

VALIDATION TESTING OF THE MULTIMEDIA CREATED AND TRANSMITTED BY
THE AXON CAPTURE MOBILE APPLICATION FOR APPLE iOS

by

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ABSTRACT

The police body camera revolution allowed for the innovation of smartphone mobile applications for law enforcement to consolidate traditional tools and modernize digital evidence management systems (DEMS). The smartphone media created is being stored next to body-worn videos in cloud-based DEMS. Over 20 years ago, the international community established that maintaining the data integrity of digital evidence upon seizure is a basic principle. The Scientific Working Group on Digital Evidence (SWGDE) recommends that new software should be subjected to validation or verification testing to identify limitations, minimize errors, and build confidence in forensic science.

The Axon Capture version 5.7.0 (13) mobile application developed by Axon Enterprises, Inc. was tested on an iPhone device, which included the Axon Citizen for Officers feature. A known dataset was created, and forensic software was used to extract the multimedia. The Secure Hash Algorithm 256 (SHA-256) algorithm was used to calculate file and stream hash values. The known dataset was transmitted through the various Axon Capture and Citizen features and uploaded to Evidence.com, which is a cloud-based DEMS. The hash values of the Axon downloaded media were compared against the known dataset. Forensic authentication software was also used to generate reports on the format and file structures of the Axon multimedia. The information reported by the forensic tools was used to create comparison charts.

The Axon Capture and Axon Citizen digital evidence collection options altered most of the multimedia transmitted to Evidence.com. The multimedia created by the mobile application features was not consistent with native iPhone media. Limitations were identified and some of the Axon features can be used to obscure localized digital evidence tampering, may impact forensic examinations, and potentially introduce errors in the justice system.

The form and content of this abstract are approved. I recommend its publication.

Approved: Catalin Grigoras

DEDICATION

I dedicate this thesis to my wife Lourdes, my two daughters Sofia and Ana, and my son Ramon. Thank you for all your sacrifices and support through this academic endeavor. No more “I have homework” excuses.

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LIST OF ABBREVIATIONS

- AAC – Advanced Audio Coding
- ALAC – Apple Lossless Audio Codec
- ARGO – Forensic Video Authentication System
- AVC – Advanced Video Codec
- CDG – Center for Digital Government
- DEMS – Digital Evidence Management System
- EXIF – Exchangeable Image File Format
- FAAS – Forensic Audio Analysis System
- FIAS – Forensic Image Analysis System
- HEIC – High Efficiency Image Container
- HEIF – High Efficiency Image File Format
- HEVC – High Efficiency Video Coding
- ISO – International Organization for Standardization
- JPEG – Joint Photographic Experts Group
- NCMF – National Center for Media Forensics
- SHA-256 – Secure Hash Algorithm 256
- SWGDE – Scientific Working Group on Digital Evidence

CHAPTER I

INTRODUCTION

The adoption of body-worn cameras by law enforcement has accelerated technological innovations in the public safety industry. Examples of these modernizations include the use of a cloud-based DEMS to store and share body-worn videos and the development of smartphone applications to collect and transmit digital evidence to DEMS. In 2022, the Center for Digital Government (CDG) conducted a nationwide survey of 100 small, medium, and large-sized U.S. law enforcement agencies. According to the CDG survey, 50% of the respondents' organizations already use a cloud-based DEMS or plan to use this type of technology within one to three years. The report also stated larger agency respondents were 66% more likely to share a submission link with the public to collect digital evidence [1].

The Axon Capture mobile application, developed by Axon Enterprises, Inc., is a real-world example of a technology enhancement application designed to create, collect, and transmit digital evidence from the field [2]. According to the company, Axon Capture is a smartphone technology that eliminates the need for the officer to carry three separate devices for photos, video, and audio recording [3]. In March 2013, Axon released the Evidence Mobile Application for Android and planned to release an Apple iOS version later that year [4]. In 2016, the company changed the Evidence Mobile Application name to Axon Capture, which is now available for Android and Apple mobile devices.

Axon Capture allows public safety users to create or collect digital multimedia for evidentiary purposes and transmit the data over a wireless connection. The Axon Citizen for Officers is a feature within the Axon Capture application and allows investigators to send digital evidence submission requests over text message or email to civilians, who may have media of

probative value on their smartphones or devices. Shown in figure 1 is an overview of the Axon Capture for iOS workflows.

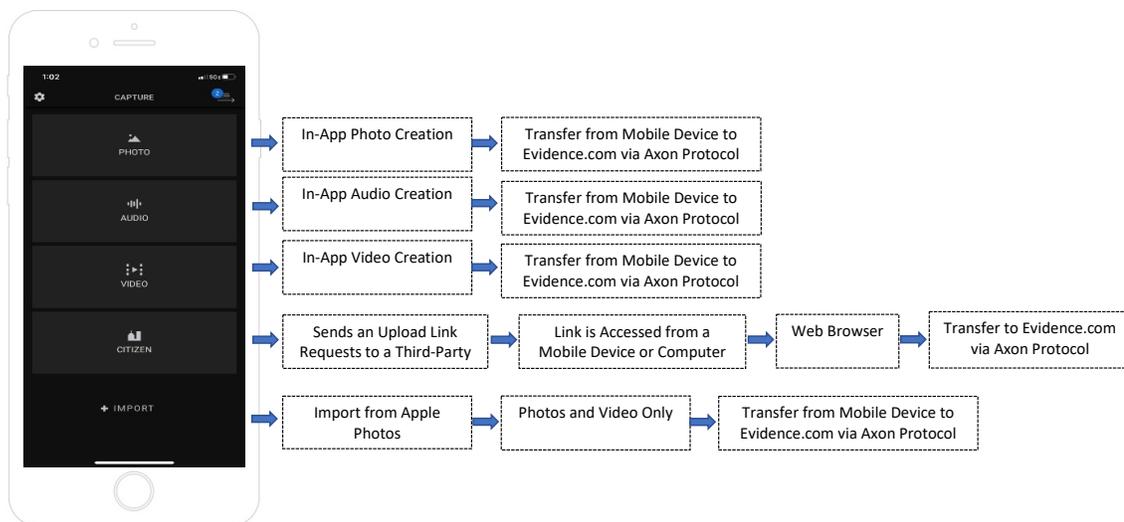


Figure 1. Overview of the Axon Capture for iOS Features

New software tools can present investigators with limitations and potentially introduce errors in legal contexts [5]. In forensic science, maintaining the data integrity of digital evidence upon seizure was a basic principle established by the international community over 20 years ago [6]. This basic principle remains unchanged. SWGDE recommends validation or verification testing for tools used in digital and multimedia forensics [7]. This includes acquisition and preservation tools that directly interact with original media or best evidence. Scientific testing can help us understand the strengths and limitations of new software, tools, or methods and build confidence in forensics.

The research conducted on Axon technology was two-fold. First, the SWGDE guidelines [8] were followed and used to develop test scenarios and transmit a known dataset stored on an iPhone 12 through the Axon Capture and Citizen digital evidence collection features to Evidence.com. The SHA-256 algorithm was used to calculate the hash values of the iPhone 12 known dataset and the Axon transmitted and collected data. The hash values of both datasets

were compared and most of the Axon multimedia hash values did not match the known dataset and much of the multimedia transmitted through the Axon protocol was altered.

The second study involved empirical observation to compare the file structures and technical characteristics of the known dataset to its equivalent content created by the Axon Capture and Citizen features. Comparison charts were created to better understand the technical differences and similarities between the known dataset and Axon transmitted multimedia. Based on the research findings, almost all files created or transmitted by the Axon protocols were inconsistent with the native iPhone 12 file structures.

Previous Research

A keyword search was conducted for literature related to validating or verifying Axon Capture or Citizen software using the WorldCat®, Google Scholar™, and ProQuest® scholarly databases. The search did not yield published scientific papers related to the topic and the researcher is not aware of any study that examines the Axon Capture mobile application or the Axon Citizen technology from a forensic science validation or verification perspective. The information located on Axon Capture and Axon Citizen was limited to vendor case studies and an open-access research paper published on the internet. In 2016, Axon Enterprise, Inc. published a case study on the use of Axon Capture by the Redmond Police Department in Washington State [9] and stated the technology reduced yearly costs by transforming how digital evidence was captured and uploaded to a cloud-based DEMS. In 2018, Axon Enterprises, Inc. published a case study [10] that reported the challenges experienced by Cumbria Constabulary in the United Kingdom with collecting digital evidence from the community. The report stated Axon Citizen technology created business efficiencies and was “a proven public submission tool backed by Axon Evidence”. Wood, S.E. [11] researched modern policing and the impacts law

enforcement technology platforms, such as Axon Capture and Axon Citizen, have on society from an interdisciplinary cultural perspective.

The impetus of this paper is based on an academic assignment performed by the author and another University of Colorado National Center for Media Forensics (NCMF) graduate student. In 2020, the Axon Citizen email and text message delivery options were tested using Axon Capture for Apple iOS version 5.1.2 (2). Scientific validation testing guidelines [8] were followed to create test scenarios and transmit a known dataset through the Axon protocol. The SHA-256 algorithm was used to compare the hash values of the transferred data to the known dataset. Axon Citizen requests were accessed on a desktop computer and uploaded to Evidence.com were not altered. Most all the data accessed on the iPhone 11 was altered by the Axon Protocol and the results were presented by the author at the 74th American Academy for Forensic Science Annual Scientific Conference [12]. Additionally, the findings were disclosed to Axon Enterprises, Inc. and responsible notification was made to a program developer, who stated the product team would review the issues identified. This research builds upon the initial academic validation study and uses additional forensic software and techniques to examine the Axon technology further.

CHAPTER II

MATERIALS

Validation Testing

Test Device Configuration

An Apple iPhone 12 (Model: MGEK3LL/A) running iOS 15.6.1 was used to create the known dataset. Before creating the known dataset, the iPhone 12 used was reset to the factory defaults by selecting ‘Erase All Content and Settings’ in the device’s General Settings. The iPhone 12 was set up as a new device and not from an iPhone backup. After the device was configured and before creating the known dataset, the Apple Camera Format and Voice Memos audio quality settings were documented. The Apple iPhone 12 factory default camera setting was set to ‘High Efficiency’ and the audio quality was set to ‘Compressed’.

iPhone 12 Multimedia Format Options

The Apple iPhone 12 native applications Camera and Voice Memo were used to create and store the known dataset. The front-facing (selfie) and back lenses were used, and two different Apple Camera formats ‘Most Compatible’ and ‘High Efficiency’ options were selected. By default, the device was configured to capture images in High Efficiency Image Container (HEIC) media format and video in High Efficiency Video Coding (HEVC) or H.265 format. Apple defines ‘High Efficiency’ as standard media formats with reduced file sizes for photos and videos that offer better compression than JPEG and H.264 while preserving the same visual quality [13]. The second camera format option available (user-defined) and examined was ‘Most Compatible’. This format recorded video in Advanced Video Codec (AVC) or H.264 format and photos in JPEG format. Apple Voice Memos also offered two different format options: ‘Compressed’ or ‘Lossless’ audio quality. The compressed audio was recorded in Advanced

Audio Coding (AAC) and lossless audio was recorded in Apple Lossless Audio Codec (ALAC) format. By default, the Apple Voice Memos audio quality was set to ‘Compressed’.

Axon Capture for iOS Configuration

On August 26, 2022, the Axon Capture for iOS version 5.7.0 (13) mobile application was downloaded from the Apple App Store and installed on the iPhone 12. The Axon Capture application was granted permission to the iPhone 12 camera, microphone, photo library, and GPS location services. A law enforcement organization’s test environment of Evidence.com was used for the study. Axon Capture was connected to Evidence.com by entering authorized user credentials. This allowed access to all the application features and data transfer to Evidence.com. Shown in figure 2 is the Evidence.com configuration policy and features and options were enabled for testing. At the system configuration level, the Axon Citizen feature within the Axon Capture was enabled by setting the Citizen Management ‘Invite Individual’ permission to ‘Allowed’ under ‘Roles & Permissions’. End users should consult the most recent version of the Axon Evidence User and Administrator Reference Guide [14], which was publicly available from the vendor’s website, for a full list of Axon configurations and settings. The same version of Axon Capture was used throughout the experiment.

Studio Setup

A photography studio setup was used to capture photos, video, and audio reference samples with the iPhone 12. Materials included: a tripod, ISO 12233 resolution test chart, a forensic scale (metric), and professional lights. Although out of scope for this study, SWGDE guidelines [15] were used to determine the maximum field of view in which the iPhone 12 may be used to achieve 1,000 pixels per inch and known dataset exemplars were captured at this distance. The information collected can be used for future research opportunities.

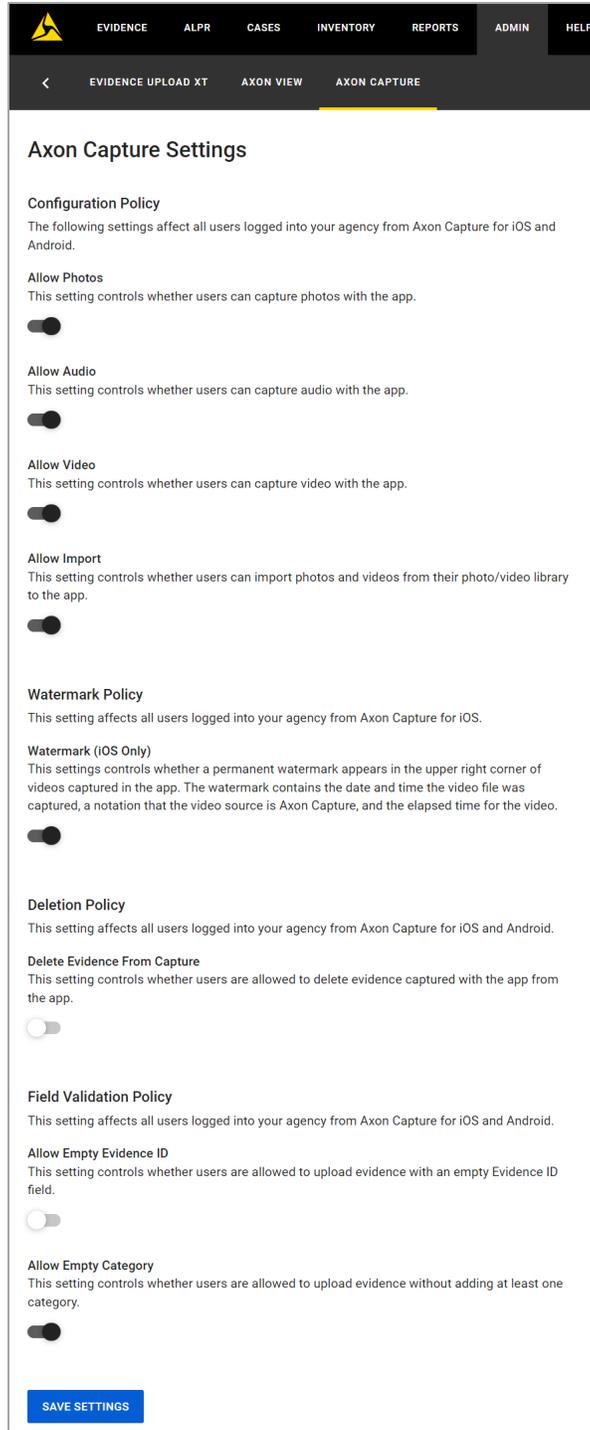


Figure 2. Evidence.com Axon Capture Configuration Policy

Axon Capture and Axon Citizen Details

The Axon Capture photo, audio, and video file create features, and the import feature, which allows the user to navigate to the Apple Photo Library were tested (figure 1). Additionally, the Axon Citizen for Officers feature was tested, and submission links were sent to the iPhone 12 to access the known dataset natively. The research of Axon Citizen for Officers was limited to accessing links on an iPhone 12 running the Apple Safari web browser. Once an Axon Citizen link was accessed, the submission recipient was presented with three options (figure 3) for providing digital evidence to the requesting organization:

- Axon Citizen for iOS Option A: ‘Photo Library’
- Axon Citizen for iOS Option B: ‘Take Photo or Video’
- Axon Citizen for iOS Option C: ‘Browse’

Option A allowed the user to navigate to Apple Photos and add images and videos stored in the library or albums. Option B used the device camera system to capture photos or videos and add the media to the Citizen request. Option C allowed the user to navigate to Apple Files or a user-enabled cloud storage platform (e.g., iCloud, Microsoft OneDrive, Google Drive) to add evidence files. Previous research conducted by [12], used Option C to navigate to a third-party cloud storage application and transfer a known dataset. The experimental design of this study did not examine the use of a third-party cloud application and instead focused on the transmission of the known dataset from the Apple Files application. According to [14], an Axon Citizen for Officers private link can only be used for one submission and the link expires after three days. Each submission is limited to a maximum of 16 files, with a maximum size of 60 GB per file and a total submission size of 200 GB.

