SUPREME COURT OF NEW JERSEY
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| STATE OF NEW JERSEY<br><br>Plaintiff-Respondent,<br><br>v.<br><br>SHAQUAN KNIGHT,<br><br>Defendant-Petitioner | CRIMINAL ACTION<br><br>On Appeal From:<br>Superior Court of New Jersey,<br>Appellate Division.<br><br>Sat Below:<br><br>Hon. Jack M. Sabatino, P.J.A.D.<br>Hon. Joseph L. Marczyk, J.A.D.<br>Hon. Mark K. Chase, J.A.D. |

# BRIEF OF PROPOSED *AMICUS CURIAE* JUSTIN ROSANDER, FORENSIC VIDEO ANALYST

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## INTEREST OF AMICUS CURIAE

Amicus, Justin Rosander, is an expert in forensic audio and video analysis. *Amicus* submits this brief to explain why it is essential for the Court to consider the robust issues surrounding forensic video examination. Specifically, Mr. Rosander provides the information set forth in this brief to assist the Court in understanding that any alterations made to video to assist the try of fact should be documented, repeatable and nondestructive.

Mr. Rosander is forensic audio and video analyst. Mr. Rosander is a Certified Forensic Video Analyst through Law Enforcement & Emergency Services Video Association International, Inc., an Amped FIVE Certified Examiner, a Medex Certified Media Examiner, and an Axion Investigate (iNPUT-ACE) Certified Operator, Examiner and Metrologist. Mr. Rosander holds a Private Investigator License in California. Mr. Rosander operates JSM Forensics providing forensic services for law enforcement, law firms, insurance and investigative firms. Mr. Rosander has contracts with Axon Investigate as a forensic video training contractor and as a professional consultant and contractor with the California Department of Justice Police Shooting Investigation Team as a Forensic Audio and Video Consultant. He has provided expert testimony on forensic video analysis and forensic video enhancement for both the defense and prosecution in federal and state court

proceeding and trials across the country. A copy of Mr. Rosander's CV is attached to this Brief as JR1-23.

## PRELIMINARY STATEMENT

Forensic Video Analysis is the scientific examination, comparison and/or evaluation of video in legal matters. Video can be understood as a sequence of still images or frames that are played back at a specific speed or time. Forensic Video Analysis is a science that benefits from reproducibility, documentation and adherence to best practices. The field of Forensic Video Analysis, like all forensic sciences, involves standards and best practices which, for example, have been promulgated by the Scientific Working Group on Digital Evidence ("SWDGE"), a collaboration between organizations engaged in digital and multimedia evidence. The present case involves the slow motion playback of video for a jury, along with pauses to inspect individual frames of the video. Thus, in order for this Court to accurately assess and decide the issue before it regarding the appropriate replay of video for a fact finder, it is necessary to understand the operation of digital video, the possible alterations, both intentional and unintentional, and the need for standards and best practices. With this in mind, adjustments to a video for the purpose of aiding the fact finder should be performed with a tool that is fit for

the purpose with adequate safe guards to prevent impermissible alteration or misinterpretation of the evidence.

## STATEMENT OF FACTS AND PROCEDURAL HISTORY[1]

Amicus relies on the statement of facts and procedure as stated by the parties.

## ARGUMENT

### I. UNDERSTANDING DIGITAL VIDEO AND STORAGE.

Digital video recording devices are ubiquitous. As of 2018, there were over 70 million surveillance cameras in the United States, and that number has steadily risen. Stanislava Ilic-Godfrey, *Artificial intelligence: taking on a bigger role in our future security*, U.S. BUREAU OF LABOR STATISTICS (2021).[2] This year, the Newark School District approved a contract to have 7,000 security cameras installed in its schools. Nayha Marshal*, N.J.'s largest school district adding 7K security cameras powered by AI*, NEW JERSEY ADVANCE MEDIA (2024).[3] The wide availability and lower price of home surveillance systems have made cameras even more present, even in the homes of private citizens. Until 2024, Ring doorbell cameras established partnerships with

