



Multimedia Section
Forensic Audio Analysis and Enhancement
Digital and Multimedia Evidence Division



1. Forensic Audio Analysis

1.1. Scope

- 1.1.1. This procedure applies to Multimedia Section analysts who are authorized to analyze and enhance audio evidence with the intention of increasing intelligibility.

1.2. Limitations

- 1.2.1. Applying filters that are not suited for the identified issues or improperly configuring filter settings could negatively affect the intelligibility of the audio content of interest.
- 1.2.2. Applying filters out of order of the recommended order of processing could negatively affect the intelligibility of the audio evidence.
- 1.2.3. Down-sampling and/or lossy compression should be avoided to preserve the integrity of the audio evidence.

1.3. Recommended Equipment/Software:

- Computer with USB ports, optical media drive, etc.
- Sound card or digital audio interface
- Headphones with manufacturer documented frequency response information (preferably with a flat frequency response)
- Active Stereo Monitors with manufacturer documented frequency response information (preferably with a flat frequency response)
- Digital Camera, scanner, or photocopier (as needed)
- Sound treated space for minimal sound reflections (when using active Stereo Monitors)
- Cables required for recommended equipment / adapters
- Recommended Digital Audio Workstations (DAW)
 - iZotope RX Audio Editor
 - Adobe Audition
 - Audacity

1.4. Procedure

- 1.4.1. It is recommended that the analyst consults with the submitter to establish if the highest quality version of the audio recording was submitted. If it was not, it is recommended that the analyst and submitter determine whether the highest quality version of the audio recording is available. If the highest quality version of the audio recording is not available, it should be communicated to the submitter that a lower quality audio recording may adversely affect the ability to analyze and enhance the recording. It is recommended that the analyst document any relevant information regarding the origin of the submitted recording.
- 1.4.2. Inspect submitted items for physical damage (this includes cassette housings, magnetic tape, CDs). If damage is found, document the condition of the media received in the case record and report.
- 1.4.3. Describe and document the items received (e.g. type of media, manufacturer information, write protection, previous markings).



- 1.4.4. To preserve the integrity of a digital original, make a bit stream duplicate to use as a working copy. To preserve the integrity of an original analog recording, enable any physical write protection tabs on the media or playback device (if available).
- 1.4.5. Document any available file specification information (i.e. codecs, sample rate, bit depth, number of audio channels, duration, etc.).
- 1.4.6. Converting the audio file(s) may be necessary in order to prepare them for enhancement in a DAW. When necessary, convert to an up-sampled, uncompressed format.
- 1.4.7. If analyzing analog evidence, determine the proper equipment for playback. Analog to digital conversion (ADC) will be done in an uncompressed digital format. **Personal cell phones will be turned off when performing an analog to digital conversion in the audio analysis room.** The configured sampling rate for the ADC should be in accordance with the Nyquist theorem, in which the sampling rate value must be at minimum twice the value of the highest frequency to be reproduced. The analyst will retain the original ADC recording they have produced as is and create a bit stream duplicate working copy for any enhancements.

1.5. Audio Enhancement Procedure

- 1.5.1. Determine the proper type of audio device and connections to accurately playback the original audio recording.
 - 1.5.1.1. Analog audio mediums may require optimization of the playback device prior to playback. This will be verified by the analyst prior to use.
 - 1.5.1.2. Verify that the audio playback device is working properly.
- 1.5.2. Play back the entire duration of the requested time range from the audio recording to analyze, identify, and document issues affecting intelligibility.
 - 1.5.2.1. This should be done using critical listening in conjunction with visual representations of the audio recording such as a spectrograph and waveform.
- 1.5.3. The recommended order of operations for processing generally ensures that the filters applied have their effectiveness maximized. Processing may be carried out outside of this order of operations if it yields a more effective result than the recommended order of operations.
 - 1.5.3.1. Recommended order of operations:
 - 1.5.3.1.1. Level Optimization (-3dB DBFS)
 - 1.5.3.1.2. Address distortions – De-Click, De-Clip, Spectral Repair
 - 1.5.3.1.3. Source separation – Blind Source Separation (BSS), Reference Cancellation
 - 1.5.3.1.4. Remove continuous noise – De-Hum, Static Filters, EQ
 - 1.5.3.1.5. Remove dynamic noise – Adaptive Filters, Dynamic Filters
 - 1.5.3.1.6. De-reverberation
 - 1.5.3.1.7. Gain correction – Equalization, Compression, Expander, Manual Gain, Limiter
 - 1.5.3.1.8. Normalization
 - 1.5.3.1.9. Time-Shifting
- 1.5.4. Document the filter(s), filter settings, their order of use, and the specific regions in which they are used. The documentation will be done in the case notes (e.g. using screenshots, charts, tables, or an audit trail in the software).



- 1.5.4.1. The analyst shall provide sufficient documentation to make all processing reproducible.
- 1.5.5. Once all processing has been completed, an A to B comparison comparing the submitted audio recording and the enhanced audio recording should be done. If the processing has proven to increase intelligibility, the work product should be exported in a lossless format and should avoid being converted to a lower bit depth if possible.
- 1.5.6. If recording to analog media, start the recording of the blank media first and then start playback of the original audio recording to ensure that all of the pertinent speech is captured.
- 1.5.7. Finalized produced media should be reviewed to verify it plays back as intended prior to release.
- 1.5.8. All original items and derivatives will be returned to the requesting agency.

1.6. References

SWGDE. "SWGDE Best Practices for Forensic Audio." *SWGDE Best Practices for Forensic Audio*, Scientific Working Group on Digital Evidence (SWGDE), 2016

Zjalic , James. "A PROPOSED FRAMEWORK FOR FORENSIC AUDIO ENHANCEMENT." *A PROPOSED FRAMEWORK FOR FORENSIC AUDIO ENHANCEMENT*, University of Colorado, 2017