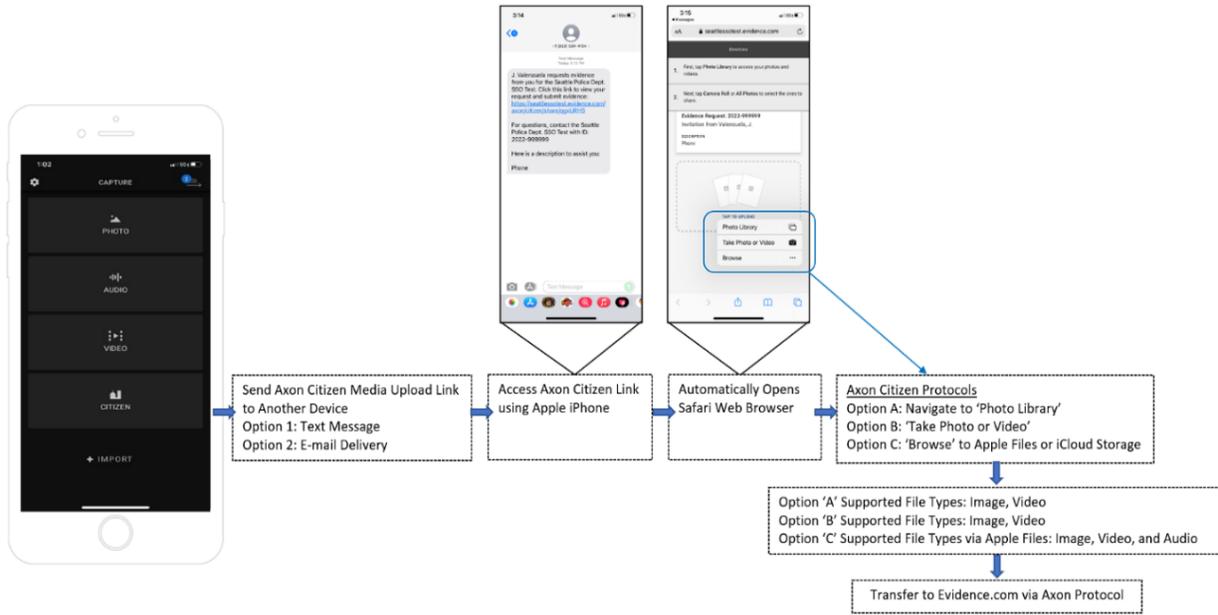


Figure 3. Axon Citizen for Officers Workflow and Apple iPhone Submission Options

Cloud-Based DEMS

Axon Evidence Configuration

A test environment of Evidence.com was used to upload, store, and download multimedia created and transmitted for the experiment. Evidence.com was accessed using the Google Chrome web browser on a computer running Windows 10. The version number of Evidence.com used throughout the experiment was ‘v2022-08-12.126203 Axon Evidence July 2022 CHROME 104’. A periodic review of the Axon Release Notes is recommended as updates to Axon Capture and Evidence.com tend to be frequent. Release notes were found on Evidence.com under the ‘Help’ tab and some user guide information was publicly available on Axon’s website. From January 2020 through August 2022, Axon released 29 updates and changes to its software and products (table 1), which included occasional updates to Axon Capture for iOS.

Table 1. Axon Release Notes January 2020 – August 2020

Document Title	Document Version	Revision	Release Date
Axon August 2022 Release Notes	2022.8	A	08/2022
Axon July 2022 Release Notes	2022.7	B	07/26/2022
Axon June 2022 Release Notes	2022.6	A	06/23/2022
Axon April 2022 Release Notes	2022.4	A	04/27/2022
Axon March 2022 Release Notes	2022.3	A	03/22/2022
Axon February 2022 Release Notes	2022.2	A	02/22/2022
Axon January 2022 Release Notes	2022.1	A	01/25/2022
Axon December 2021 Release Notes	2021.12	A	12/14/2021
Axon October 2021 Release Notes	2021.10	A	10/26/2021
Axon September 2021 Release Notes	2021.9	A	09/28/2021
Axon August 2021 Release Notes	2021.8	A	08/24/2021
Axon July 2021 Release Notes	2021.7	B	07/27/2021
Axon June 2021 Release Notes	2021.6	A	06/23/2021
Axon May 2021 Release Notes	2021.5	A	05/25/2021
Axon April 2021 Release Notes	2021.4	A	04/27/2021
Axon March 2021 Release Notes	2021.3	A	03/23/2021
Axon February 2021 Release Notes	2021.3	A	02/25/2021
Axon January 2021 Release Notes	2021.1	B	01/26/2021
Axon December 2020 Release Notes	2020.12	B	12/08/2020
Axon October 2020 Release Notes	2020.10	A	10/27/2020
Axon September 2020 Release Notes	2020.9	A	09/22/2020
Axon August 2020 Release Notes	2020.8	A	08/26/2020
Axon July 2020 Release Notes	2020.7	A	07/28/2020
Axon June 2020 Release Notes	2020.6	A	06/23/2020
Axon May 2020 Release Notes	2020.5	A	05/27/2020
Axon April 2020 Release Notes	2020.4	A	04/28/2020
Axon March 2020 Release Notes	2020.3	A	03/24/2020
Axon February 2020 Release Notes	2020.2	A	02/25/2020
Axon January 2020 Release Notes	2020.1	B	01/28/2020

Analysis Software

Data Extraction Software

Cellebrite UFED (version 7.57.0.13) forensic software was used to extract a logical copy of the iPhone 12. This process required the use of an Apple Lightning to USB 2.0 cable to connect the iPhone 12 to a computer running Windows 10 Home (10.0.19044 Build 19044) and run the UFED application.

Hashing Software

The SHA-256 hash algorithm was used to calculate file and stream hash values of the iPhone 12 known dataset and Axon created and transmitted data. The following system report and software were used to calculate SHA-256 hash values and cross-verify results throughout the experiment:

- Axon Evidence Audit Trail Reports
- Cellebrite Physical Analyzer Version 7.57.0.5.1
- Jacksum version 1.7.0
- FFmpeg version 5.1.1
- Microsoft CertUtil (version 10.0.1.19041.1466)

Authentication Software

Video, image, and audio authentication software was used to analyze multimedia and generate reports on file format and structure. The following applications were used:

- Amped Authenticate Build Date: 20220202, Revision: 23481
- Forensic Audio Analysis System (FAAS) v.2022.04.03
- Forensic Image Analysis System (FIAS) v.2022.04.13
- Forensic Video Authentication System (ARGO) v.2022.02.20
- Medex Version 1.63, Reference Library Version 2.2.44

The authentication tools used for analysis were randomized and anonymized throughout this paper and they are referred to as Tool A, Tool B, Tool C, Tool D, and Tool E.

CHAPTER III

METHODOLOGY

Known Dataset

Known Dataset Creation

A studio setup was used to capture photos, video, and audio reference samples with the iPhone 12. The smartphone was mounted on a tripod and an ISO 12233 resolution test chart was used as the visual subject of the media (figure 4). Apple Camera and Apple Voice Memos were used to capture the multimedia. Shown in table 2 were the pre-determined identification numbers used to distinguish between the various Apple format and lens options selected. Where applicable, a printed ID label and forensic scale were placed within the composition.

Table 2. iPhone 12 Settings and Testing ID Numbers

ID	Media	Format Settings	iPhone Application	Lens	Duration	GPS
1.1	Photo	Most Compatible (JPEG)	Apple Camera	Rear 1x	-	Yes
1.2	Photo	Most Compatible (JPEG)	Apple Camera	Front	-	Yes
1.3	Video	Most Compatible (AVC/H264)	Apple Camera	Rear 1x	30 sec	Yes
1.4	Video	Most Compatible (AVC/H264)	Apple Camera	Front	30 sec	Yes
1.5	Photo	High Efficiency (HEIF)	Apple Camera	Rear 1x	-	Yes
1.6	Photo	High Efficiency (HEIF)	Apple Camera	Front	-	Yes
1.7	Video	High Efficiency (HEVC/H265)	Apple Camera	Rear 1x	30 sec	Yes
1.8	Video	High Efficiency (HEVC/H265)	Apple Camera	Front	30 sec	Yes
1.9	Audio	Compressed (AAC)	Voice Memos	-	30 sec	Yes
1.10	Audio	Lossless (ALAC)	Voice Memos	-	30 sec	Yes

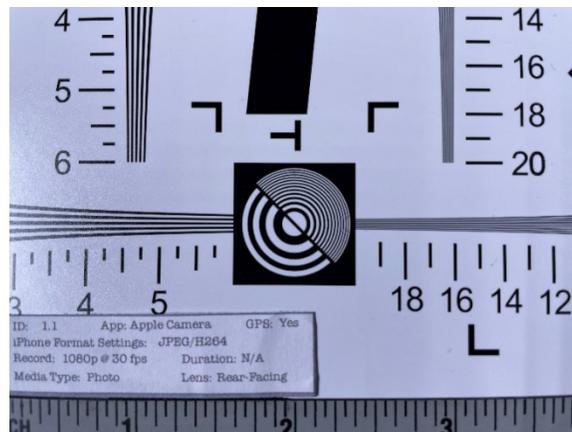


Figure 4. Known Dataset JPEG Image Composition with ISO 12233 Resolution Chart

Known Dataset Collection

The iPhone 12 known dataset was extracted using Cellebrite UFED software. This process required the use of an Apple Lightning to USB 2.0 cable to connect the iPhone 12 to a Windows computer. The Cellebrite UFED step-by-step procedures were followed to search for the iPhone 12 model number and create an ‘Advanced Logical’ backup copy. Cellebrite Physical Analyzer software was used to load the logical copy and access the iPhone 12 iOS file system. The camera’s original image and video files were accessed by navigating to the ‘DCIM’ folder and the original audio files were selected by navigating to the “Recording’ folder. Once the reference data was located, the Cellebrite software was used to calculate SHA-256 hash values and then export duplicate copies of the originals. The extracted data was hash verified using Jacksum (1.7.0) utility software. Shown in table 3 are the filenames, file paths, and hash values of the known dataset.

Table 3. iPhone 12 Known Dataset Description

ID	Media	Filename	File Path	SHA-256
1.1	Photo	IMG_0001.JPG	iPhone/mobile/Media/DCIM/100APPLE/	a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fe53d461b51d05a20f9dc
1.1	Live Video	IMG_0001.MOV	iPhone/mobile/Media/DCIM/100APPLE/	601dc1c144019db37f74cd646dc3df75687fc29deaa06b7cee9d66ea0ec58a11
1.2	Photo	IMG_0005.JPG	iPhone/mobile/Media/DCIM/100APPLE/	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdce
1.2	Live Video	IMG_0005.MOV	iPhone/mobile/Media/DCIM/100APPLE/	a4e596fe0119b9fa5bfe2e501db11bb29d21ca2112d91b74cab8664ccd0d1fe8
1.3	Video	IMG_0002.MOV	iPhone/mobile/Media/DCIM/100APPLE/	b096edb18e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513
1.4	Video	IMG_0006.MOV	iPhone/mobile/Media/DCIM/100APPLE/	a676063577277bf65418d6aa0187f5737bbfc73eea81565226f0bc304282452b
1.5	Photo	IMG_0003.HEIC	iPhone/mobile/Media/DCIM/100APPLE/	b72ba22972e17b931a17ad3e809c3b7ed143ba11a8ec9fb00a60b274128e09a9
1.5	Live Video	IMG_0003.MOV	iPhone/mobile/Media/DCIM/100APPLE/	44cf397f49b8262c36659bec1fe66432a4a4ed70d3c074250fa5174feea34f7e
1.6	Photo	IMG_0007.HEIC	iPhone/mobile/Media/DCIM/100APPLE/	51708bc4958fec858829186b2c3e8648ff7fab08fa10f4edf2eea921775cd8b3
1.6	Live Video	IMG_0007.MOV	iPhone/mobile/Media/DCIM/100APPLE/	9fd95bc4a7af0df1316738e6bf4b92a5ca37b9338cc6a891ee0187c981d1ebe2
1.7	Video	IMG_0004.MOV	iPhone/mobile/Media/DCIM/100APPLE/	eebb9307f738af2a35b225b017957d0a14a914bb2ab80c092e6f6c6d6531038f
1.8	Video	IMG_0008.MOV	iPhone/mobile/Media/DCIM/100APPLE/	677854dbe130749ffbcca7286ba106269ea8d6d181aed98c3ce884d9130c9d41
1.9	Audio	20220826_094112.m4a	iPhone/mobile/Library/Recordings/	9a75c4061f23bd66ebcf0e86af00741226fcb6d325082226d1866a97d89292c8
1.10	Audio	20220826_094530.m4a	iPhone/mobile/Library/Recordings/	f12477f9ac4ed45fdda96a0040f05caaca05543aeb2d8aedb4cd4e6461bdd029

Known Dataset Transmission Options

Axon Citizen Option A: ‘Photo Library’

In this test scenario, the recipient received Axon submission invitations through the text message delivery option. The invitations’ URL link was accessed on the iPhone 12, the device automatically launched the Safari web browser and opened the Axon Citizen submission

protocol. The known dataset stored in the Apple Photos application was accessed by tapping on the Axon Citizen 'Photo Library' web browser button. By default, the Axon Citizen protocol attached an 'Actual Size' copy of the digital evidence to the request. The 'Actual Size' text button was tapped, and three additional size options were presented: 'Large', 'Medium, and 'Small' (figures 5 and 6). This research examined all four size options offered by Option A for both images and videos captured in Apple 'High-Efficiency' HEIC/HEVC and 'Most Compatible' JPEG/AVC formats.

By default, the Apple Live Photo feature was enabled on the factory reset iPhone 12. The three (3) seconds video clips associated with known dataset JPEGs and HEICs (table 3) were not recognized by the Axon Citizen protocol. As a result, the Live Photo video clips were excluded from the test plan. Navigation to Apple Voice Memos was not supported by Option A and was also excluded from the test plan. After the known dataset images and videos were added to the Axon Citizen submission request and transmitted using Option A, the digital evidence was uploaded to Evidence.com and then downloaded from the cloud-based DEMS.

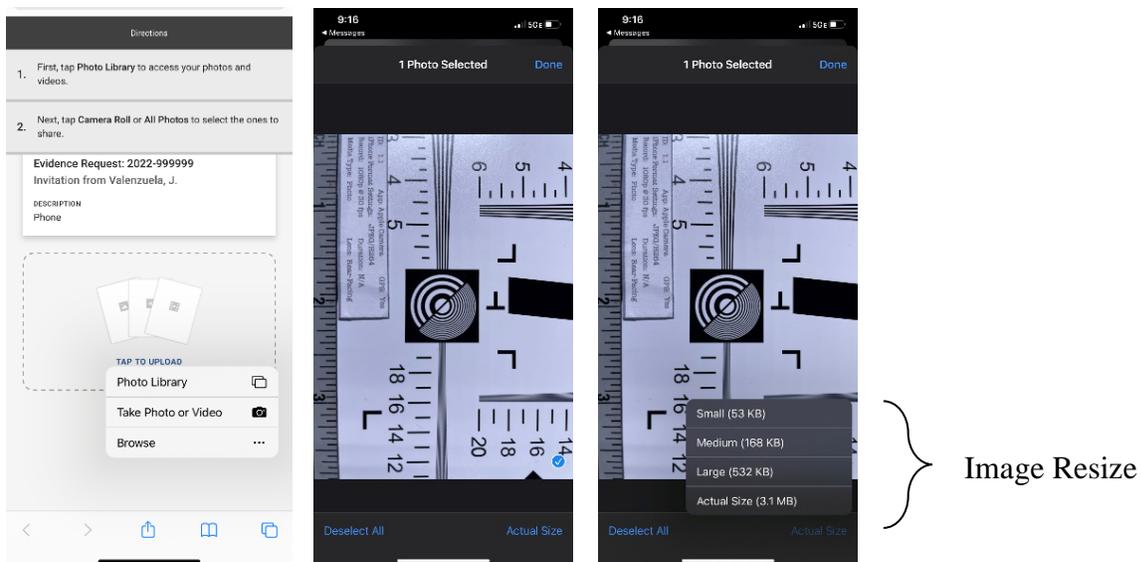


Figure 5. Axon Citizen for iOS Workflow and Image Resize Options

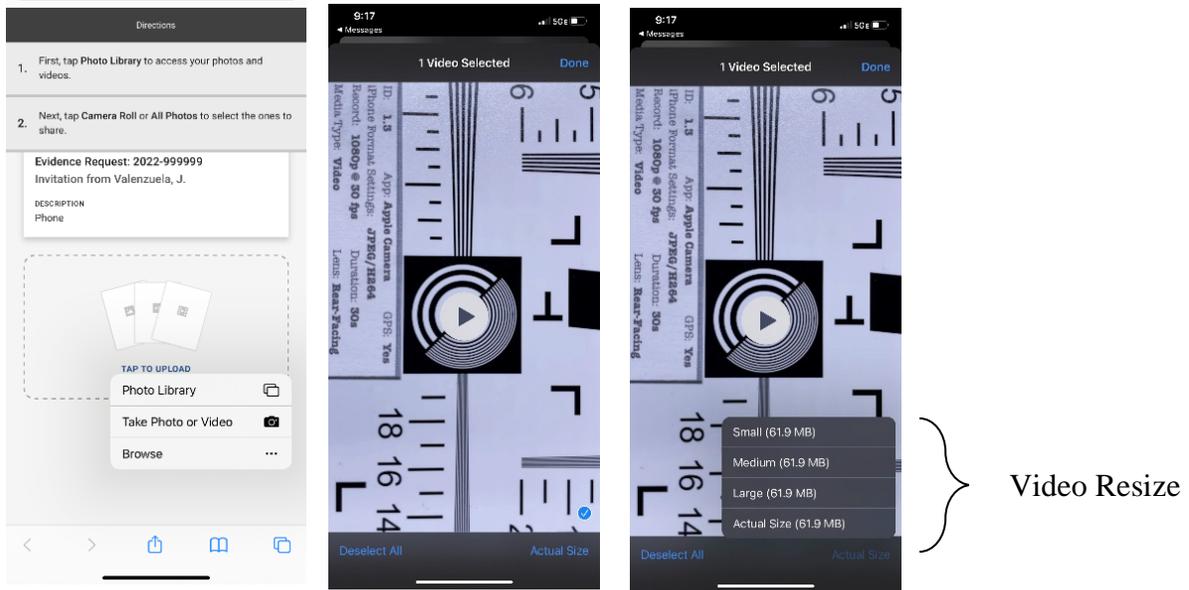


Figure 6. Axon Citizen for iOS Workflow and Video Resize Options

Axon Citizen Option C: ‘Browse’ to Apple Files

The Axon Citizen Option C allows the community member to navigate Apple default locations (e.g., Apple Files or iCloud) and user installed cloud storage applications (e.g., Microsoft OneDrive, Google Drive, etc.). Axon Citizen testing was performed by storing the known dataset in the Apple Files application on the iPhone 12 test device and transmitting reference samples to Evidence.com. Before the test plan was executed, the Apple Share ‘Save to Files’ feature was used to transfer copies of the known dataset from Apple Photos and Voice Memos to a folder in Apple Files (figure 7). An Axon Citizen submission link was sent via text message and Option C: ‘Browse’ was selected. The known dataset, which included audio, was added to the Axon Citizen submission from Apple Files by tapping ‘On My iPhone’ and selecting the files. Research conducted in [12], tested the transmission of a known dataset from a third-party cloud storage service to Evidence.com.