[1] These sections, which are inextricably intertwined, are combined for the Court's convenience.
[2] https://www.bls.gov/opub/btn/volume-10/investigation-and-security-services.htm
[3] https://www.nj.com/education/2024/05/njs-largest-school-district-adding-7k-security-cameras-powered-by-ai.html

certain police department in New Jersey which allowed the police departments to easily request footage from privately owned Ring devices in designated areas. Manahil Ahamad, *Ring is ending police access to doorbell video. These NJ towns had deals with the company*, NORTHJERSEY.COM (2024).[4] This increased level of surveillance has led to sharp uptick in videos offered as evidence during trials and court proceedings.

Last year in *State v. Watson*, 254 N.J. 558, 606 (2023), this Court articulated that elaborate video forensic techniques should be presented by a qualified expert, and as video technology advances, such expertise may become more prevalent. In the same opinion, this Court stated that specialized knowledge may not be required for other adjustments "like adjusting the speed of a video." *Id*. While video handling and speed adjustment may not always require expert knowledge, it is imperative that video is properly collected and handled and alterations should be documented and properly explained.

Like film, digital video is made up of individual images/frames, each representing a moment in time while capturing the scene. When these frames are displayed in succession, they create the appearance of a moving image. The more frames presented per second, the smoother a video will appear to the

[4] https://www.northjersey.com/story/news/2024/01/25/ring-doorbell-video-police-access-nj-and-nationally-changes/72351003007/

viewer. However, the storage and eventual replay of digital video files differs substantially which may necessitate forensic video analysis to ensure that a video shown to a finder of fact is not improperly altered or misinterpreted.

### A. Digital video is stored in a structured file format that allows playback by combining the component parts.

Rather than being stored on a physical medium like film, a digital video is stored in a structured file referred to as a file format, wrapper or container; all three terms are used, often interchangeably. A container is a standardized structural method to store the elements necessary to represent the image and audio elements of a video. Common container/wrapper formats include AVI, MP4, MKV, and MOV, and may be evident from a cursory examination of a file and indicate what software is needed to play a particular file should the file be in native or proprietary format. *See* Scientific Working Group on Digital Evidence, *Technical Overview of Digital Video Files*, (Version 17-V-001-1.3, Revised March 7, 2024), at 2.[5] Video data (video stream), audio data (audio stream), metadata, closed captioning, timecodes or date and time data that can be overlaid onto the video file are all stored within the container. *Id.* An audio file in its entirety, may be stored in a different format, such as "MP3" "M4A" or "WAV." *Id.* A video or audio stream within the container

[5] https://www.swgde.org/17-v-001/

can utilize a lossy or lossless codec (coder decoder)[6] to minimize redundancy and reduce file size, *see infra* at Section I.B.1-2. *Id.*

By using a video or audio codec, video and audio elements are stored and represented as binary data so that they can be decoded during playback. A failure to properly decode the elements of a video may cause video and audio stream to be out of sync, along with frame timing issues. A Presentation Timestamp is timestamp metadata field that is used to synchronize separate elements (audio, video and subtitles) when ultimately presented to the viewer. Scientific Working Group on Digital Evidence, *Core Technical Concepts for Time-Based Analysis for Digital Video Files* (Version 1.0, September 17, 2020), at 5.4.[7] Thus, failure to properly decode a video for a fact finder may give an inaccurate depiction of the events portrayed in the video. For this reason, it is necessary to ensure that when a video is played for the finder of fact, its component parts are properly reconstructed for an accurate view of what was recorded or captured.

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[6] "A codec is an algorithm used to encode or decode a stream of digital data or signals to a specific encoding format. Video codecs use encoding formats to compress data … Decoding extracts video data from a previously encoded file converting it into a displayable, decompressed form for playback or examination." SWDGE, *Technical Overview of Digital Video Files,* at 3.

[7] https://www.swgde.org/19-v-002/

File structure plays an important role in digital video storage, but pixel dimensions, compression, and frame rate often determine the apparent quality of video (resolution) when viewed. Frame rate may appear a fairly straight forward concept; it describes the number of individually captured images that make up the video and is traditionally measured in frames per second ("FPS"). Generally, the higher the FPS, the smoother motion in a video appears.

