based on the technical specifications of the LRAD 450XL in laboratory conditions. They do not consider the impact of environmental factors such as sound absorption and occlusion from the bodies of thousands of protestors, buildings and trees, which, combined, would considerably increase the attenuation levels illustrated above.

Earshot analysed the relative change in sound pressure levels from the silent vigil, found to be 50dB, to the moment the crowd reacts to the attack, around 80dB. This analysis, performed on 11 video recordings from the protests, shows an average increase of at least 30dB. Given the attenuation analysis of the LRAD 450XL, angular rotation of over 18° can reduce the volume of the LRAD 450XL to a level indistinguishable from, or quieter than, the ambient noise of the crowd during the attack.

The perceived intensity of sound is not solely a question of sound pressure levels (dB). Broad frequency sounds such as the sound reconstructed through the earwitness interviews are similar to the ambient broad spectrum sounds of a street. As a result, such similar sounds can be perceived as indistinguishable from ambient noise. Conversely, sounds with distinct tonal characteristics such as sirens would likely be perceived more clearly even if heard at the same intensity as ambient noise. Furthermore, due to the even more extreme decay rate that is typical with higher frequencies, the attenuation measured in the simulated position 12° and 18° off axis would be even more extreme for high frequencies (4kHz – 20kHz). The combination of sound decay across the longitudinal and latitudinal axis as well the even more extreme decay of high-frequency would likely result in the masking of the sound of the attack under the ambient noise of the silent vigil, especially given the sudden rise in the noise floor at the immediate onset of the attack. This provides one explanation as to why the LRAD 450XL sound is not directly audible in the recordings.

Additional factors such as the elevation of the LRAD's position over the street and the location along the width of the boulevard would further contribute to the LRAD sound being registered as either inaudible or barely distinguishable from the general background noise by the recording devices.

Additionally, the location of the cameras could add to the lack of verifiable sonic traces. Whilst video recordings of the event consistently show what looks like a force splitting the crowd from the middle of the street, many of the video recordings analysed were located to the sides of the road and were immediately pushed to the edges at the onset of the attack. These positions just outside of the central axis of Kralja Milena, and therefore into further attenuated zones, also explain why the sound may not be overtly registered on recording devices.

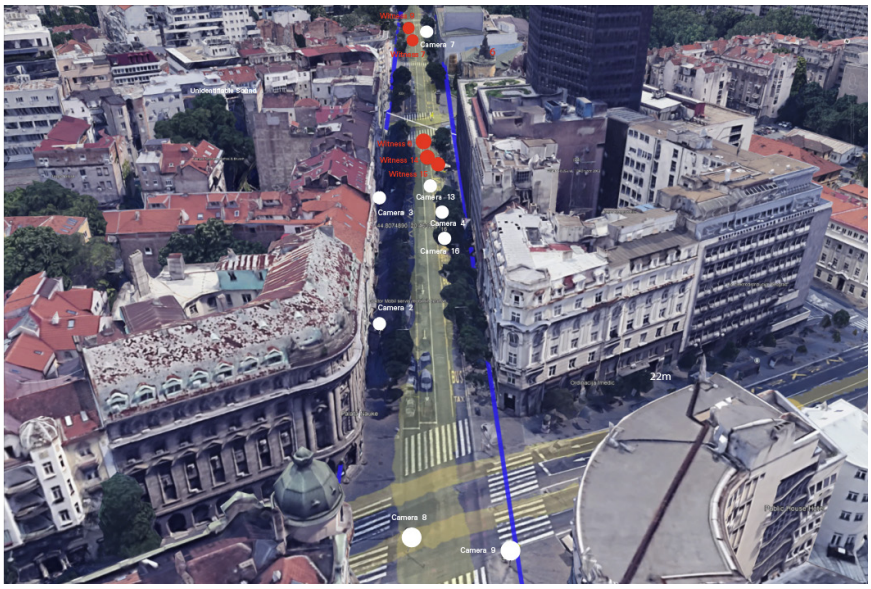

Figure 10: Map identifying location of devices from which recordings of the event where made in comparison to earwitness interviewee locations.