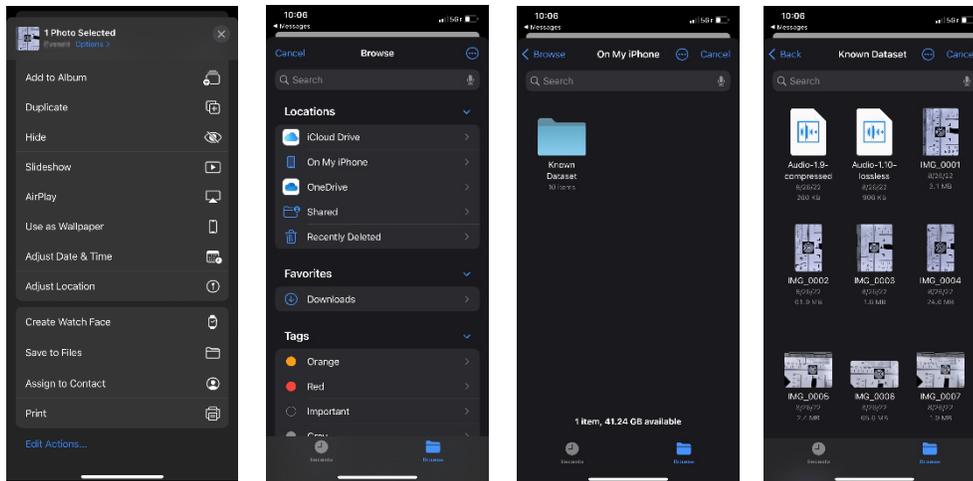


Figure 7. Axon Citizen Option C 'Browse' to Apple Files Workflow

Axon Capture 'Import' Feature

The Axon Capture 'Import' allows investigators to add photos and videos from the Apple Photos library and transmit data directly to Evidence.com. Navigation to Apple Voice Memos was not supported. In this test scenario, the mobile application was used to select known dataset photos and videos from Apple Photos. The media was placed on the Axon Capture 'Evidence List' and the tester followed the organization's workflow to enter agency identifiers and then transmitted to Evidence.com over a cellular connection (figure 8).

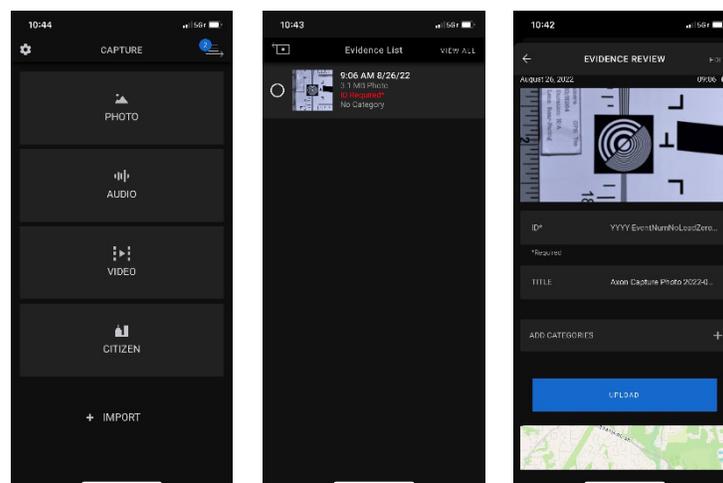


Figure 8. Axon Capture 'Import' and 'Evidence Review' Features

Axon “Live Capture” Features

Axon Capture In-App File Create

The same photography studio setup used to capture the known dataset (refer to *Known Dataset Description* section) was used to create multimedia with the Axon Capture ‘Photo’, ‘Audio’, or ‘Video’ features. The iPhone 12 Camera format settings ‘High Efficiency’ and ‘Most Compatible’ were selected to create video and image media samples. One example for each camera lens (front and rear) was taken. Two audio examples were recorded, and the Apple Voice Memo audio setting was changed between the ‘Compressed’ and ‘Lossless’ quality. The purpose of altering the native Apple format settings was to determine if the Axon Capture features were impacted by the iPhone 12 settings. The multimedia created was uploaded using the Axon Capture workflow (figure 8) to Evidence.com over cellular connectivity. Shown in table 10 is the Axon Capture transmitted and downloaded data.

Table 4. Axon Capture File Create Features – Collected Data

ID	iPhone 12 Format Settings	Lens	AXON Filename:
2.1	Most Compatible (JPEG)	Rear	Axon Capture Photo 2022-08-26 105846 7355.jpg
2.2	Most Compatible (JPEG)	Front	Axon Capture Photo 2022-08-26 111238 7355.jpg
2.3	Most Compatible (AVC)	Rear	Axon Capture Video 2022-08-26 110209 7355.MOV
2.4	Most Compatible (AVC)	Front	Axon Capture Video 2022-08-26 111516 7355.MOV
2.5	High Efficiency (HEIC)	Rear	Axon Capture Photo 2022-08-26 110441 7355.jpg
2.6	High Efficiency (HEIC)	Front	Axon Capture Photo 2022-08-26 112940 7355.jpg
2.7	High Efficiency (HEVC)	Rear	Axon Capture Video 2022-08-26 110724 7355.MOV
2.8	High Efficiency (HEVC)	Front	Axon Capture Video 2022-08-26 113138 7355.MOV
2.9	Audio Compressed (AAC)	-	Axon Capture Audio 2022-08-26 113507 7355.m4a
2.10	Audio Lossless (ALAC)	-	Axon Capture Audio 2022-08-26 113630 7355.m4a

Axon Citizen In-App File Create

The Axon Citizen for Officers Option B: ‘Take Photo or Video’ used the same testing methodology as the Axon Capture in-app file create features. Axon Citizen links were sent via text message delivery and accessed on an iPhone 12. The Axon Citizen protocol automatically opened the Apple Safari web browser, and the ‘Take Photo or Video’ option was selected. This feature allowed the recipient to take photographs or videos in real-time of content using the

mobile device camera system. The Axon Citizen feature on iOS does not provide the ability to record audio files. Shown in table 11 is the Axon Citizen Option B captured, transmitted, and downloaded from Evidence.com.

Table 5. Axon Citizen File Create Features – Collected Data

ID	iPhone 12 Format Settings	Lens	AXON Filename:
3.1	Most Compatible (JPEG)	Rear	image-4.jpg
3.2	Most Compatible (JPEG)	Front	image-2.jpg
3.3	Most Compatible (AVC)	Rear	68361242549_C6103700-C389-42ED-9CFE-28C52462C2E0.MOV
3.4	Most Compatible (AVC)	Front	68361355660_3E8B4103-2517-4569-9956-F1906764142C.MOV
3.5	High Efficiency (HEIC)	Rear	image-3.jpg
3.6	High Efficiency (HEIC)	Front	image.jpg
3.7	High Efficiency (HEVC)	Rear	68361282761_EC149F80-3DF6-4CD0-9CFD-42990969B43D.MOV
3.8	High Efficiency (HEVC)	Front	68361391096_98FD88E5-1577-49F0-AF32-805B05848D9A.MOV
3.9			Audio not supported
3.10			Audio not supported

Evidence.com Download Options

Axon [14] provides users with three different methods users can use to download content from Evidence.com:

- Download Evidence File – individual files downloaded to a computer one at a time
- Bulk Download Evidence – multiple files bundled into a ZIP archive file and download link emailed to the end user
- Bulk Download Evidence – multiple files bundled into a single ISO image file and download link emailed to the end user

The validation tests performed in [12] examined the three different Axon download options and confirmed that regardless of the download method used the SHA-256 values matched. For this study, performance verification testing was performed on the Evidence.com version (v2022-08-12.126203 Axon Evidence July 2022 CHROME 104) to confirm the results. Known dataset files were transmitted through the protocol and hash verified and the three Axon download options were tested. Performance testing confirmed that regardless of the Axon download method used

the SHA-256 values matched. To confirm the data stored in Evidence.com was not altered by the Windows 10 download process the Axon Audit Logs and Jacksum utility software were used hash verify the results. The data was not altered by the download process

File Hashing and Comparison

The SHA-256 hash algorithm was used to calculate file and stream hash values of the iPhone 12 known dataset and Axon created and transmitted data. Cellebrite Physical Analyzer software was used to calculate the SHA-256 hash values of the original files stored in the logical copy. Jacksum checksum software was used to verify the SHA-256 file hash values calculated by the forensic extraction tool. Axon Evidence system Audit Trail reports were downloaded and Jacksum software was used to cross-verify the hash values reported by Evidence.com. The stream hashing technique proposed by [16] was used as a method to confirm the data integrity of digital multimedia after the transmission and transcoding of known dataset files through the Axon protocol. This required the use of Microsoft CertUtil and FFmpeg to calculate the file and stream hashes of all the files to perform comparisons. The hashing technique proposed by [16] was automated with a batch script and the calculated hash values were archived.

The hash values calculated for each test scenario were copied into a master spreadsheet to compare the known dataset hash values against the Axon downloaded hash values (Appendix A). The full-length SHA256 64-bit hexadecimal values were truncated to easily present the data throughout this paper. For example, the calculated hash value: a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fc53d461b51d05a20f9dc was shortened by taking the first and last characters of the value and presenting it as ‘a865...f9dc’

The media files were compared and a “pass” or “fail” score was given to each file examined. The file and stream hash value variables were defined as follows:

Known Dataset

- a_1 = known reference file hash value
- a_2 = known reference video or image stream value
- a_3 = known reference audio stream value

Axon Transmitted and Downloaded

- b_1 = Axon file hash value
- b_2 = Axon video or image stream value
- b_3 = Axon audio stream value

The multimedia data streams hash values were taken into consideration and the following equivalence model was used to score the comparisons:

$$a_1 \leftrightarrow b_1 \text{ PASS}$$

$$a_1 \leftrightarrow \neg b_1 (a_2 \leftrightarrow b_2) \text{ PASS}$$

$$a_1 \leftrightarrow \neg b_1 (a_2, a_3 \leftrightarrow b_2, b_3) \text{ PASS}$$

$$a_1 \leftrightarrow \neg b_1 (\neg a_2 \leftrightarrow \neg b_2) \text{ FAIL}$$

$$a_1 \leftrightarrow \neg b_1 (\neg a_2, a_3 \leftrightarrow \neg b_2, b_3) \text{ FAIL}$$

Audio File Structure Signature Comparison Methodology

Tool B was used to perform analysis on audio files and report audio format and structure analysis information. The number of audio files examined was limited to two Axon Capture 'Audio' feature recordings and two known dataset audio files transmitted using Axon Citizen 'Browse' to Apple Files. File structure mapping was used to compare known dataset to Axon transmitted files.

JPEG Image File Structure Signature Comparison Methodology

Forensic software was used to analyze multimedia and generate reports on file format and structure. When possible, more than one software tool was used to perform the analysis. The image and video file structure information was reported for most of all the Axon data transmitted and downloaded from Evidence.com. Photos recorded in HEIC format were not processed with the forensic tools and were excluded from the file structure comparisons. The following Axon Capture and Citizen features/file formats were evaluated using the file structure signature method:

- Axon Capture – ‘Photo’ Feature (4 JPEGs)
- Axon Capture – ‘Video’ Feature (4 AVCs)
- Axon Capture – ‘Audio’ Feature 2 files (1 AAC and 1 AAC-LC)
- Axon Capture – ‘Import’ Feature (2 JPEGs, 2 AVCs, 2 HEVCs)
- Axon Citizen Option A ‘Photo Library’ (16 JPEGs and 16 AVCs)
- Axon Citizen Option B ‘Take Photo or Video’ (4 JPEGs, 4 AVCs)
- Axon Citizen Option C ‘Browse’ (4 JPEGs, 1 AAC, 1 AAC-LC)

Tool C and Tool E were both used to process JPEGs and report technical information on exchangeable image file format (EXIF) metadata, file structure, image and thumbnail quantization tables, and image Huffman codes. The parameters published by [17] were used to create comparison charts (figure 9) between the known reference sample and the Axon downloaded JPEGs and perform the empirical observation. The analysis of HEIC format images was limited and files not transcoded to JPEG by the Axon protocol were excluded from this analysis. JPEG comparison charts are disclosed in the Appendix (figures 14-41).

1 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Photo Feature
Filename:	IMG-0001.jpg	Axon Capture Photo 2022-08-26 105846_7355.jpg
SHA-256:	a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fc53d461b51d05a20f9dc	707635f6ee9dec692695bc3b2be86f42c6bbd5e69b359ed1ce76ead374528caf
Image dimensions:	4032 x 3024	4032 x 3024
Quantization Table (Y):	<pre> 1 1 1 1 2 3 4 5 6 1 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>
Huffman Code DC (Y):	151111110000000	151111110000000
Huffman Code AC (Y):	21332435544001125	21332435544001125
Huffman Code DC (Cr):	311111111000000	311111111000000
Huffman Code AC (Cr):	21244347544012119	21244347544012119
Thumbnail dimensions:	160 x 120	No thumbnail extracted.
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	No thumbnail extracted.
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	No thumbnail extracted.
EXIF Count:	66600026	4000126

Figure 9. Native Apple JPEG vs. Axon JPEG Signature Comparison Chart Example

The information from the image signature comparison charts was consolidated and nine (9) technical characteristics were used to compare the native iPhone 12 reference files from the known dataset to the collected Axon files.

1. Image pixel dimensions (Image Size)
2. Image Luminance Quantization Table (iQT Y)
3. Image Chrominance Quantization Table (iQY Cr)
4. Huffman Code DC (HC Y):
5. Huffman Code DC (HC Cr):
6. Thumbnail dimensions (TN size)
7. Thumbnail Luminance Quantization Table (tQT Y)
8. Thumbnail Chrominance Quantization Table (tQT Cr)
9. EXIF Count

Axon JPEG images were grouped into two categories. Group 1 (ID#s 1-14) consisted of 14 Axon images taken with the iPhone 12 rear camera system and compared to the image signature of the known dataset file 'IMG_0001.JPG'. Group 2 (ID#s 15-28) consisted of 14 Axon images taken with the iPhone 12 front camera system and compared to the image signature of the known dataset file 'IMG_0005.JPG'. A value of '1' was provided if there was a file difference and a value of '0' was provided when there was no difference between the known and Axon JPEG.

Video File Structure Signature Comparison Methodology

For this part of the examination, 32 Axon videos were separated into two different groups. The first group of videos (videos #1-24) consisted of known dataset videos transmitted through the Axon Capture 'Import', Axon Citizen 'Photo Library', and Axon Citizen 'Browse' options. The second video group (videos #25-32) consisted of in-app file create features that were recorded with the Axon Capture 'Video' and Axon Citizen 'Take Photo or Video' features.

Tool A and Tool D were used to report video information on metadata, file structure, and unique structure signatures. Tool A contained a reference library of 56,839 known video exemplars and the platform was used to process the dataset iPhone 12 AVC and HEVC videos as well as the Axon transmitted and downloaded videos to report unique file signature numbers. The technical characteristics as well as the file structural signature/mapping technique used by [18] were used to create individual comparison charts and a summary table to compare iPhone 12 unique file structure numbers to Axon video unique file structures (figures 41-46). Shown in figure 10 is an example of a file structural mapping comparison chart. Videos with identical file signatures were marked as "consistent" and those that did not match the iPhone 12 reference samples were marked as "inconsistent". Both video groups were analyzed using the same file structural mapping methodology.

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Capture for iOS 5.7.0 (13) – Import Feature
Filename:	IMG_0002.MOV	Axon_Capture_Video_2022-08-26_091022_7355.MOV
File SHA-256:	b096edbf8e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513	ed3c7a370fc20720d03b35f497387d695f29852b3b5ee023a288bba29d5b587
Video dimensions:	1920 x 1080	1280 x 720
Format	MPEG-4/AVC	MPEG-4/AVC
File Signature	rl.879	pf.279
	<pre> ffyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.80% clief - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mdhd - 3.84% hdlr - 3.85% minf - 3.83% vmhd - 3.83% hdrl - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtp - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mdhd - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdrl - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% sgpd - 6.13% sbgp - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdcp - 0.37% mdia - 0.37% mdhd - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdrl - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdcp - 0.37% mdia - 0.40% mdhd - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdrl - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdcp - 0.30% mdia - 0.30% mdhd - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdrl - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mdta - 0.48% mdta - 0.48% mdta - 0.48% mdta - 0.50% mdta - 0.30% mdta - 0.28% ilst - 0.05% data - 0.40% data - 0.50% data - 0.28% data - 0.35% data - 0.31% data - 0.25% </pre>	<pre> ffyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% edts - 53.45% elst - 53.45% mdia - 53.37% mdhd - 53.37% hdlr - 53.37% minf - 53.37% smhd - 2.88% hdrl - 53.37% dinf - 53.37% dref - 53.37% alis - 0.49% stbl - 53.37% stsd - 53.37% sgpd - 0% sbgp - 0% stts - 0.93% stsc - 12.62% stsz - 12.62% stco - 12.62% trak - 13.99% tkhd - 13.99% tapt - 0% clief - 0% prof - 0% enof - 0% edts - 1.84% elst - 1.84% mdia - 2.00% mdhd - 2.00% hdlr - 2.00% minf - 2.00% vmhd - 0% hdrl - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% stts - 1.78% ctts - 0.00% csig - 0.00% stss - 0.00% sdtp - 0.00% stsc - 0.05% stsz - 0.05% stco - 0.05% meta - 0.00% hdlr - 0.00% keys - 0.00% mdta - 0.27% mdta - 0.01% mdta - 0.02% mdta - 0.05% mdta - 0.05% mdta - 0.02% ilst - 0.00% data - 0.05% data - 0.01% data - 0.02% data - 0.02% data - 0.01% data - 0.02% </pre>

Figure 10. Native Apple AVC vs. Axon AVC Signature Comparison Chart Example

CHAPTER IV

RESULTS

Known Dataset Transmission Results

Axon Citizen Option A: Navigate to 'Photo Library'

Shown in table 6 are the “pass” or “fail” results of the 32 Axon transmitted files (16 images and 16 videos) downloaded from Evidence.com. Taking into consideration the video or image stream hash values, the Axon protocol altered 68.75% of the data transmitted through Option A.