The image quality of a video is referred to as the resolution; however, commercially it is typically expressed as the number of pixels captured horizontally and vertically. The more pixels in a given image, the more detail that can potentially be portrayed. By the same logic, the fewer pixels in a given image, the more difficult it may be to make out fine details or high frequency data.

### B. Apparent digital video quality is typically influenced by frame rate and pixel dimensions which can be altered by compression of video files.

Given the above information, digital video follows a reasonably straightforward format: a sequence of images are stored in a file, the higher the pixel dimensions and the more images present, the higher the apparent quality or resolution of the video playback. However, additional factors complicate analysis and playback.

In practice, in order to facilitate the storage and workability of large digital video files, compression is employed. Compression uses codecs to reduce the size of a data file by re-encoding/transcoding the data to minimize redundancy. *See* SWGDE, *Technical Overview of Digital Video Files*, at 6. Some compression is considered "lossless" and uses algorithms that retain all of the original pixel information, while "lossy" compression results in a loss of data including original pixel information. *Id.* at 6.1, 6.2. Generally, lossy compression methods result in smaller file size, but will also result in the loss of original data when compared with the original video file. And subsequent lossy compression will result in further loss of data and reduced resolution or image quality resulting in noticeable issues including but not limited to, pixelation, frame rate issues, imagery being out of sync with the audio stream, compression error, and inaccurate frame timing.

1. Compression of Frames in Digital Video

Not all digital video frames contain equal information. Predictive techniques can be employed during compression of video frames called picture types or frame types, with compression occurring across several frames or "temporal compression, also referred to as inter-frame or inter compression." SWGDE, *Technical Overview of Digital Video Files*, at 6.2.4. Three major picture types are used in video algorithms: intraframe ("I-frame"), predicted

frame ("P-frame") and bidirectional frame ("B-frame"). *Id*. When arranged together, these frames become a group of pictures or often referred to as a "GOP", and the structure specifies the order of the various frames. An I-frame is a complete image that contains all newly encoded information while P-frames reference off of a previous I or P frame within the GOP. *Id*. For example, an I-frame may show a car on a street, and as the car moves down the street, assuming there are no changes to the background, only the car's movement needs to be encoded or referenced and predicted in the P-frames. The encoder does not store the unchanging street background, but instead it can reference the previous I-frame for the unchanged street background and encode only the car's movement as new information. Meanwhile, a B-frame can save even more space by referencing both the I or P frames that proceed within the GOP and the I or P frames that follow it within the GOP, and thus it can encode information by considering both what has already occurred and what will come next in the GOP sequence. *Id*.

The Scientific Working Group on Digital Evidence cautions that there are potential issues that arise from compression of digital frames. "The adverse effects of this are similar areas can be copied or moved from previous frames, making it possible to miss small changes within an individual frame of video." SWGDE, *Technical Overview of Digital Video Files*, at 6.2.1.

Scrutinizing individual frames, without understanding how they fit into the group of pictures structure or knowing what predictions are based on, can lead to falsely attributing value to a minor detail that was an artifact left over from compression or an incorrect prediction.

2. Spatial Compression

Many are already familiar with spatial or image compression, especially if one has saved or copied an image at a lower quality, and later noticed that it is pixelated or lacks the fine details of the original. While some video compression reduces data contained in a GOP sequence with temporal compression, spatial compression, also referred to as intra-frame or intra compression, subsequently reduces data within a single frame or image. Spatial compression minimizes redundancy within areas of similar color or luminance value by viewing information in a defined region and examining each pixel in relation to the other pixels in that region. SWGDE, *Technical Overview of Digital Video Files*, at 6.2. Additional methods such as Chroma Subsampling, Discrete Cosine Transform ("DTC"), and Quantization, first sort the pixel values so the pixel information can be more easily compressed during the Quantization process. However, the greater the degree of chroma subsampling and DCT, the more information can be irretrievably lost during the Quantization process in most instances.