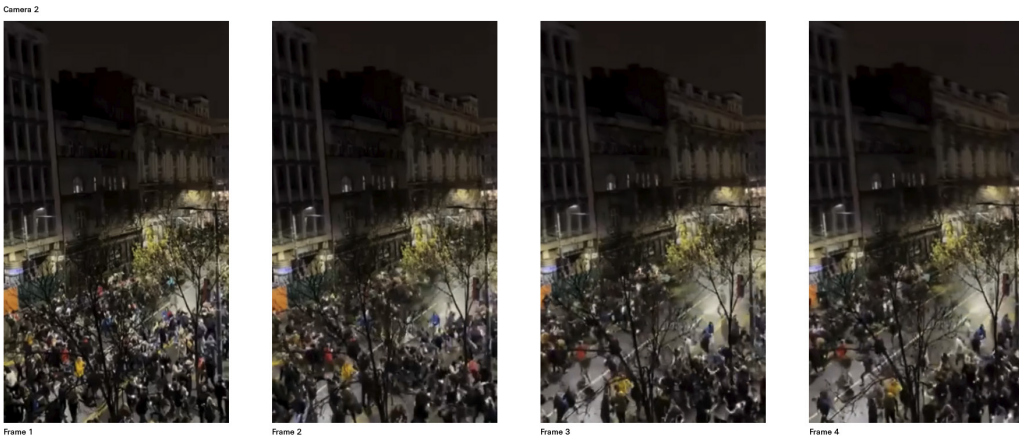

Figure 11: 4 separate frames taken from Camera 2 (referred to in the above image) showing a force moving protestors from the center of the street to the sides.

As described above, slight rotational movements at the source can produce dramatic impacts on the capacity for recording devices to register the sound. The simulations mentioned above illustrate the minimum amount of volume attenuation that could have been produced as a result of a 30° 'front beam' operation zone. While this is the LRAD 450XL's standard zone of propagation, the specification shows it is also possible for the operator to reduce the beam width of the zone further, making it even more directional.[21] The more directional the beam, the more dramatic its attenuation, especially on the latitudinal axis. Under these specific conditions, and if recorded from

21 Crystal Research Associates, LLC, Executive Informational Overview: LRAD Corp. (LRAD–NASDAQ) (New York: Crystal Research Associates, February 13, 2012).

a location on the sides of the street, this directional beam becomes even further indistinguishable from the background noise of the recording. Moreover, the built-in speech intelligibility algorithms and digital signal processing compression in mobile devices is likely to create further attenuation of this signal. This creates a discrepancy between how the device registers sound and how humans experience auditory events.

The combination of the factors outlined in Part 4 of this report – namely, the highly directional propagation of sound, the ability to reduce further the width of the 'front beam' operational zone, the ability to upload any sound to the device, the position and recording capabilities of the cameras, and the sound energy absorption capacity of several thousands of people – offers some explanation as to why the recordings of the incident alone cannot confirm the use of a sonic weapon.

Although unidentifiable sounds highlighted in the recordings cannot be conclusively attributed to an LRAD 450XL, the use of a highly directional weapon such as the LRAD 450XL could explain why the sonic attack was not, or was poorly, registered by recording devices.

Earshot identifies a correlative relationship between the anomalous experiences that earwitnesses describe regarding the acoustic behaviour of the attack and a weapon with an exceptionally directional acoustic profile, such as the LRAD 450XL. The use of such weaponry during the silent vigil cannot be ruled out.

7 Conclusions

Earshot's investigation into the events of 15 March 2025 during the silent vigil in Belgrade point to the highly likely use of a highly directional sonic weapon against the crowd of protestors. This conclusion is based on the following findings:

- Witnesses demonstrated clear analytical capacity during the event: they were able to distinguish between different sounds and assess their surroundings, contradicting claims that the panic was triggered by crowd-generated noise or otherwise explainable acoustic triggers, such as fireworks.

- While the FSB report states that the crowd movement "can only be achieved through coordination by organisers within a crowd and is not possible with a brief use of a special device.", Earshot's findings demonstrate how this claim is demonstrably false when reviewing the capacities of the LRAD 450XL in its user manual. This device was known to both be present that night and to be in the possession of the Serbian police.

- A high level of consistency and cross-corroboration was observed across the 15 earwitness interviews and the 3,244 written statements. This consistency enabled the reconstruction of the anomalous sound heard during the vigil.

- The absence of the sound on recorded devices could indicate, rather than disqualify, the use of an LRAD-like device given the specific and patented mechanisms by which it propagates sound from its speaker array.

Taken together, these findings refute key claims made in the FSB report and substantiate the testimonies of thousands of people present that night, demonstrating that it is highly likely the protestors have been subjected to an attack by a highly directional acoustic weapon.