Table 6. Axon Citizen Option A 'Photo Library' Hash Results

Source	ID	Filename	SHA256 (File Hash)	SHA256 (Video or Image Stream)	SHA256 (Audio Stream)	RESULTS
Known JPEG	1.1	IMG_0001.JPG	a865...f9dc	28aa...730a	-	
Axon Option A	Actual Size	571C8AE4-F07A-41EC-A6B9-F1A81DBC9C7F.jpeg	a865...f9dc	28aa...730a	-	PASS
Axon Option A	Large	253C90BA-4B96-49B3-B09F-2D3742952D1D.jpeg	de59...7437	e4c2...d19f	-	FAIL
Axon Option A	Medium	B4F457B5-96D1-420D-B546-C8E3294DD955.jpeg	52e6...8ba3	7b29...f529	-	FAIL
Axon Option A	Small	866965FE-DD9D-4EB8-BD61-E5D13DE13C5C.jpeg	01db...8207	b64f...90a6	-	FAIL
Known JPEG	1.2	IMG_0005.JPG	019f...2fdc	5af2...6da2	-	
Axon Option A	Actual Size	A517AF45-A797-41B8-A7CE-137C8A182CED.jpeg	019f...2fdc	5af2...6da2	-	PASS
Axon Option A	Large	9A1428F3-DF3C-44CA-8107-25F46B8316C3.jpeg	7c09...ca86	6018...4720	-	FAIL
Axon Option A	Medium	7C63A91F-1497-4DAB-8DDE-9F08BFAFF753.jpeg	5bac...ac0d	828a...d50d	-	FAIL
Axon Option A	Small	15E6CC78-4FEB-437F-8757-492A62F2A1F9.jpeg	78e5...0a6f	3644...49ec	-	FAIL
Known AVC	1.3	IMG_0002.MOV	b096...6513	4296...7959	ec37...a623	
Axon Option A	Small	IMG_0002.MOV	490a...2f28	4296...7959	ec37...a623	PASS
Axon Option A	Medium	IMG_0002-2.MOV	78ed...1ec3	4296...7959	ec37...a623	PASS
Axon Option A	Actual Size	IMG_0002-3.MOV	3311...cb6b	4296...7959	ec37...a623	PASS
Axon Option A	Large	IMG_0002-4.MOV	3e00...7dba	4296...7959	ec37...a623	PASS
Known AVC	1.4	IMG_0006.MOV	a676...452b	51a9...2a8e	0871...aa03	
Axon Option A	Actual Size	IMG_0006.MOV	40b6...a9c2	51a9...2a8e	0871...aa03	PASS
Axon Option A	Large	IMG_0006-2.MOV	ba03...d6ea	51a9...2a8e	0871...aa03	PASS
Axon Option A	Medium	IMG_0006-3.MOV	22fd...d1e4	51a9...2a8e	0871...aa03	PASS
Axon Option A	Small	IMG_0006-4.MOV	df4d...9b04	51a9...2a8e	0871...aa03	PASS
Known HEIC	1.5	IMG_0003.HEIC	b72b...09a9	**Stream Hash Not Supported**	-	
Axon Option A	Actual Size	5EB92EBF-670E-4895-BC37-FC2451CA190A.jpeg	9644...7ad9	8e06...90ba	-	FAIL
Axon Option A	Large	1E410261-5D9F-45C4-A6DF-B0D8790842EE.jpeg	5e2b...c456	8296...15ad	-	FAIL
Axon Option A	Medium	CD7F0BA1-7485-4901-A2BB-1505C282E82D.jpeg	6a24...6c30	fa06...8126	-	FAIL
Axon Option A	Small	3FCD8007-1B7A-43E8-BDFB-62F5975372BD.jpeg	ead7...0f1a	d760...aeae	-	FAIL
Known HEIC	1.6	IMG_0007.HEIC	5170...d8b3	**Stream Hash Not Supported**	-	
Axon Option A	Actual Size	6D04CF3F-7B0A-4039-A67A-30C8A565CE9C.jpeg	2fb8...ac7f	6b66...8d74	-	FAIL
Axon Option A	Large	76E9C563-BBCA-4465-9A4A-18EB3934DB0C.jpeg	bd25...d5f7	f197...e334	-	FAIL
Axon Option A	Medium	B3E55497-D247-466F-8449-6F02265AF409.jpeg	e004...8460	3c89...5d66	-	FAIL
Axon Option A	Small	DB815CF8-6AEB-4C71-8B60-246B512D572D.jpeg	4dda...3ad9	3b3a...58b5	-	FAIL
Known HEVC	1.7	IMG_0004.MOV	eebb...038f	e590...226d	780d...a283	
Axon Option A	Actual Size	IMG_0004.MOV	fec4...cc9f	b8dd...43ca	780d...a283	FAIL
Axon Option A	Large	IMG_0004-2.MOV	5afd...03d5	b8dd...43ca	780d...a283	FAIL
Axon Option A	Medium	IMG_0004-3.MOV	8d04...40a9	b8dd...43ca	780d...a283	FAIL
Axon Option A	Small	IMG_0004-4.MOV	2cb7...c9ea	b8dd...43ca	780d...a283	FAIL
Known HEVC	1.8	IMG_0008.MOV	6778...9d41	14d2...5c88	69b0...821e	
Axon Option A	Actual Size	IMG_0008.MOV	ad23...1088	0b37...45d9	69b0...821e	FAIL
Axon Option A	Large	IMG_0008-2.MOV	16c8...a621	0b37...45d9	69b0...821e	FAIL
Axon Option A	Medium	IMG_0008-3.MOV	c8f2...72e4	0b37...45d9	69b0...821e	FAIL
Axon Option A	Small	IMG_0008-4.MOV	49fc...6e03	0b37...45d9	69b0...821e	FAIL

Axon Citizen Option C: ‘Browse’ to Apple Files

The Axon Citizen Option C: ‘Browse’ to Apple Files was analyzed using the same methodology as Axon Citizen Option A. Unlike Option A, Option C allowed the transmission of all known dataset media files (audio, video, and images). In this test scenario, 100% of the Axon transmitted received a “pass” score (table 7).

Table 7. Axon Citizen Option C ‘Browse’ to Apple Files Hash Results

Source	ID	Filename	SHA256 (File Hash)	SHA256 (Video or Image Stream)	SHA256 (Audio Stream)	RESULTS
Known JPEG	1.1	IMG_0001.JPG	a865...f9dc	28aa...730a	-	
Axon Citizen Option C	1.1	IMG_0001.JPG	a865...f9dc	28aa...730a	-	PASS
Known JPEG	1.2	IMG_0005.JPG	019f...2fde	5af2...6da2	-	
Axon Citizen Option C	1.2	IMG_0005.JPG	019f...2fde	5af2...6da2	-	PASS
Known AVC	1.3	IMG_0002.MOV	b096...6513	4296...7959	ec37...a623	
Axon Citizen Option C	1.3	IMG_0002.MOV	b096...6513	4296...7959	ec37...a623	PASS
Known AVC	1.4	IMG_0006.MOV	a676...452b	51a9...2a8e	0871...aa03	
Axon Citizen Option C	1.4	IMG_0006.MOV	a676...452b	51a9...2a8e	0871...aa03	PASS
Known HEIC	1.5	IMG_0003.HEIC	b72b...09a9	-	-	
Axon Citizen Option C	1.5	IMG_0003.HEIC	b72b...09a9	-	-	PASS
Known HEIC	1.6	IMG_0007.HEIC	5170...d8b3	-	-	
Axon Citizen Option C	1.6	IMG_0007.HEIC	5170...d8b3	-	-	PASS
Known HEVC	1.7	IMG_0004.MOV	eebb...038f	e590...226d	780d...a283	
Axon Citizen Option C	1.7	IMG_0004.MOV	eebb...038f	e590...226d	780d...a283	PASS
Known HEVC	1.8	IMG_0008.MOV	6778...9d41	14d2...5c88	69b0...821e	
Axon Citizen Option C	1.8	IMG_0008.MOV	6778...9d41	14d2...5c88	69b0...821e	PASS
Known AAC	1.9	20220826_094112.m4a	9a75...92c8	-	2623...4dde	
Axon Citizen Option C	1.9	Audio-1.9-compressed.m4a	9a75...92c8	-	2623...4dde	PASS
Known ALAC	1.10	20220826_094530.m4a	f124...d029	-	b3d1...7d67	
Axon Citizen Option C	1.10	Audio-1.10-lossless.m4a	f124...d029	-	b3d1...7d67	PASS

Axon Capture ‘Import’ Feature

The Axon Capture ‘Import’ did not require the use of the Apple Safari web browser to transmit data. Instead, Axon Capture selected images and videos from Apple Photos, which were imported to the Axon Capture ‘Evidence List’ and transmitted to Evidence.com. The transmission of audio was not supported by the import feature. In this test scenario, 50% of the files examined were altered by the Axon protocol (table 8).

Table 8. Axon Capture ‘Import’ Hash Results

Source	ID	Filename	SHA256 (File Hash)	SHA256 (Video or Image Stream)	SHA256 (Audio Stream)	RESULTS
Known JPEG	1.1	IMG_0001.JPG	a865...f9dc	28aa...730a	-	
Axon Citizen Option C	1.1	Axon_Capture_Photo_2022-08-26_090602_7355.JPG	a865...f9dc	28aa...730a	-	PASS
Known JPEG	1.2	IMG_0005.JPG	019f...2fdc	5af2...6da2	-	
Axon Citizen Option C	1.2	Axon_Capture_Photo_2022-08-26_092748_7355.JPG	019f...2fdc	5af2...6da2	-	PASS
Known AVC	1.3	IMG_0002.MOV	b096...6513	4296...7959	ec37...a623	
Axon Citizen Option C	1.3	Axon_Capture_Video_2022-08-26_091022_7355.MOV	ed3c...b587	9484...e802	ec37...a623	FAIL
Known AVC	1.4	IMG_0006.MOV	a676...452b	51a9...2a8e	0871...aa03	
Axon Citizen Option C	1.4	Axon_Capture_Video_2022-08-26_093028_7355.MOV	df78...f0da	0c47...26ab	0871...aa03	FAIL
Known HEIC	1.5	IMG_0003.HEIC	b72b...09a9	-	-	
Axon Citizen Option C	1.5	Axon_Capture_Photo_2022-08-26_091552_7355.HEIC	b72b...09a9	-	-	PASS
Known HEIC	1.6	IMG_0007.HEIC	5170...d8b3	-	-	
Axon Citizen Option C	1.6	Axon_Capture_Photo_2022-08-26_093357_7355.HEIC	5170...d8b3	-	-	PASS
Known HEVC	1.7	IMG_0004.MOV	eebb...038f	e590...226d	780d...a283	
Axon Citizen Option C	1.7	Axon_Capture_Video_2022-08-26_091718_7355.MOV	f08c...d9f7	8996...0fe4	780d...a283	FAIL
Known HEVC	1.8	IMG_0008.MOV	6778...9d41	14d2...5c88	69b0...821e	
Axon Citizen Option C	1.8	Axon_Capture_Video_2022-08-26_093620_7355.MOV	30c5...aa37	a46a...326a	69b0...821e	FAIL

Axon Capture and Citizen File Structures Results

JPEG File Structure Analyses

Tools C and E were used to load the 28 JPEGs and generate format and structure analysis reports. Technical characteristics from the reports were used to create image signature charts (Appendix A). Shown in table 9 are the difference scores between the known dataset and the Axon files.

Table 9. Axon JPEGs Difference Score Summary Results

ID	Lens	Axon Protocol:	Image Size	iQT (Y)	iQT (Cr)	HC (Y)	HC (Cr)	TN Size	tQT (Y)	tQT (Cr)	EXIF Count	Differences	Results	
1	Rear	Axon Capture – ‘Photo’	0	0	0	0	0	1	1	1	1	4	INCONSISTENT	
2	Rear	Axon Capture – ‘Photo’	0	0	0	0	0	1	1	1	1	4	INCONSISTENT	
3	Rear	Axon Capture – ‘Import’	0	0	0	0	0	0	0	0	0	0	CONSISTENT	
4	Rear	Axon Citizen Option A Actual Size (JPEG → JPEG)	0	0	0	0	0	0	0	0	0	0	CONSISTENT	
5	Rear	Axon Citizen Option A Large (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
6	Rear	Axon Citizen Option A Medium (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
7	Rear	Axon Citizen Option A Small (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
8	Rear	Axon Citizen Option A Actual Size (HEIC → JPEG)	0	0	0	0	0	0	0	0	0	1	INCONSISTENT	
9	Rear	Axon Citizen Option A Large (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
10	Rear	Axon Citizen Option A Medium (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
11	Rear	Axon Citizen Option A Small (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
12	Rear	Axon Citizen Option B ‘Take Video or Photo’	0	1	1	0	0	1	1	1	1	6	INCONSISTENT	
13	Rear	Axon Citizen Option B ‘Take Video or Photo’	0	1	1	0	0	1	1	1	1	6	INCONSISTENT	
14	Rear	Axon Citizen Option C ‘Browse’ (JPEG)	0	0	0	0	0	0	0	0	0	0	CONSISTENT	
15	Front	Axon Capture – ‘Photo’	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
16	Front	Axon Capture – ‘Photo’	0	1	1	0	0	1	1	1	1	6	INCONSISTENT	
17	Front	Axon Capture – ‘Import’	0	0	0	0	0	0	0	0	0	0	CONSISTENT	
18	Front	Axon Citizen Option A Actual Size (JPEG → JPEG)	0	0	0	0	0	0	0	0	0	0	CONSISTENT	
19	Front	Axon Citizen Option A Large (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
20	Front	Axon Citizen Option A Medium (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
21	Front	Axon Citizen Option A Small (JPEG → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
22	Front	Axon Citizen Option A Actual Size (HEIC → JPEG)	0	1	1	0	0	0	0	0	0	1	3	INCONSISTENT
23	Front	Axon Citizen Option A Large (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
24	Front	Axon Citizen Option A Medium (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
25	Front	Axon Citizen Option A Small (HEIC → JPEG)	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
26	Front	Axon Citizen Option B ‘Take Video or Photo’	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
27	Front	Axon Citizen Option B ‘Take Video or Photo’	1	1	1	0	0	1	1	1	1	7	INCONSISTENT	
28	Front	Axon Citizen Option C ‘Browse’ (JPEG)	0	0	0	0	0	0	0	0	0	0	CONSISTENT	

Almost all (78.58%) of the Axon JPEG file structures examined and compared to the original iPhone 12 ‘Most Compatible’ JPEG file structure were inconsistent with the original

reference samples. The Axon Citizen ‘Photo Library’ Option A was the most destructive transmission method. Original Apple HEIC ‘High Efficiency’ encoded photos submitted using the ‘Actual Size’ option were transcoded to JPEG format. Additionally, Citizen Option A allowed the submitter to resize images using predetermined dimensions, this user-defined option was not observed in other Axon features. The resize option allowed originally sized images with pixel dimensions of 4032 x 3024 to be reduced to 1280 x 960, 640 x 480, or 320 x 240 size. When these ‘Large’, ‘Medium’, or ‘Small’ resize options were selected, the Axon Citizen protocol changed the JPEG quantization tables, reduced image quality, removed the image thumbnail, and striped most of the EXIF metadata, which included GPS information. Although GPS data was removed from the file structure, the information was available on Evidence.com. Shown in figure 11 is the location information (redacted) powered by the Evidence.com platform.

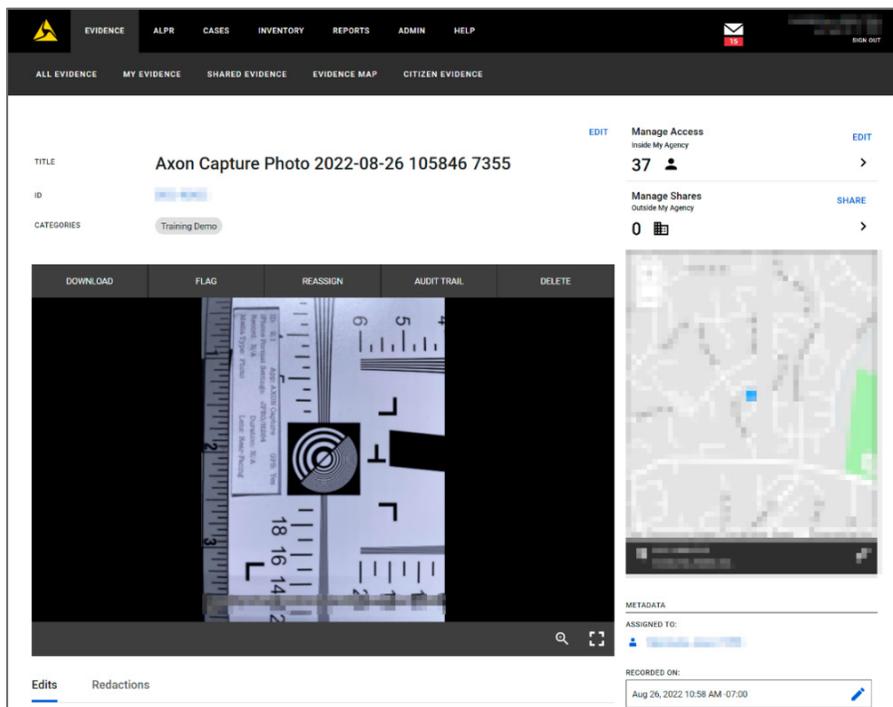


Figure 11. Axon Evidence.com User Interface

JPEG images submitted through the Axon Capture ‘Import’ and originally encoded JPEGs (not transcoded from HEIC) submitted through Axon Citizen Options A and C were consistent with the original iPhone reference samples. Photos taken with the rear camera system and the Axon Citizen Option B ‘Take Video or Photo’ feature recorded images with pixel dimensions 4032 x 3024 but front (selfie) lens images created 3088 x 2316 sized images. A review of the JPEG EXIF reported by Tool C and E revealed the text-string entry ‘Photoshop 3.0’ in the hexadecimal (figure 12). The ‘Photoshop’ keyword appeared in 22 out of the 28 files examined and was not present in the 6 unaltered JPEGs (IDs 3,4,14,17,18,28).

```

Offset (d) 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15
00000000 FF D8 FF E0 00 10 4A 46 49 46 00 01 01 00 00 48  ÿØÿà..JFIF.....H
00000016 00 48 00 00 FF E1 00 58 45 78 69 66 00 00 4D 4D  .H..ÿá.XExif..MM
00000032 00 2A 00 00 00 08 00 02 01 12 00 03 00 00 00 01  .*.....
00000048 00 06 00 00 87 69 00 04 00 00 00 01 00 00 00 26  ....+i.....&
00000064 00 00 00 00 00 03 A0 01 00 03 00 00 00 01 FF FF  ....ÿÿ
00000080 00 00 A0 02 00 04 00 00 00 01 00 00 0F C0 A0 03  .. .....À .
00000096 00 04 00 00 00 01 00 00 0B D0 00 00 00 00 FF ED  ....Ð....ÿí
00000112 00 38 50 68 6F 74 6F 73 68 6F 70 20 33 2E 30 00  .8Photoshop 3.0.
00000128 38 42 49 4D 04 04 00 00 00 00 00 00 38 42 49 4D  8BIM.....8BIM

```

Figure 12. ‘Axon_Capture_Photo_2022-08-26_105846_7355.jpg’ JPEG File Header

Video File Structure Analyses

Tools A and D were used to process 32 Axon videos as well as the four (4) known iPhone reference samples to generate technical reports. The report data was used to compare the videos' file structure and technical characteristics. Unique file signatures from Tool A and select technical attributes of the videos were compiled to observe the differences between Axon videos and the reference samples (table 21). Using this methodology, 87.5 % of the Axon files transmitted and/or created using the Axon features were inconsistent with the known reference files.