The adverse effect of spatial compression is that by grouping similar pixels, high-frequency information and details can be lost such as high contrast edges, text, facial features, tattoos, and subtle changes in pattern, texture or color.

3. Variable Frame Rate

Variable Frame Rate (VFR) is a technique used in video encoding where the frame rate of the video can change dynamically depending on the content being displayed. Unlike Constant Frame Rate (CFR), where each second of video has the constant number of frames and a constant frame duration time for each frame, VFR allows for a varying number of frames per second resulting in a variable frame duration time. Scientific Working Group on Digital Evidence, *Considerations for the Use of Time-Based Analysis of Digital Video for Court* (Version 1.0, Revised September 17, 2020), at 5.2, 5.6. This flexibility can lead to significant benefits in terms of storage efficiency and video quality. A lowered frame rate may be preferred in darker environments to extend the exposure time, or sample duration time per frame, allowing the image sensor to capture more light, which results in brighter footage.

Some VFR adjusts the frame rate on-the-fly, increasing it during scenes with more motion and decreasing the FPS during static scenes. *Id*. at 5.2. This

adaptability makes VFR particularly useful in scenarios where bandwidth and storage are limited, or where the content itself has varying levels of complexity. However, this reduced frame rate may lead to reduced video quality during play back and may be exacerbated during slow motion playback.

During slow motion playback, the speed at which the individual frames are shown to the viewer are reduced giving the effect that the event is occurring at a reduced rate. However, subject to the frame rate at which the video was originally recorded, a video can appear choppy and segmented as the frame rate reduces. Further, as a variable frame rate video is slowed down, movement may appear increasingly choppy as there are fewer frames available. Because a variable frame rate recording might contain different frame rates and refresh rates within a single video, comparison of the events shown may become more difficult for a finder of fact as movement may appear fluid in one sequence, but "choppier" and more disjoined in another sequence of frames.

4. Interpolation

Some methods are used to increase the apparent quality of a video. Interpolation is "a method of image processing whereby one pixel, block, or frame is displayed or stored based on the differences between the previous and

subsequent pixel, block, or frame of information. [] This is often done to increase the apparent clarity of an image and make a small video easily viewable." Scientific Working Group on Digital Evidence, *Glossary of Terms*.[8]

AI frame interpolation is a tool or plugin, typically found within in commercial nonlinear editors, that uses algorithms to enhance video quality, generating new frames between existing ones which may appear to improve smoothness of video. However, AI frame interpolation is inappropriate in a forensic setting because it adds information to a video that was not initially present at the time of recording.

Likewise, pixel interpolation may be employed when an image is resized to make it more easily viewable. Digital images have a given size in pixels, but when there is a need to display an image on a medium that had a different resolution in pixels (either higher or lower), there is a need to estimate the value of pixels in positions that were not present in the original image. *See* AmpedSoftware, *Image Enhancement Is an Essential Part of Forensic Video Analysis*, FORENSIC FOCUS (2021).[9] However, when pixel interpolation is employed, it is recommended to "compar[e] the results obtained with different

[8] https://www.swgde.org/glossary/

[9] https://www.forensicfocus.com/news/image-enhancement-is-an-essential-part-of-forensic-video-analysis/

interpolation algorithms and with the original image." *Id.* "[T]o analyze something made by a very limited number of pixels, especially in a single frame, there may not be enough information to distinguish details whether there is interpolation or not." *Id.* The appropriate interpolation algorithm should be employed after careful consideration. Scientific Working Group on Digital Evidence, *Fundamentals of Resizing Imagery and Considerations for Legal Proceedings* (Version 1.1, Revised September 22, 2022), at 6.[10]

### C. Slow motion replay may allow a fact finder to scrutinize a video more carefully.

Slow motion replay can assist the trier of fact, assuming tools that are fit for the purpose are used to reduce the frame rate and Presentation Timestamp values are reflected appropriately. Changing the playback speed alters the original frame rate of the video. Depending on the video player or video software used, this could be accomplished by dropping frames, or adding frames, or by playing the frame rate from the header of the file and not the Presentation Timestamps. Different video players handle video playback and adjustments differently; some players are reliable, and some have technical limitations. While some players and software are proprietary and others

[10] https://www.swgde.org/22-v-001/

opened sourced, they are not all created equal and must be interrogated before use in a forensic setting.