Table 10. Axon Video Comparison Summary Results

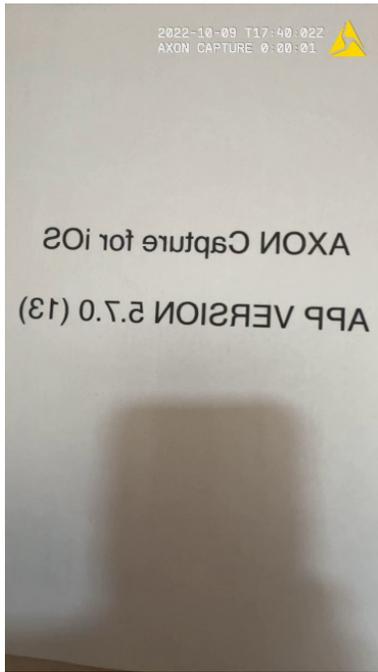
#	Lens	Filename	Signature	Device Classification	File Size	Resolution	File Size	Format	Profile	GPS	Rotation	DAR	Results
Kn	Rear	IMG_0002.MOV (Known Reference)	rl.879	iPhone 12 (match)	61886874	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	
1	Rear	Axon Capture – Import Feature	pf.279	No Device Available	10594949	1280 x 720	31 s 855 ms	AVC	High@L3.1	Yes	180	16:9	INCONSISTENT
2	Rear	Axon Citizen Option A 'Photo Library' – Actual Size	rl.563	iPhone 12 (partial)	61865367	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
3	Rear	Axon Citizen Option A 'Photo Library' – Large	rl.563	iPhone 12 (partial)	61865367	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
4	Rear	Axon Citizen Option A 'Photo Library' – Medium	rl.563	iPhone 12 (partial)	61865367	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
5	Rear	Axon Citizen Option A 'Photo Library' – Small	rl.563	iPhone 12 (partial)	61865379	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
6	Rear	Axon Citizen Option C 'Browse' to Apple Files	rl.879	iPhone 12 (match)	61886874	1920 x 1080	31 s 855 ms	AVC	High@L4	Yes	90	16:9	CONSISTENT
Kn	Front	IMG_0006.MOV (Known Reference)	rl.879	iPhone 12 (match)	65624594	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	
7	Front	Axon Capture – Import Feature	pf.279	No Device Available	11154681	1280 x 720	33 s 802 ms	AVC	High@L3.1	Yes	180	16:9	INCONSISTENT
8	Front	Axon Citizen Option A 'Photo Library' – Actual Size	rl.563	iPhone 12 (partial)	65603047	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
9	Front	Axon Citizen Option A 'Photo Library' – Large	rl.563	iPhone 12 (partial)	65603047	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
10	Front	Axon Citizen Option A 'Photo Library' – Medium	rl.563	iPhone 12 (partial)	65603071	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
11	Front	Axon Citizen Option A 'Photo Library' – Small	rl.563	iPhone 12 (partial)	65603071	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
12	Front	Axon Citizen Option C 'Browse' to Apple Files	rl.879	iPhone 12 (match)	65624594	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	CONSISTENT
Kn	Rear	IMG_0004.MOV (Known Reference)	rl.1193	iPhone 13 Pro (match)	24611033	1920 x 1080	32 s 123 ms	HEVC	Main 10@L4@Main	Yes	90	16:9	
13	Rear	Axon Capture – Import Feature	pf.279	No Device Available	10637637	1280 x 720	32 s 122 ms	AVC	High@L3.1	Yes	90	16:9	INCONSISTENT
14	Rear	Axon Citizen Option A 'Photo Library' – Actual Size	rl.563	iPhone 12 (partial)	59094979	1920 x 1080	32 s 123 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
15	Rear	Axon Citizen Option A 'Photo Library' – Large	rl.563	iPhone 12 (partial)	59094979	1920 x 1080	32 s 123 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
16	Rear	Axon Citizen Option A 'Photo Library' – Medium	rl.563	iPhone 12 (partial)	59095035	1920 x 1080	32 s 123 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
17	Rear	Axon Citizen Option A 'Photo Library' – Small	rl.563	iPhone 12 (partial)	59095043	1920 x 1080	32 s 123 ms	AVC	High@L4	Yes	90	16:9	INCONSISTENT
18	Rear	Axon Citizen Option C 'Browse' to Apple Files	rl.1193	iPhone 13 Pro (match)	24611033	1920 x 1080	32 s 123 ms	HEVC	Main 10@L4@Main	Yes	90	16:9	CONSISTENT
Kn	Front	IMG_0008.MOV (Known Reference)	rl.1193	iPhone 13 Pro (match)	19443198	1920 x 1080	33 s 502 ms	HEVC	Main 10@L4@Main	Yes	180	16:9	
19	Front	Axon Capture – Import Feature	pf.279	No Device Available	10818654	1280 x 720	33 s 502 ms	AVC	High@L3.1	Yes	180	16:9	INCONSISTENT
20	Front	Axon Citizen Option A 'Photo Library' – Actual Size	rl.563	iPhone 12 (partial)	59839950	1920 x 1080	33 s 502 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
21	Front	Axon Citizen Option A 'Photo Library' – Large	rl.563	iPhone 12 (partial)	59839994	1920 x 1080	33 s 502 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
22	Front	Axon Citizen Option A 'Photo Library' – Medium	rl.563	iPhone 12 (partial)	59840006	1920 x 1080	33 s 502 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
23	Front	Axon Citizen Option A 'Photo Library' – Small	rl.563	iPhone 12 (partial)	59840018	1920 x 1080	33 s 502 ms	AVC	High@L4	Yes	180	16:9	INCONSISTENT
24	Front	Axon Citizen Option C 'Browse' to Apple Files	rl.1193	iPhone 13 Pro (match)	19443198	1920 x 1080	33 s 502 ms	HEVC	Main 10@L4@Main	Yes	180	16:9	CONSISTENT
Kn	Rear	IMG_0002.MOV (Known Reference)	rl.879	iPhone 12 (match)	61886874	1920 x 1080	31 s 857 ms	AVC	High@L4	Yes	90	16:9	
25	Rear	Axon Capture – Video Feature	rl.311	iPhone 12 (partial)	8481251	720 x 1280	-	AVC	High@L4.1	No	Unkn	0.563	INCONSISTENT
26	Rear	Axon Citizen Option B 'Take Photo or Video'	rl.881	iPhone 12 (match)	3306470	480 x 360	32 s 897 ms	AVC	Baseline@L3	No	90	4:3	INCONSISTENT
Kn	Front	IMG_0006.MOV (Known Reference)	rl.879	iPhone 12 (match)	65624594	1920 x 1080	33 s 802 ms	AVC	High@L4	Yes	180	16:9	
27	Front	Axon Capture – Video Feature	rl.311	iPhone 12 (partial)	9605487	720 x 1280	-	AVC	High@L4.1	No	Unkn	0.563	INCONSISTENT
28	Front	Axon Citizen Option B 'Take Photo or Video'	rl.881	iPhone 12 (match)	3440708	480 x 360	-	AVC	Baseline@L3	No	180	4:3	INCONSISTENT
Kn	Rear	IMG_0004.MOV (Known Reference)	rl.1193	iPhone 13 Pro (match)	24611033	1920 x 1080	32 s 123 ms	HEVC	Main 10@L4@Main	Yes	90	16:9	
29	Rear	Axon Capture – Video Feature	rl.311	iPhone 12 (partial)	7978006	720 x 1280	-	AVC	High@L4.1	No	Unkn	0.563	INCONSISTENT
30	Rear	Axon Citizen Option B 'Take Photo or Video'	rl.881	iPhone 12 (match)	3186769	480 x 360	-	AVC	Baseline@L3	No	90	4:3	INCONSISTENT
Kn	Front	IMG_0008.MOV (Known Reference)	rl.1193	iPhone 13 Pro (match)	19443198	1920 x 1080	33 s 502 ms	HEVC	Main 10@L4@Main	Yes	180	16:9	
31	Front	Axon Capture – Video Feature	rl.311	iPhone 12 (partial)	8714996	720 x 1280	-	AVC	High@L4.1	No	Unkn	0.563	INCONSISTENT
32	Front	Axon Citizen Option B 'Take Photo or Video'	rl.881	iPhone 12 (match)	3234781	480 x 360	-	AVC	Baseline@L3	No	180	4:3	INCONSISTENT

The Axon Capture ‘Import’ feature was the most destructive process for transmitting video. Known dataset videos in AVC/H264 and HEVC/H265 formats transmitted through the Axon Capture ‘Import’ option were transcoded to AVC format and the video quality reduced from 1080p to 720p resolution. Videos transmitted through the Axon Citizen ‘Photo Library’ feature were selected from the Apple Photos library and uploaded using the ‘Actual Size’, ‘Large’, ‘Medium’, and ‘Small’ options. These size reduction options did not have the same effect observed with JPEG images. In the Option A test scenario, the video resolution remained consistent with the original iPhone 12 reference samples, but Tool A reported a different file structure signature (rl.563) for the AVC and HEVC format videos transmitted through the Axon protocol. The rl.563 file structure had a partial structural match to four different iPhone devices, which included the iPhone 12. Videos transmitted through Axon Citizen ‘Browse’ to Apple Files

were not transcoded by the Axon protocol and the transmitted videos maintained all the technical characteristics as the known reference samples. Tool A reported a file signature of rl.879 (AVC) and rl.1193 (HEVC) for transmitted videos that were consistent with the known reference sample reported file signatures.

The Axon Citizen Option B 'Take Photo or Video' feature encodes video in AVC/H264 format with pixel dimensions of 480 x 360 and a display aspect ratio of 4:3. Tool A reported a file signature of rl.881 and associates the file structure consistent with four iPhone devices that includes the iPhone 12. The Axon Capture mobile application generated vertical-sized video encoded in MPEG-4/AVC format with a pixel dimension of 720 x 1080 and a display aspect ratio of 0.563. Tool A reported a file signature of rl.311 which shared partial structural characteristics with one Samsung device and six Apple devices, which included the iPhone 12. Videos recorded with the Axon Capture 'Video' feature included a watermarked timestamp with Axon's yellow delta logo and exemplars captured with the front (selfie) iPhone 12 lens resulted in flipped content (figure 13). From a content analysis perspective, these characteristics can be used to easily recognize Axon Capture video.

iPhone 12 Front (Selfie) Lens



iPhone 12 Rear Lens

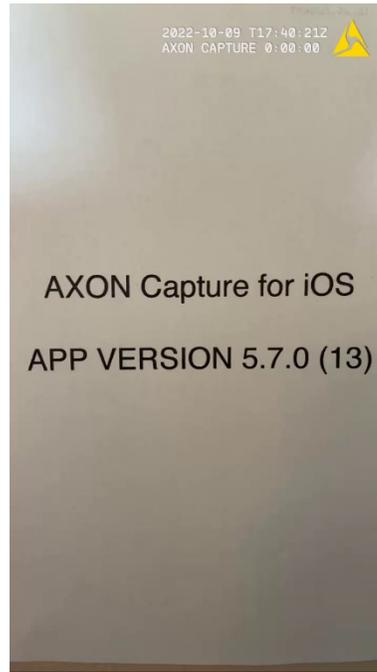


Figure 13. Axon Capture 'Video' Feature – Flipped Video Example

CHAPTER V

CONCLUSIONS

The Axon Capture and Citizen for Officers is modern technology built for Axon Enterprise, Inc. customers, which according to Axon [19] includes local, state, and federal law enforcement, military, and public safety organizations. The Axon mobile technology leverages a cloud-based DEMS Evidence.com to store digital multimedia evidence. One of the fundamental principles of evidence collection is maintaining the data integrity upon seizure of original or best evidence. I found through validation testing that the Axon Capture version 5.7.0 (13) for Apple iOS and the Axon Citizen for Officers features accessed on an iPhone 12 altered digital multimedia evidence. Not all the multimedia was altered, and some Axon protocols were more destructive than others. The file modifications were dependent on the originally encoded Apple format and method of transmission.

For example, the Axon Citizen ‘Photo Library’ feature accessed on an iPhone 12 using the mobile version of the Safari web browser transcoded images in HEIC format to JPEG format and removed metadata from the file structure. The Axon Citizen ‘Photo Library’ was the most destructive evidence collection feature and allowed JPEGs to be reduced to smaller image sizes and the keyword “Photoshop” was written into the file structure by the Axon protocol. From an image authentication perspective, these characteristics can cast doubt on the admissibility of digital evidence or even worse be used to obscure localized image manipulations (e.g., clone and paste, image splicing, pixel deletion, etc.). The Axon feature can potentially be used to electronically submit tampered evidence to a government organization and introduce errors.

The Axon Citizen for ‘Photo Library’ feature was not as destructive towards video files. The feature did transcode known dataset videos originally encoded in HEVC/H265 format to

AVC/H264 but the resize options did not impact the video. The novel file verification technique proposed by [16], used stream hashing to provide a deeper insight into the integrity of video files. This was a new technique used in conjunction with file hash validation testing. In the Axon Citizen ‘Photo Library’ test scenario, the AVC video hash values of the known dataset and Axon transmitted videos did not match. Stream hashing was used to compare the video and audio streams and the results provided support that Axon videos are consistent with original iPhone content. Further research and validation testing with stream hashing are required by the community but the results are promising.

The Axon Citizen ‘Browse’ feature was accessed on an iPhone through the mobile web browser Safari and was previously tested by navigating to a third-party cloud storage system [12]. In both test scenarios, the known dataset was not altered by the Axon Citizen for Officers protocol. This feature supported all media types and was the most consistent and reliable Axon transmission method. The Axon Capture ‘Import’ feature, which allows end users to add photos and videos from the Apple Photos library, resized and transcoded video files. The use of the import feature altered the original iPhone 12 videos and reduced the video resolution from 1080p to 720p. In this scenario, the officer or detective would be unknowingly using an investigative tool to transmit video evidence for safekeeping that has been modified by the Axon Capture application. Reduced video quality has the potential of impacting investigative leads and forensic video examinations.

The forensic techniques used by [17] and [18] were used to examine the known dataset transmission and “live capture” features of Axon Capture and Citizen protocols. Although the transmission of a known dataset to test the Axon “live capture” features was not possible, empirical observation of the image and video file structure signatures was used to gain known

insights into Axon transmitted media and report information to the forensic community. The iPhone 12 format settings (High Efficiency vs. Most Compatible) did not have an impact on the media created by Axon Capture and Citizen features. The reported Axon media format and file structure characteristics can be used to populate databases with known references for authentication and comparison purposes.

The Axon Capture and Citizen technology developed by Axon Enterprises, Inc. is an innovative technology for supported Apple iOS and Android devices. Technology has revolutionized how police officers and detectives document and collect digital multimedia evidence. The validation testing used a known dataset created with an iPhone 12 and the two Apple Camera format settings and two Apple Voice Memos quality settings. It was limited to Axon Capture for iOS version 5.7.0 (13) and Axon Citizen for Officers text message submission links sent to an iPhone 12 and accessed with the Safari web browser.

The validation testing performed revealed that most digital multimedia is altered by the Axon Capture and Axon Citizen technology platforms accessed on an Apple iPhone. The technology on Apple iOS has limitations (e.g., transcoding, resizing, quality reduction, EXIF removal, and flipped video frames). These limitations may be unintentional by the vendor and specific to the Axon Capture and Citizen features accessed on Apple iOS. Further research is required to identify the root cause. As such, Axon Capture for Apple iOS should not be the primary method used to collect digital imagery by law enforcement for forensic analysis. The use of Axon Citizen links for imagery to be provided by the public (outside of law enforcement acquisition) should also be used with caution due to the challenges presented by data alteration in the submission process. Periodic validation or verification testing of the Axon Capture and Citizen features is recommended.

Future Research

Future research in this area could include the validation of the Axon Capture and Citizen features on the Android platform. A comprehensive study on both Apple and Android mobile application versions should provide Axon users and the broader community with a better understanding of the technology limitations and opportunities. Future research could also provide vendors with a path forward for developing solutions that more strictly follow digital evidence best practices and/or integrate verified digital evidence transmission protocols into software regression test models. Once these basic digital evidence principles are fully integrated into existing platforms, then research and development could be conducted to methodically grow smartphone technology to perform more complex investigative and forensic tasks (e.g., fingerprint or pattern evidence preservation, photogrammetry, authentication, etc.). Finally, other research topics on Axon Capture could include calculating the mathematical pixel differences between the original and transmitted data, a more in-depth analysis of Axon Capture audio files, and scientifically assessing the visual image quality of Axon Capture media to other multimedia sources.

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Table 12. Axon Citizen Option C ‘ Browse ’ to Apple Files Hash Results Master Spreadsheet

A	B	C	D	E	F	G
Source	ID	Filename	Bytes	SHA256 (File Hash)	0x-SHA256 (Video or Image Stream)	1.x-SHA256 (Audio Stream)
Known Reference AXON Transmitted	1.1 1.1	IMG_0001.JPG IMG_0001.JPG	3088387 3088387	a865085f638864544de20296e86c7b97da4f653461b51d05a2079bd a865085f638864544de20296e86c7b97da4f653461b51d05a2079bd	28aa96f1a484f03021e50e4e4a24e6951719538a42ad5c84f54acc9730a 28aa96f1a484f03021e50e4e4a24e6951719538a42ad5c84f54acc9730a	
Known Reference AXON Transmitted	1.2 1.2	IMG_0005.JPG IMG_0005.JPG	2432353 2432353	019f7b77a20cc47ca0470776a0d9495020a581c179aa1bd62c2b94b66128d 019f7b77a20cc47ca0470776a0d9495020a581c179aa1bd62c2b94b66128d	5a2b62333734657276cead0e2c3a96e7c558af3e2120746b24ab484e8f6dad 5a2b62333734657276cead0e2c3a96e7c558af3e2120746b24ab484e8f6dad	
Known Reference AXON Transmitted	1.3 1.3	IMG_0002.MOV IMG_0002.MOV	61886874 61886874	b096edf8e894f8a8330910f41a1013ebc098812af9ac3dae0c2faac7e06513 b096edf8e894f8a8330910f41a1013ebc098812af9ac3dae0c2faac7e06513	4296053a7b2e2658f5ccteda02b0aacc1ee3291e233b216374d1b4c2b27e6d7959 4296053a7b2e2658f5ccteda02b0aacc1ee3291e233b216374d1b4c2b27e6d7959	
Known Reference AXON Transmitted	1.4 1.4	IMG_0006.MOV IMG_0006.MOV	65624594 65624594	a67606357727685418d6aa01875737bb6c77e8a81565226ffbc304282452b a67606357727685418d6aa01875737bb6c77e8a81565226ffbc304282452b	51a94bc41741fab561434cb08760b2f5b3cddc4aa474398d297de4e7652a8e 51a94bc41741fab561434cb08760b2f5b3cddc4aa474398d297de4e7652a8e	
Known Reference AXON Transmitted	1.5 1.5	IMG_0003.HEIC IMG_0003.HEIC	1638716 1638716	b72ba22972e176931a17adae809c3b7ed143ba11a8ee9b0a060274128e09a9 b72ba22972e176931a17adae809c3b7ed143ba11a8ee9b0a060274128e09a9		
Known Reference AXON Transmitted	1.6 1.6	IMG_0007.HEIC IMG_0007.HEIC	1935709 1935709	51708bc4958fe838829186b2c3e8648ff7fb086a10f6cd2ee921775cd883 51708bc4958fe838829186b2c3e8648ff7fb086a10f6cd2ee921775cd883		
Known Reference AXON Transmitted	1.7 1.7	IMG_0004.MOV IMG_0004.MOV	24611033 24611033	e6b9307f73847a34251017957d0a14a914bb2ab80c092e0f6c6d531038f e6b9307f73847a34251017957d0a14a914bb2ab80c092e0f6c6d531038f	e596a01344709add1e45c53a43ad495b66d72556db0b97fc4f6a3e701226d e596a01344709add1e45c53a43ad495b66d72556db0b97fc4f6a3e701226d	
Known Reference AXON Transmitted	1.8 1.8	IMG_0008.MOV IMG_0008.MOV	19443198 19443198	677854d8e130749ff8cca7286ba106269ea5d6d4818aac098e7ce884d9130c9441 677854d8e130749ff8cca7286ba106269ea5d6d4818aac098e7ce884d9130c9441	696026c7e91570eb91379b9dc5fb06573c9070e0db914e082b0ccf37dfe821e 696026c7e91570eb91379b9dc5fb06573c9070e0db914e082b0ccf37dfe821e	
Known Reference AXON Transmitted	1.9 1.9	20220826_094112.m4a Audio-1.9-compressed.m4a	259508 259508	9a75c4061e233df66ebc7e6a00741226f65bdf325082226d1866a97689292c8 9a75c4061e233df66ebc7e6a00741226f65bdf325082226d1866a97689292c8	26232150108a09e84ae1209d8e38e816979dae4f6bc6186c36d8dhec1aef6ddc 26232150108a09e84ae1209d8e38e816979dae4f6bc6186c36d8dhec1aef6ddc	
Known Reference AXON Transmitted	1.10 1.10	20220826_094530.m4a Audio-1.10-lossless.m4a	906189 906189	f12477f9acc4e45fdda96a04005caac05543aeb288aedb1cd4e616bdd4029 f12477f9acc4e45fdda96a04005caac05543aeb288aedb1cd4e616bdd4029	b3d1e6f7c7c8e8f9887af575bd4ad5abbe40a9ac48c5599c16d1431d07467 b3d1e6f7c7c8e8f9887af575bd4ad5abbe40a9ac48c5599c16d1431d07467	
				GREEN = PASS RED = FAIL		

Table 13. Axon Capture ‘ Import’ Feature Hash Results Master Spreadsheet

A	B	C	D	E	F	G
Source	ID	Filename	Bytes	SHA256 (File Hash)	0xSHA256 (Video or Image Stream Hash)	1.x.SHA256 (Audio Stream Hash)
Known Reference	1.1	IMG_0001.JPG	3083387	a8650d485f8a386d45444ead290a80c7b97d64c534461b16160520b9dc	23a90f1a4bb4f03021e0e4a4a024e95171933bab42ad2c84fc3aca9730a	
AXON Transmitted	1.1	Axon_Capture_Photo_2022-08-36_094602_7355.JPG	3083387	a8650d485f8a386d45444ead290a80c7b97d64c534461b16160520b9dc	23a90f1a4bb4f03021e0e4a4a024e95171933bab42ad2c84fc3aca9730a	
Known Reference	1.2	IMG_0005.JPG	2432353	019f7b7a3bc647ca0470276a049502a3b81c179aa0f602c42b9d8612f4c	5a7f60333734657276caad49e23a96e7c538af7e270748621a81e48f66a2	
AXON Transmitted	1.2	Axon_Capture_Photo_2022-08-36_092748_7355.JPG	2432353	019f7b7a3bc647ca0470276a049502a3b81c179aa0f602c42b9d8612f4c	5a7f60333734657276caad49e23a96e7c538af7e270748621a81e48f66a2	
Known Reference	1.3	IMG_0003.MOV	6188874	b096ed48f89d8f8a833093681410134e0498812af9c3d0e23aac7e6513	4296053a7b2a36585ee1eda02b0caee3291e23b216374d1b7c2b27e6f959	e37fea79c438736805e2769146589281966121c0772c6774c6d46375a623
AXON Transmitted	1.3	Axon_Capture_Video_2022-08-36_091022_7355.MOV	1059499	e4d5a5706c2072d0d6b534897387d69529323b3b7ee023428bba2636337	9438e924a4885796c31b625af15006765817944d08706d99485d6d4802	e37fea79c438736805e2769146589281966121c0772c6774c6d46375a623
Known Reference	1.4	IMG_0006.MOV	65624594	a678663772776d6511846aa01875737b46c73ee8f1562226f0c30428242b	51a94bc41714fab561154e68f760627b7c4dc4aa84743982d97d64e4652a8e	0871fe057d1ae7cda3807d696d4f9866c23404c801029656276014f386a03
AXON Transmitted	1.4	Axon_Capture_Video_2022-08-36_095302_7355.MOV	11154681	d74394bb4d083db19a36381b241d4d5924f4a4e1d3f0c8827b4e8d470da	0c41e45742aad74496e90aa98035981183700eb7f53b1aa1eabd126ab	0871fe057d1ae7cda3807d696d4f9866c23404c801029656276014f386a03
Known Reference	1.5	IMG_0003.HEIC	1638716	b7ba22972e17b951af17adef809c3b7ed143ba1188e0900a06b274128e9a9		
AXON Transmitted	1.5	Axon_Capture_Photo_2022-08-36_091532_7355.HEIC	1638716	b7ba22972e17b951af17adef809c3b7ed143ba1188e0900a06b274128e9a9		
Known Reference	1.6	IMG_0007.HEIC	1935709	51708cc4938ec83829186b2c34843077b0808a10fe4d27ea021775cd8b3		
AXON Transmitted	1.6	Axon_Capture_Photo_2022-08-36_093357_7355.HEIC	1935709	51708cc4938ec83829186b2c34843077b0808a10fe4d27ea021775cd8b3		
Known Reference	1.7	IMG_0004.MOV	24611033	e6b9307738af2a5226017957d0a14e914b62ab0c097466c6d6351038f	e590a013447094d1e4a5c535453ad49366d73566e0897c306ca701226d	780db3026591967334d8b208270901c10001b74db53f6056648529a59a333
AXON Transmitted	1.7	Axon_Capture_Video_2022-08-36_091718_7355.MOV	10657657	f0889764660114522aac0a26af093f41b4259453604b3a4727fe2b097	8996d8d729148031c0b0e9111206188935eadab43c78134136d8384944	780db3026591967334d8b208270901c10001b74db53f6056648529a59a333
Known Reference	1.8	IMG_0008.MOV	19443198	677851db13071908cca7286ba106299a646d181aed09c3e38140130c9441	14d297bc84aa093ad423cd4457a706b737ed49a3015c73431271465c88	696026c7491570e49137990e4cf06575a9339e4b914e08820c4f74d4821e
AXON Transmitted	1.8	Axon_Capture_Video_2022-08-36_095820_7355.MOV	10818634	30c33aba40264906017c738e474262423597c0d49424e84848b7a3a37	a4666c739d76317a2696857b51b7921204230617206b6c65457527328a	696026c7491570e49137990e4cf06575a9339e4b914e08820c4f74d4821e
				GREEN = PASS		
				RED = FAIL		

1 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Photo Feature																																																																																																																																
Filename:	IMG-0001.jpg	Axon_Capture_Photo_2022-08-26_105846_7355.jpg																																																																																																																																
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Figure 14. Axon Capture – Photo Feature (Rear) JPEG Signature Comparison Chart

2 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Photo Feature																																																																																																																																
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Figure 15. Axon Capture – Photo Feature (Rear) JPEG Signature Comparison Chart

3 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Import Feature																																																																																																																																
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Figure 16. Axon Capture – Import Feature (Rear) JPEG Signature Comparison Chart

4 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Actual Size																																																																																																																																
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Figure 17. Axon Citizen – Option A ‘Actual Size’ (Rear) JPEG Signature Comparison Chart

5 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Large																																																																																																																																
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Figure 18. Axon Citizen – Option A ‘Large’ (Rear) JPEG Signature Comparison Chart

6 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Medium																																																																																																																																
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Figure 19. Axon Citizen – Option A ‘Medium’ (Rear) JPEG Signature Comparison Chart

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Figure 20. Axon Citizen – Option A ‘Small’ (Rear) JPEG Signature Comparison Chart

8 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Actual Size (HEIC ► JPEG)																																																																																																																																																
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Figure 21. Axon Citizen – Option A ‘Actual Size’ (Rear) JPEG Signature Comparison Chart

9 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Large (HEIC ► JPEG)																																																																																																																																
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Figure 22. Axon Citizen – Option A ‘Large’ (Rear) JPEG Signature Comparison Chart

10 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Medium (HEIC ► JPEG)																																																																																																																																
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Figure 23. Axon Citizen – Option A ‘Medium’ (Rear) JPEG Signature Comparison Chart

11 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Small (HEIC ► JPEG)																																																																																																																																																
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Figure 24. Axon Citizen – Option A ‘Small’ (Rear) JPEG Signature Comparison Chart

12 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen – Option B – ‘Take Photo or Video’																																																																																																																																																
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EXIF Count:	66 6 0 0 26	4 0 0 0 126																																																																																																																																																

Figure 25. Axon Citizen – Option B ‘Take Photo’ (Rear) JPEG Signature Comparison Chart

13 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen – Option B – ‘Take Photo or Video’
Filename:	IMG-0001.jpg	image-3.jpg
SHA-256:	a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fc53d461b51d05a20f9dc	08bc7f8f053f74ba565fde4594d7b49d250f10c73a086929acf116f84d59a20
Image dimensions:	4032 x 3024	4032 x 3024
Quantization Table (Y):	<pre> 1 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	<pre> 2 2 2 3 4 6 7 8 2 2 2 3 4 6 7 8 2 2 3 4 6 7 8 10 3 3 4 6 7 8 10 12 4 4 6 7 8 10 12 13 6 6 7 8 10 12 13 13 7 7 8 10 12 13 13 13 8 8 10 12 13 13 13 13 </pre>
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	<pre> 2 2 3 6 14 14 14 14 2 3 3 9 14 14 14 14 3 3 8 14 14 14 14 14 6 9 14 </pre>
Huffman Code DC (Y):	1511111100000000	1511111100000000
Huffman Code AC (Y):	21332435544001125	21332435544001125
Huffman Code DC (Cr):	3111111110000000	3111111110000000
Huffman Code AC (Cr):	21244347544012119	21244347544012119
Thumbnail dimensions:	160 x 120	No thumbnail extracted.
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	No thumbnail extracted.
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	No thumbnail extracted.
EXIF Count:	66 6 0 0 26	4 0 0 0 126

Figure 26. Axon Citizen – Option B ‘Take Photo’ (Rear) JPEG Signature Comparison Chart

14 – Rear Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen for iOS – Option C ‘Browse’ to Apple Files
Filename:	IMG-0001.jpg	IMG-0001.jpg
SHA-256:	a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fc53d461b51d05a20f9dc	a8650d85fe3fa38b64544d4eea02960e86cf7b97da4fc53d461b51d05a20f9dc
Image dimensions:	4032 x 3024	4032 x 3024
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>
Huffman Code DC (Y):	1511111100000000	1511111100000000
Huffman Code AC (Y):	21332435544001125	21332435544001125
Huffman Code DC (Cr):	3111111110000000	3111111110000000
Huffman Code AC (Cr):	21244347544012119	21244347544012119
Thumbnail dimensions:	160 x 120	160 x 120
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>
EXIF Count:	66 6 0 0 26	66 6 0 0 26

Figure 27. Axon Citizen – Option C ‘Browse’ (Rear) JPEG Signature Comparison Chart

15 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Photo Feature
Filename:	IMG-0005.jpg	Axon_Capture_Photo_2022-08-26_111238_7355.jpg
SHA-256:	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdc	511196932bd6e7620378c3c581e4f02c805a11ea298408216ec9d9eb082d35e3
Image dimensions:	4032 x 3024	3088 x 2316
Quantization Table (Y):	<pre> 2 2 2 2 3 4 5 6 7 2 2 2 3 4 5 6 7 2 2 3 4 5 6 7 9 3 2 4 5 6 7 9 10 4 4 5 6 7 9 10 12 5 5 6 7 9 10 12 12 6 6 7 9 10 12 12 12 7 7 9 10 12 12 12 12 </pre>	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>
Quantization Table (Cr):	<pre> 2 2 3 5 12 12 12 12 2 3 3 8 12 12 12 12 3 3 7 12 12 12 12 12 5 8 12 </pre>	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>
Huffman Code DC (Y):	1511111110000000	1511111110000000
Huffman Code AC (Y):	21332435544001125	21332435544001125
Huffman Code DC (Cr):	3111111111000000	3111111111000000
Huffman Code AC (Cr):	21244347544012119	21244347544012119
Thumbnail dimensions:	160 x 120	No thumbnail extracted.
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	No thumbnail extracted.
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	No thumbnail extracted.
EXIF Count:	65 6 0 0 26	4 0 0 1 26

Figure 28. Axon Capture – Photo Feature (Front) JPEG Signature Comparison Chart

16 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Photo Feature
Filename:	IMG-0005.jpg	Axon-Capture-Photo-2022-08-26-112940-7355.jpg
SHA-256:	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdc	01673300042ab348e08b73260ac0840b8d338c9ca9213b483c620b9c7d25339c
Image dimensions:	4032 x 3024	4032 x 3024
Quantization Table (Y):	<pre> 2 2 2 2 3 4 5 6 7 2 2 2 3 4 5 6 7 2 2 3 4 5 6 7 9 3 2 4 5 6 7 9 10 4 4 5 6 7 9 10 12 5 5 6 7 9 10 12 12 6 6 7 9 10 12 12 12 7 7 9 10 12 12 12 12 </pre>	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>
Quantization Table (Cr):	<pre> 2 2 3 5 12 12 12 12 2 3 3 8 12 12 12 12 3 3 7 12 12 12 12 12 5 8 12 </pre>	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>
Huffman Code DC (Y):	1511111110000000	1511111110000000
Huffman Code AC (Y):	21332435544001125	21332435544001125
Huffman Code DC (Cr):	3111111111000000	3111111111000000
Huffman Code AC (Cr):	21244347544012119	21244347544012119
Thumbnail dimensions:	160 x 120	No thumbnail extracted.
Quantization Table (Y):	<pre> 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9 </pre>	No thumbnail extracted.
Quantization Table (Cr):	<pre> 1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 </pre>	No thumbnail extracted.
EXIF Count:	65 6 0 0 26	4 0 0 1 26

Figure 29. Axon Capture – Photo Feature (Front) JPEG Signature Comparison Chart

17 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Capture for iOS version 5.7.0 (13) – Import Feature																																																																																																																																
Filename:	IMG-0005.jpg	Axon-Capture-Photo-2022-08-26-092748-7353.jpg																																																																																																																																
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Figure 30. Axon Capture – Import Feature (Front) JPEG Signature Comparison Chart

18 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Actual Size																																																																																																																																
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Figure 31. Axon Citizen – Option A ‘Actual Size’ (Front) JPEG Signature Comparison Chart