## II. ANY TOOL USED TO PLAY VIDEO FOR A FINDER OF FACT SHOULD BE WIDELY AVALAIBLE AND SUBJECT TO INSPECTION.

### A. Proprietary Video Adds Layers of Complication

Security cameras and recording devices often use proprietary software complicating the issue of collecting and analyzing digital video. Despite the relative ubiquity of surveillance video, these systems are often proprietary in nature and require a proprietary software produced by the manufacturer to extract and (often improperly) play the collected recordings. *See* Scientific Working Group on Digital Evidence, *Best Practice for Frame Timing Analysis of Video Stored in ISO Base Media Formats* (Version 1.1, Revised June 9, 2022), at 3. When video and audio are collected from the recording or capture device, it must be recovered in a manner that produces the best quality possible, which often requires obtaining the native or proprietary files. Scientific Working Group on Digital Evidence, *Best Practices for Data Acquisition from Digital Video Recorders* (Version: 1.0, Revised April 25, 2018), at 5.[11] Of course, given the proprietary nature of the software and file formats, it is not immediately evident what is happening behind the scenes

[11] https://www.swgde.org/17-v-002/

when a video is encoded and played back. *Id*. Furthermore, many investigators who recover the video evidence lack technical training in the field of video recovery, and may not be knowledgeable about the best practices and forensic workflow necessary to extract the best evidence and ensure data integrity. *Id*. at 2, 3. It is for this reason, when an investigator cannot play a proprietary file, they often export the standard file formant simply because it will open on most open-sourced media players, not realizing the technical challenges of the standard file format. Native or proprietary file formats are often overlooked; however, the proprietary file will have the best quality video along with the original timing. SWGDE, *Best Practice for Frame Timing Analysis of Video Stored in ISO Base Media Formats*, at 3.

A 2022 survey of video evidence practitioners revealed that proprietary CCTV/DVR video files was the second most common issue when working with video evidence in 2022. AmpedSoftware, *5 Video Forensics Trends to Be Aware of in 2023*, FORENSICFOCUS (2023).[12] Proprietary players are created by surveillance system manufacturers, sometimes with a focus on price rather than robust attention toward properly preserving video for forensic examiners. For example, a proprietary player may play the video file with an incorrect or

[12] https://www.forensicfocus.com/news/5-video-forensics-trends-to-be-aware-of-in-2023/

no frame rate, altered aspect ratio, incorrect color space, or drop video frames. SWGDE, *Best Practice for Frame Timing Analysis of Video Stored in ISO Base Media Formats*, at 7. When video is exported, it may be in an incorrect format and some proprietary systems have no export options whatsoever. Further, proprietary players may employ heavy compression while exporting to standard format with large group of pictures (GOP), along with incorrect resizing interpolation and the issues mentioned earlier.

SWGDE advises that there are certain limitations when working with proprietary digital video.

> Proprietary video files may store metadata with the video and audio data streams in a proprietary container and may not adhere to an encoding standard. Due to the unique nature of their file structure, proprietary video files may result in inaccurate frame rate reporting in many video playback/processing software programs.

[SWGDE, *Best Practice for Frame Timing Analysis of Video Stored in ISO Base Media Formats*, at 3.][13]

In the present case, the video played for the jury was in the AVI (audio video interleave) file format, which contains both audio and video data and is able to be played by many video players. Db at 11 fn. 5.[14] It may be possible

[13] https://www.swgde.org/19-v-005

[14] "Db" is Defendant-Petitioner Shaquan K. Knight's Supplemental Brief filed on July 2, 2024.

the AVI at issue in this case is an identical copy of the native video; however, it cannot be determined without further testing of the surveillance system the video was originally recorded on. The AVI does not contain variability in the frame rate and frame duration time and would be converted to a standard frame rate due to the technical issues of the file format. A review of the video file did not immediately reveal visual indications of variability; however, undetected variability remains a concern.