19 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Large																																																																																																																																
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Figure 32. Axon Citizen – Option A ‘Large’ (Front) JPEG Signature Comparison Chart

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Figure 33. Axon Citizen – Option A ‘Medium’ (Front) JPEG Signature Comparison Chart

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Figure 34. Axon Citizen – Option A ‘Small’ (Front) JPEG Signature Comparison Chart

22 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Actual Size (HEIC ► JPEG)																																																																																																																																
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Figure 35. Axon Citizen – Option A ‘Actual Size’ (Front) JPEG Signature Comparison Chart

23 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Large (HEIC ► JPEG)																																																																																																																																
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Figure 36. Axon Citizen – Option A ‘Large’ (Front) JPEG Signature Comparison Chart

24 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Medium (HEIC ► JPEG)																																																																																																																																
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Figure 37. Axon Citizen – Option A ‘Medium’ (Front) JPEG Signature Comparison Chart

25 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen iOS – Option A ‘Photo Library’ – Small (HEIC ► JPEG)																																																																																																																																
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Figure 38. Axon Citizen – Option A ‘Small’ (Front) JPEG Signature Comparison Chart

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Figure 39. Axon Citizen – Option B ‘Take Photo’ (Front) JPEG Signature Comparison Chart

27 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen – Option B – ‘Take Photo or Video’
Filename:	IMG-0005.jpg	image-2.jpg
SHA-256:	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdc	b1402243bc4f628d9d5c0d3fe470a44953ce9f444b91ccb34631141e98b5a02a
Image dimensions:	4032 x 3024	3088 x 2316
Quantization Table (Y):	2 2 2 2 3 4 5 6 7 2 2 2 3 4 5 6 7 2 2 3 4 5 6 7 9 3 2 4 5 6 7 9 10 4 4 5 6 7 9 10 12 5 5 6 7 9 10 12 12 6 6 7 9 10 12 12 12 7 7 9 10 12 12 12 12	2 2 2 2 3 4 6 7 8 2 2 2 3 4 6 7 8 2 2 3 4 6 7 8 10 3 3 4 6 7 8 10 12 4 4 6 7 8 10 12 13 6 6 7 8 10 12 13 13 7 7 8 10 12 13 13 13 8 8 10 12 13 13 13 13
Quantization Table (Cr):	2 2 3 5 12 12 12 12 2 3 3 8 12 12 12 12 3 3 7 12 12 12 12 12 5 8 12 12 12 12 12 12 12 12 12 12 12 12 12 12	2 2 3 6 14 14 14 14 2 3 3 9 14 14 14 14 3 3 8 14 14 14 14 14 6 9 14 14 14 14 14 14 14 14 14 14 14 14 14 14
Huffman Code DC (Y):	1 5 1 1 1 1 1 1 0 0 0 0 0 0 0 0	1 5 1 1 1 1 1 1 0 0 0 0 0 0 0 0
Huffman Code AC (Y):	2 1 3 3 2 4 3 5 5 4 4 0 0 1 1 2 5	2 1 3 3 2 4 3 5 5 4 4 0 0 1 1 2 5
Huffman Code DC (Cr):	3 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0	3 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
Huffman Code AC (Cr):	2 1 2 4 4 3 4 7 5 4 4 0 1 2 1 1 9	2 1 2 4 4 3 4 7 5 4 4 0 1 2 1 1 9
Thumbnail dimensions:	160 x 120	No thumbnail extracted.
Quantization Table (Y):	1 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9	No thumbnail extracted.
Quantization Table (Cr):	1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9	No thumbnail extracted.
EXIF Count:	65 6 0 0 0 26	4 0 0 0 1 26

Figure 40. Axon Citizen – Option B ‘Take Photo’ (Front) JPEG Signature Comparison Chart

28 – Front Lens	iPhone 12 iOS 15.6.1 Camera Default Settings	Axon Citizen for iOS – Option C ‘Browse’ to Apple Files
Filename:	IMG-0005.jpg	IMG-0005.jpg
SHA-256:	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdc	019f7b77a26cc47ca04707276a60495020a5b81c479aa0bd62cd2b9dbf612fdc
Image dimensions:	4032 x 3024	4032 x 3024
Quantization Table (Y):	2 2 2 2 3 4 5 6 7 2 2 2 3 4 5 6 7 2 2 3 4 5 6 7 9 3 2 4 5 6 7 9 10 4 4 5 6 7 9 10 12 5 5 6 7 9 10 12 12 6 6 7 9 10 12 12 12 7 7 9 10 12 12 12 12	2 2 2 2 3 4 5 6 7 2 2 2 3 4 5 6 7 2 2 3 4 5 6 7 9 3 2 4 5 6 7 9 10 4 4 5 6 7 9 10 12 5 5 6 7 9 10 12 12 6 6 7 9 10 12 12 12 7 7 9 10 12 12 12 12
Quantization Table (Cr):	2 2 3 5 12 12 12 12 2 3 3 8 12 12 12 12 3 3 7 12 12 12 12 12 5 8 12 12 12 12 12 12 12 12 12 12 12 12 12 12	2 2 3 5 12 12 12 12 2 3 3 8 12 12 12 12 3 3 7 12 12 12 12 12 5 8 12 12 12 12 12 12 12 12 12 12 12 12 12 12
Huffman Code DC (Y):	1 5 1 1 1 1 1 1 0 0 0 0 0 0 0 0	1 5 1 1 1 1 1 1 0 0 0 0 0 0 0 0
Huffman Code AC (Y):	2 1 3 3 2 4 3 5 5 4 4 0 0 1 1 2 5	2 1 3 3 2 4 3 5 5 4 4 0 0 1 1 2 5
Huffman Code DC (Cr):	3 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0	3 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
Huffman Code AC (Cr):	2 1 2 4 4 3 4 7 5 4 4 0 1 2 1 1 9	2 1 2 4 4 3 4 7 5 4 4 0 1 2 1 1 9
Thumbnail dimensions:	160 x 120	160 x 120
Quantization Table (Y):	1 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9	1 1 1 1 2 3 4 5 6 1 1 1 2 3 4 5 6 1 1 2 3 4 5 6 7 2 2 3 4 5 6 7 8 3 3 4 5 6 7 8 9 4 4 5 6 7 8 9 9 5 5 6 7 8 9 9 9 6 6 7 8 9 9 9 9
Quantization Table (Cr):	1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9	1 1 2 4 9 9 9 9 1 2 2 6 9 9 9 9 2 2 5 9 9 9 9 9 4 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9
EXIF Count:	65 6 0 0 0 26	65 6 0 0 0 26

Figure 41. Axon Citizen – Option C ‘Browse’ (Front) JPEG Signature Comparison Chart

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Citizen Option A ‘Photo Library’ – Actual Size
Filename:	IMG_0002.MOV	IMG_0002-3.MOV
File SHA-256:	b096edbf8e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513	3112c03ed2a2acc591c294635f748513fd4b2a372c78bcb89dd93f47936cb6b
Video dimensions:	1920 x 1080	1920 x 1080
Format	MPEG-4/AVC	MPEG-4/AVC
File Signature	rl.879	rl.563
	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvdh - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.80% clcf - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mhdh - 3.84% hdlr - 3.83% minf - 3.83% vmhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtg - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mhdh - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% ssgp - 6.13% sbgp - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mhdh - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mhdh - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mhdh - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mda - 0.48% mda - 0.48% mda - 0.44% mda - 0.50% mda - 0.30% mda - 0.28% illt - 0.05% data - 0.40% data - 0.50% data - 0.28% data - 0.35% data - 0.31% data - 0.25% </pre>	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvdh - 56.86% trak - 56.86% tkhd - 56.86% edts - 53.45% elst - 53.45% mdia - 53.37% mhdh - 53.37% hdlr - 53.37% minf - 53.37% smhd - 2.88% hdlr - 53.37% dinf - 53.37% dref - 53.37% alis - 0.49% stbl - 53.37% stsd - 53.37% ssgp - 0% sbgp - 0% stts - 0.93% stsc - 12.62% stsz - 12.62% stco - 12.62% trak - 13.99% tkhd - 13.99% tapt - 0% clcf - 0% prof - 0% enof - 0% edts - 1.84% elst - 1.84% mdia - 2.00% mhdh - 2.00% hdlr - 2.00% minf - 2.00% smhd - 0% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% stts - 1.78% stss - 0.29% sdtg - 0.26% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mhdh - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mhdh - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mhdh - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mda - 0.48% mda - 0.48% mda - 0.44% mda - 0.50% mda - 0.30% mda - 0.28% illt - 0.05% data - 0.40% data - 0.50% data - 0.28% data - 0.35% data - 0.31% data - 0.25% </pre>

Figure 42. Video File Structure Mapping Comparison Chart (Tool A Signature rl.879 vs. rl.563)

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Capture for iOS 5.7.0 (13) – Import Feature
Filename:	IMG_0002.MOV	Axon_Capture_Video_2022-08-26_091022_7355.MOV
File SHA-256:	b096edb8e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513	ed3c7a370fc20720d03b35f497387d695f29852b3b5ee023a288bba29d5b587
Video dimensions:	1920 x 1080	1280 x 720
Format	MPEG-4/AVC	MPEG-4/AVC
File Signature	rl.879	pf.279
	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.80% clfp - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mhhd - 3.84% hdlr - 3.83% minf - 3.83% vmhd - 3.83% hdlr - 3.83% dinf - 3.83% alif - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtg - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mhhd - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% sgpp - 6.13% sgpd - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mhhd - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mhhd - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mhhd - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mdta - 0.48% mdta - 0.48% mdta - 0.44% mdta - 0.50% mdta - 0.30% mdta - 0.28% ilst - 0.05% data - 0.40% data - 0.50% data - 0.25% data - 0.35% data - 0.31% data - 0.25% </pre>	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% edts - 53.45% elst - 53.45% mdia - 53.37% mhhd - 53.37% hdlr - 53.37% minf - 53.37% smhd - 2.88% hdlr - 53.37% dinf - 53.37% dref - 53.37% alis - 0.49% stbl - 53.37% stsd - 53.37% sgpd - 0% sgpp - 0% stts - 0.93% stsc - 12.62% stsz - 12.62% stco - 12.62% trak - 13.99% tkhd - 13.99% tapt - 0% clfp - 0% prof - 0% enof - 0% edts - 1.84% elst - 1.84% mdia - 2.00% mhhd - 2.00% hdlr - 2.00% minf - 2.00% vmhd - 0% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% stts - 1.78% ctts - 0.00% cslg - 0.00% stss - 0.00% sdtg - 0.00% stsc - 0.05% stsz - 0.05% stco - 0.05% meta - 0.00% hdlr - 0.00% keys - 0.00% mdta - 0.27% mdta - 0.01% mdta - 0.02% mdta - 0.05% mdta - 0.01% mdta - 0.02% ilst - 0.01% data - 0.05% data - 0.03% data - 0.02% data - 0.02% data - 0.01% data - 0.02% </pre>

Figure 43. Video File Structure Mapping Comparison Chart (Tool A Signature rl.879 vs. rl.279)

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Capture for iOS 5.7.0 (13) – Video Feature
Filename:	IMG 0002.MOV	Axon Capture Video 2022-08-26 110209 7355.MOV
File SHA-256:	b096edbf8e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513	b4181a534692ff3652143fddb694ac0bf750eabf17529545a51b8b5671916536
Video dimensions:	1920 x 1080	720 x 1080
Format	MPEG-4/AVC	MPEG-4/AVC
File Signature	rl.879	rl.311
	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.80% tkhd - 56.86% tapt - 3.80% clief - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mhdh - 3.84% hdlr - 3.85% minf - 3.83% vmhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtp - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mhdh - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% sgpp - 6.13% sbgp - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mhdh - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mhdh - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mhdh - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mdat - 0.48% mdta - 0.48% mdta - 0.44% mdta - 0.30% mdta - 0.30% mdta - 0.28% ilrt - 0.00% data - 0.40% data - 0.50% data - 0.20% data - 0.35% data - 0.31% data - 0.25% </pre>	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.80% tkhd - 56.86% tapt - 3.80% clief - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mhdh - 3.84% hdlr - 3.85% minf - 3.83% vmhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% ctts - 1.15% ctss - 1.10% stts - 1.10% sdtp - 1.10% stsc - 1.10% stsz - 1.10% stco - 1.10% trak - 1.25% tkhd - 1.25% edts - 1.08% elst - 1.08% mdia - 1.08% mhdh - 1.08% hdlr - 1.08% minf - 1.08% smhd - 1.08% hdlr - 1.08% dinf - 1.08% dref - 1.08% alis - 1.08% stbl - 1.08% stsd - 1.08% sgpp - 0.02% sbgp - 0.02% stts - 0.04% stsc - 0.05% stsz - 0.05% stco - 0.05% trak - 1.08% tkhd - 1.08% edts - 1.08% elst - 1.08% tref - 0.02% cdsc - 0.02% cdep - 0.02% mdia - 0.02% mhdh - 0.02% hdlr - 0.02% minf - 0.02% gmhd - 0.02% gmin - 0.02% hdlr - 0.02% dinf - 0.02% dref - 0.02% alis - 0.02% stbl - 0.02% stsd - 0.02% stts - 0.02% stsc - 0.02% stsz - 0.02% stco - 0.02% trak - 0.02% tkhd - 0.02% edts - 0.02% elst - 0.02% tref - 0.02% cdsc - 0.02% cdep - 0.02% mdia - 0.02% mhdh - 0.02% hdlr - 0.02% minf - 0.02% gmhd - 0.02% gmin - 0.02% hdlr - 0.02% dinf - 0.02% dref - 0.02% alis - 0.02% stbl - 0.02% stsd - 0.02% stts - 0.02% stsc - 0.02% stsz - 0.02% stco - 0.02% meta - 0.02% hdlr - 0.02% keys - 0.02% mdat - 0.02% mdta - 0.02% ilrt - 0.02% data - 0.02% </pre>

Figure 44. Video File Structure Mapping Comparison Chart (Tool A Signature rl.879 vs. rl.311)

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Citizen Option B ‘Take Photo or Video’
Filename:	IMG_0002.MOV	68361242549_C6103700-C389-42ED-9CFE-28C52462C2E0.MOV
File SHA-256:	b096edbf8e89df8a8330930f41a1013ebc0498812af9ac3dae0e2faac7e06513	3112c03ed2a2acc591c294635f748513f4d4b2a372c78bcb89dd93f47936cb6b
Video dimensions:	1920 x 1080	480 x 360
Format	MPEG-4/AVC	MPEG-4/AVC
File Signature	rl.879	rl.881
	<pre> ffyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.80% clif - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mvhd - 3.84% hdlr - 3.83% minf - 3.83% smhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtp - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mvhd - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% sgpd - 6.13% sbgp - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mvhd - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mvhd - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mvhd - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mdat - 0.48% mdat - 0.48% mdat - 0.44% mdat - 0.50% mdat - 0.30% mdat - 0.28% list - 0.05% data - 0.40% data - 0.50% data - 0.28% data - 0.35% data - 0.31% data - 0.25% </pre>	<pre> ffyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvhd - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.80% clif - 3.80% prof - 3.80% enof - 3.80% edts - 3.78% elst - 3.78% mdia - 3.84% mvhd - 3.84% hdlr - 3.83% minf - 3.83% smhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% stts - 3.14% stss - 1.99% sdtp - 1.99% stsc - 2.16% stsz - 2.16% stco - 2.16% trak - 1.84% tkhd - 1.84% edts - 1.84% elst - 1.84% mdia - 2.00% mvhd - 2.00% hdlr - 2.00% minf - 2.00% smhd - 2.00% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% sgpd - 6.13% sbgp - 6.13% stts - 1.31% stsc - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mvhd - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stsc - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.40% mvhd - 0.40% hdlr - 0.40% minf - 0.40% gmhd - 0.40% gmin - 0.40% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.40% stbl - 0.77% stsd - 0.77% stts - 0.77% stsc - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.30% cdsc - 0.30% cdep - 0.30% mdia - 0.30% mvhd - 0.30% hdlr - 0.30% minf - 0.30% gmhd - 0.30% gmin - 0.30% hdlr - 0.30% dinf - 0.30% dref - 0.30% alis - 0.30% stbl - 0.30% stsd - 0.30% stts - 0.30% stsc - 0.30% stsz - 0.30% stco - 0.30% meta - 0.27% hdlr - 0.27% keys - 0.27% mdat - 0.48% mdat - 0.48% mdat - 0.44% mdat - 0.50% list - 0.21% data - 0.38% data - 0.44% data - 0.40% data - 0.50% </pre>