If the AVI file in this case was just intended to show the events as they occurred and no technical analysis or forensic opinions were concluded, the AVI file might be sufficient. Best practices require a video recovery report to determine if there is a time offset between the time displayed on the video recording system and real time. *See* SWGDE, *Best Practices for Data Acquisition from Digital Video Recorders*, at Appendix A (Sample Audio/Video Field Retrieval Form). However, the individual who recovered the video in the first instance must have calculated the timing offset at the time the video was recovered. *See id.*

### B. Any adjustments in video playback intended to aid the finder of fact should be properly documented for repeatability.

When a video is played for the finder of fact, it is crucial that it is not altered or tampered with such that it does not accurately portray what the

proponent of the evidence claims. All processed changed to digital multimedia evidence must be documented and should be nondestructive, precise, reproducible and verifiable. The Scientific Working Group on Digital Evidence recommends precisely this:

> Any processing performed on the video files should be completed on the working copy and sufficiently documented so that the methods can be reproduced and independently evaluated. This documentation should include the order and settings in which the processes were applied to ensure the integrity and the reproducibility of the results.

[Scientific Working Group on Digital Evidence, *Best Practices for Digital Forensic Evidence* (Version 18-V-001-1.1, Revised March 3, 2022), at 4.3.3.][15]

Tools like Amped FIVE[16] and Axon Investigate (iNPUT-ACE)[17] both create a workflow report for all processed files that are created within the software. Each of these software employs tools, filters, algorithms, and encoding parameters that follow the best practices set forth within the scientific and forensic video and image analysis community. Subsequently, all files received along with exported files should be hashed[18] either within the software or with an external hashing application, for integrity verification.

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[15] https://www.swgde.org/18-v-001/

[16] https://ampedsoftware.com/five

[17] https://www.axon.com/news/introducing-axon-investigate

[18] A hash value is a fixed length string of characters that act as a unique identifier for a file's contents. Comparing hash values of two files allows one to determine if the files' contents are identical. This is beneficial so parties can verify they are working with and have received the same files.

### C. A competent witness should testify regarding any significant alterations.

*Amicus* does not take a position on the ultimate disposition of the present case. However, there are certain principles that the Court should consider when assessing how to best approach the treatment of alterations and adjustments made to video evidence for the benefit of a finder of fact.

In other forensic fields, a lab technician or expert performs analysis and makes a determination that they then present to the jury; in other words, they are showing their results. With video, we expect the jury as the finder of fact to make the determination themselves. Thus, every effort to preserve the originality of the file should be made and to the extent alternations are necessary, they should be properly documented and introduced through a witness competent to testify regarding those alterations.

New Jersey law already provides some guidelines for when a party seeks to enhance a video. As this Court stated in *State v. Watson*, 254 N.J. 558, 606 (2023):

> Any party may hire an expert to enhance the quality of an electronic or video recording. The witness, if qualified as an expert, can testify about the modification, consistent with N.J.R.E. 702.

*Id.* at 606.

This Court further elaborated its view that specialized knowledge would not ordinarily be "required for other types of adjustments, like adjusting the speed of a video or creating a straightforward composite video, a screenshot or an enlarged photo from a video. A lay witness can testify about those basic techniques, and parties can, of course, stipulate to admissibility in this and other areas." *Id.* at 606. Because of compression, interpolation algorithms, timing, and reliability issues, qualified and trained individuals should give testimony on what adjustments were conducted and explain the processes. Even a composite video may contain several videos with variability within the frame rates requiring specialized training and tools to place the videos into a timeline without timing issues. And of course, adjustments should not be employed that change the character of the video evidence, or alter it so is not an accurate portrayal.

## CONCLUSION

Given the forgoing, alterations to video for the benefit of the finder of fact should be properly documented, using appropriate tools, and introduced through a witness competent to testify regarding any alterations. When possible, best practices should be adhered to insure the reliability in the recovery, storage and handling of video.

Respectfully submitted,

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