Figure 45. Video File Structure Mapping Comparison Chart (Tool A Signature rl.879 vs. rl.881)

	iPhone 12 iOS 15.6.1 – Known Reference	Axon Citizen Option A ‘Photo Library’ – Actual Size
Filename:	IMG_0004.MOV	IMG_0004.MOV
File SHA-256:	eebb930f738af2a35b225b017957d0a14a914bb2ab80c092e6f6c6d6531038f	fec461ce743cd5888faf36878951011fe3101944ad5e7d25ea26ab96440cc9f
Video dimensions:	1920 x 1080	1920 x 1080
Format	MPEG-4/HEVC	MPEG-4/AVC
File Signature	rl.1193	rl.563
	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvdh - 56.86% trak - 56.86% tkhd - 56.86% tapt - 3.88% cief - 3.88% prof - 3.88% enof - 3.88% edts - 3.78% elst - 3.78% mdia - 3.84% mhdh - 3.84% hdlr - 3.85% minf - 3.83% vmhd - 3.83% hdlr - 3.83% dinf - 3.83% dref - 3.83% alis - 3.81% stbl - 3.81% stsd - 3.81% sgpd - 1.67% sgpd - 0.62% sgpp - 0.36% stts - 0.35% cts - 0.35% colg - 0.35% stsz - 0.33% sdtp - 0.53% stco - 0.35% stzr - 0.35% stco - 0.35% trak - 0.36% tkhd - 0.36% edts - 0.36% mdia - 0.36% mhdh - 0.36% hdlr - 0.36% minf - 0.36% vmhd - 0.36% hdlr - 0.36% dinf - 0.36% dref - 0.36% alis - 0.36% stbl - 0.36% stsd - 0.36% sgpd - 0.36% sgpp - 0.36% stts - 0.35% stco - 0.35% stzr - 0.35% stco - 0.35% trak - 0.05% tkhd - 0.05% edts - 0.05% tref - 0.05% cdsc - 0.05% cdep - 0.05% Apple mdia - 0.11% mhdh - 0.11% hdlr - 0.11% minf - 0.11% gmhd - 0.11% gmin - 0.11% hdlr - 0.69% dinf - 0.69% dref - 0.69% alis - 0.11% stbl - 0.69% stsd - 0.69% stts - 0.69% stco - 0.69% stzr - 0.69% stco - 0.69% trak - 0.49% tkhd - 0.49% edts - 0.49% elst - 0.49% tref - 0.05% cdsc - 0.05% cdep - 0.05% mdia - 0.17% mhdh - 0.17% hdlr - 0.17% minf - 0.17% gmhd - 0.05% gmin - 0.05% hdlr - 0.05% dinf - 0.05% dref - 0.05% alis - 0.05% stbl - 0.05% stsd - 0.05% stts - 0.05% stco - 0.05% stzr - 0.05% stco - 0.05% trak - 0.05% tkhd - 0.05% edts - 0.05% elst - 0.05% tref - 0.05% cdsc - 0.05% cdep - 0.05% mdia - 0.05% mhdh - 0.05% hdlr - 0.05% minf - 0.05% gmhd - 0.05% gmin - 0.05% hdlr - 0.05% dinf - 0.05% dref - 0.05% alis - 0.05% stbl - 0.05% stsd - 0.05% stts - 0.05% stco - 0.05% stzr - 0.05% stco - 0.05% meta - 0.06% hdlr - 0.06% keys - 0.06% mta - 0.28% mta - 0.25% mta - 0.17% mta - 0.20% mta - 0.13% mta - 0.11% ilst - 0.03% data - 0.25% data - 0.26% data - 0.16% data - 0.17% data - 0.11% data - 0.08% </pre>	<pre> ftyp - 99.30% wide - 57.35% mdat - 57.72% moov - 56.84% mvdh - 56.86% trak - 56.86% tkhd - 56.86% edts - 53.45% elst - 53.45% mdia - 53.37% mhdh - 53.37% hdlr - 53.37% minf - 53.37% vmhd - 2.88% hdlr - 53.37% dinf - 53.37% dref - 53.37% alis - 0.49% stbl - 53.37% stsd - 53.37% sgpd - 0% sgpp - 0% stts - 0.93% stic - 12.62% stsz - 12.62% stco - 12.62% trak - 13.99% tkhd - 13.99% tapt - 0% cief - 0% prof - 0% enof - 0% edts - 1.84% elst - 1.84% mdia - 2.00% mhdh - 2.00% hdlr - 2.00% minf - 2.00% vmhd - 0% hdlr - 2.00% dinf - 2.00% dref - 2.00% alis - 1.79% stbl - 2.00% stsd - 2.00% stts - 1.78% stsz - 0.29% sdtp - 0.26% stic - 1.57% stsz - 1.57% stco - 1.57% trak - 1.52% tkhd - 1.52% edts - 1.52% elst - 1.52% tref - 0.37% cdsc - 0.37% cdep - 0.37% Apple mdia - 0.37% mhdh - 0.37% hdlr - 0.37% minf - 0.37% gmhd - 0.37% gmin - 0.37% hdlr - 0.44% dinf - 0.44% dref - 0.44% alis - 0.39% stbl - 0.45% stsd - 0.45% stts - 0.45% stic - 0.45% stsz - 0.45% stco - 0.45% trak - 0.37% tkhd - 0.37% edts - 0.37% elst - 0.37% tref - 0.37% cdsc - 0.37% cdep - 0.37% mdia - 0.46% mhdh - 0.46% hdlr - 0.46% minf - 0.46% gmhd - 0.46% gmin - 0.46% hdlr - 0.77% dinf - 0.77% dref - 0.77% alis - 0.46% stbl - 0.77% stsd - 0.77% stts - 0.77% stic - 0.77% stsz - 0.77% stco - 0.77% trak - 0.32% tkhd - 0.32% edts - 0.32% elst - 0.32% tref - 0.36% cdsc - 0.36% cdep - 0.36% mdia - 0.36% mhdh - 0.36% hdlr - 0.36% minf - 0.36% gmhd - 0.36% gmin - 0.36% hdlr - 0.36% dinf - 0.36% dref - 0.36% alis - 0.36% stbl - 0.36% stsd - 0.36% stts - 0.36% stic - 0.36% stsz - 0.36% stco - 0.36% meta - 0.27% hdlr - 0.27% keys - 0.27% mta - 0.48% mta - 0.44% mta - 0.50% mta - 0.30% mta - 0.28% ilst - 0.05% data - 0.44% data - 0.50% data - 0.28% data - 0.35% data - 0.31% data - 0.25% </pre>

Figure 46. Video File Structure Mapping Comparison Chart (Tool A Signature rl.1193 vs. rl.563)

	Voice Memos – Audio (Compressed)	Axon Capture – Audio Feature
Filename:	20220826-094112.m4a	Axon-Capture-Audio-2022-08-26-113507-7355.m4a
File SHA-256:	9a75c4061f23bd66ebcf0e86af00741226fcb6325082226d1866a97d89292c8	f749f401ec18979e4662113f0e15df25dba2531c513504890addebc70b12a063
Format:	AAC	AAC
Frequency:	480000 Hz	480000 Hz
Channels:	1	1
	OfS: 4 -> ftyp OfS: 8 -> MAA OfS: 10 -> MAA OfS: 14 -> isom OfS: 18 -> mp42 OfS: 20 -> mdat OfS: 7F63 -> mvhd OfS: 7FCF -> trak OfS: 7FD7 -> tkhd OfS: 8033 -> mdia OfS: 803B -> mdhd OfS: 8058 -> hdlr OfS: 8067 -> soun OfS: 8077 -> Core Media Audio OfS: 808C -> minf OfS: 8094 -> smhd OfS: 80AA -> dinf OfS: 80AC -> dref OfS: 80BC -> url OfS: 80C8 -> stbl OfS: 80D0 -> stsd OfS: 80E0 -> mp4a OfS: 8104 -> esds OfS: 8137 -> stts OfS: 814F -> stsc OfS: 8177 -> stsz OfS: 848B -> stco OfS: 84AF -> udta OfS: 84D3 -> meta OfS: 84DF -> hdlr OfS: 84EB -> mdia OfS: 8501 -> ilst OfS: 8511 -> mean OfS: 8519 -> com.apple.iTunes OfS: 8519 -> com.apple.iTunes OfS: 852D -> name OfS: 8548 -> data OfS: 8548 -> data OfS: 857C -> @too OfS: 8584 -> data OfS: 8584 -> data OfS: 8590 -> com.apple.VoiceMemos OfS: 85AE -> iPhone (null)) OfS: 85B5 -> (null)) OfS: 85E8 -> mdat OfS: C3B4 -> mdat OfS: FF55 -> mdat OfS: 141C4 -> mdat OfS: 1802E -> mdat OfS: 1BDC2 -> mdat OfS: 1FC92 -> mdat OfS: 2A137 -> mdat OfS: 27FCB -> mdat OfS: 2BE01 -> mdat OfS: 2FA28 -> mdat OfS: 33B6C -> mdat OfS: 379F5 -> mdat OfS: 3B7A3 -> mdat OfS: 3D8FF -> moov OfS: 3D907 -> mvhd OfS: 3D973 -> trak OfS: 3D97B -> tkhd OfS: 3D9D7 -> mdia OfS: 3D9DF -> mdhd OfS: 3D9FF -> hdlr OfS: 3DA0B -> soun OfS: 3DA1B -> Core Media Audio OfS: 3DA30 -> minf OfS: 3DA30 -> smhd OfS: 3DA48 -> dinf OfS: 3DA50 -> dref OfS: 3DA60 -> url OfS: 3DA6C -> stbl OfS: 3DA74 -> stsd OfS: 3DA84 -> mp4a OfS: 3DA88 -> esds OfS: 3DA0B -> stts OfS: 3DAF3 -> stsc OfS: 3DC5F -> stsz OfS: 3F333 -> stco OfS: 3F3EB -> udta OfS: 3F40F -> meta OfS: 3F41B -> hdlr OfS: 3F427 -> mdia OfS: 3F43D -> ilst OfS: 3F44D -> data OfS: 3F44D -> data OfS: 3F479 -> mean OfS: 3F481 -> com.apple.iTunes OfS: 3F481 -> com.apple.iTunes OfS: 3F495 -> name OfS: 3F4B0 -> data OfS: 3F4B0 -> data OfS: 3F4E4 -> @too OfS: 3F4EC -> data OfS: 3F4EC -> data OfS: 3F4F8 -> com.apple.VoiceMemos OfS: 3F516 -> iPhone (null)) OfS: 3F51D -> (null)) OfS: 3F528 -> free OfS: 3F540 -> data OfS: 3F540 -> data OfS: 3F574 -> @too OfS: 3F57C -> data OfS: 3F57C -> data OfS: 3F588 -> com.apple.VoiceMemos OfS: 3F5A6 -> iPhone (null)) OfS: 3F5AD -> (null))	OfS: 4 -> ftyp OfS: 8 -> MAA OfS: 10 -> MAA OfS: 14 -> mp42 OfS: 18 -> isom OfS: 20 -> moov OfS: 28 -> mvhd OfS: 94 -> trak OfS: 9C -> tkhd OfS: F8 -> mdia OfS: 100 -> mdhd OfS: 120 -> hdlr OfS: 12C -> soun OfS: 142 -> minf OfS: 14A -> smhd OfS: 15A -> dinf OfS: 162 -> dref OfS: 172 -> url OfS: 17E -> stbl OfS: 186 -> stsd OfS: 196 -> mp4a OfS: 1BA -> esds OfS: 14A -> smhd OfS: 15A -> dinf OfS: 162 -> dref OfS: 172 -> url OfS: 17E -> stbl OfS: 186 -> stsd OfS: 196 -> mp4a OfS: 1BA -> esds OfS: 1ED -> stts OfS: 205 -> stsc OfS: 22D -> stsz OfS: 1909 -> stco OfS: 1A0D -> udta OfS: 1A15 -> meta OfS: 1A21 -> hdlr OfS: 1A2D -> mdia OfS: 1A43 -> ilst OfS: 1A53 -> mean OfS: 1A5B -> com.apple.iTunes OfS: 1A5B -> com.apple.iTunes OfS: 1A6F -> name OfS: 1A77 -> iTunSMPB OfS: 1A83 -> data OfS: 1A83 -> data OfS: 1B07 -> free OfS: EFCF -> mdat

Figure 47. Axon Capture 'Audio' Feature – File Structure Mapping Comparison Chart

	Voice Memos – Audio (Compressed)	Axon Capture – Audio Feature
Filename:	20220826-094112.m4a	Axon-Capture-Audio-2022-08-26-113630-7355.m4a
File SHA-256:	9a75c4061f23bd66ebcf0e86af00741226fcb6325082226d1866a97d89292c8	3112c03ed2a2acc591c294635f748513fd4b2a372c78bcb89dd93f47936cb6b
Format:	AAC	AAC
Frequency:	480000 Hz	480000 Hz
Channels:	1	1
	Ofcs: 4 => ftyp Ofcs: 8 => M4A Ofcs: 10 => M4A Ofcs: 14 => isom Ofcs: 18 => mp42 Ofcs: 20 => mdat Ofcs: 7f63 => mvhd Ofcs: 7fcf => trak Ofcs: 7fd7 => tkhd Ofcs: 8033 => mdia Ofcs: 8038 => mdhd Ofcs: 8058 => hdlr Ofcs: 8067 => soun Ofcs: 8077 => Core Media Audio Ofcs: 808c => minf Ofcs: 8094 => smhd Ofcs: 80A4 => dinf Ofcs: 80AC => dref Ofcs: 80Bc => url Ofcs: 80C8 => stbl Ofcs: 80D0 => stsd Ofcs: 80E0 => mp4a Ofcs: 8104 => esds Ofcs: 8137 => stts Ofcs: 814F => stsc Ofcs: 8177 => stsz Ofcs: 8480 => stco Ofcs: 84AF => udta Ofcs: 84D3 => meta Ofcs: 84DF => hdlr Ofcs: 84EB => mdir Ofcs: 8501 => ilst Ofcs: 8511 => mean Ofcs: 8519 => com.apple.iTunes Ofcs: 8519 => com.apple.iTunes Ofcs: 8520 => name Ofcs: 8548 => data Ofcs: 8548 => data Ofcs: 857C => @too Ofcs: 8584 => data Ofcs: 8584 => data Ofcs: 8590 => com.apple.VoiceMemos Ofcs: 85AE => iPhone (null) Ofcs: 85B5 => (null) Ofcs: 85E8 => mdat Ofcs: C384 => mdat Ofcs: FF55 => mdat Ofcs: 141C4 => mdat Ofcs: 1802E => mdat Ofcs: 18DC2 => mdat Ofcs: 1FC92 => mdat Ofcs: 24137 => mdat Ofcs: 27FCB => mdat Ofcs: 2BE01 => mdat Ofcs: 2FA28 => mdat Ofcs: 3386c => mdat Ofcs: 379F5 => mdat Ofcs: 3B7A3 => mdat Ofcs: 3D8FF => moov Ofcs: 3D907 => mvhd Ofcs: 3D973 => trak Ofcs: 3D978 => tkhd Ofcs: 3D907 => mdia Ofcs: 3D90F => mdhd Ofcs: 3D9FF => hdlr Ofcs: 3DA08 => soun Ofcs: 3DA1B => Core Media Audio Ofcs: 3DA30 => minf Ofcs: 3DA38 => smhd Ofcs: 3DA48 => dinf Ofcs: 3DA50 => dref Ofcs: 3DA60 => url Ofcs: 3DA6C => stbl Ofcs: 3DA74 => stsd Ofcs: 3DA84 => mp4a Ofcs: 3DA88 => esds Ofcs: 3DA08 => stts Ofcs: 3DAF3 => stsc Ofcs: 3DC5F => stsz Ofcs: 3F333 => stco Ofcs: 3F3E8 => udta Ofcs: 3F40F => meta Ofcs: 3F418 => hdlr Ofcs: 3F427 => mdir Ofcs: 3F43D => ilst Ofcs: 3F44D => data Ofcs: 3F44D => data Ofcs: 3F479 => mean Ofcs: 3F481 => com.apple.iTunes Ofcs: 3F481 => com.apple.iTunes Ofcs: 3F495 => name Ofcs: 3F480 => data Ofcs: 3F480 => data Ofcs: 3F4E4 => @too Ofcs: 3F4EC => data Ofcs: 3F4EC => data Ofcs: 3F4F8 => com.apple.VoiceMemos Ofcs: 3F516 => iPhone (null) Ofcs: 3F51D => (null) Ofcs: 3F528 => free Ofcs: 3F540 => data Ofcs: 3F540 => data Ofcs: 3F574 => @too Ofcs: 3F57C => data Ofcs: 3F57C => data Ofcs: 3F588 => com.apple.VoiceMemos Ofcs: 3F5A6 => iPhone (null) Ofcs: 3F5AD => (null)	Ofcs: 4 => ftyp Ofcs: 8 => M4A Ofcs: 10 => M4A Ofcs: 14 => mp42 Ofcs: 18 => isom Ofcs: 20 => moov Ofcs: 28 => mvhd Ofcs: 94 => trak Ofcs: 9C => tkhd Ofcs: F8 => mdia Ofcs: 100 => mdhd Ofcs: 120 => hdlr Ofcs: 12C => soun Ofcs: 142 => minf Ofcs: 14A => smhd Ofcs: 15A => dinf Ofcs: 162 => dref Ofcs: 172 => url Ofcs: 17E => stbl Ofcs: 186 => stsd Ofcs: 196 => mp4a Ofcs: 1BA => esds Ofcs: 1ED => stts Ofcs: 205 => stsc Ofcs: 22D => stsz Ofcs: 18ED => stco Ofcs: 19F1 => udta Ofcs: 19F9 => meta Ofcs: 1A05 => hdlr Ofcs: 1A11 => mdir Ofcs: 1A27 => ilst Ofcs: 1A37 => mean Ofcs: 1A3F => com.apple.iTunes Ofcs: 1A3F => com.apple.iTunes Ofcs: 1A53 => name Ofcs: 1A5B => iTunSMPB Ofcs: 1A67 => data Ofcs: 1A67 => data Ofcs: 1AEB => free Ofcs: EFC => mdat

Figure 48. Axon Citizen Option C ‘Browse’ – AAC File Structure Mapping Comparison Chart

	Voice Memos – Audio (Compressed)	Axon Citizen Option C ‘Browse’ to Apple Files
Filename:	20220826-094112.m4a	Audio-1-9-compressed.m4a
File SHA-256:	9a75c4061f23b666ebcf0e86af00741226fcb6325082226d1866a97d89292c8	9a75c4061f23b666ebcf0e86af00741226fcb6325082226d1866a97d89292c8
Format:	AAC	AAC
Frequency:	480000 Hz	480000 Hz
Channels:	1	1
	Ofcs: 4 -> ftyp Ofcs: 8 -> M4A Ofcs: 10 -> M4A Ofcs: 14 -> isom Ofcs: 18 -> mp42 Ofcs: 20 -> mdat Ofcs: 7F63 -> mvhd Ofcs: 7FCF -> trak Ofcs: 7FD7 -> tkhd Ofcs: 8033 -> mdia Ofcs: 803B -> mdhd Ofcs: 805B -> hdlr Ofcs: 8067 -> soun Ofcs: 8077 -> Core Media Audio Ofcs: 808C -> minf Ofcs: 8094 -> smhd Ofcs: 80A4 -> dinf Ofcs: 80AC -> dref Ofcs: 80BC -> urll Ofcs: 80C8 -> stbl Ofcs: 80D0 -> stsd Ofcs: 80E0 -> mp4a Ofcs: 8104 -> esds Ofcs: 8137 -> stts Ofcs: 814F -> stsc Ofcs: 8177 -> stsz Ofcs: 848B -> stco Ofcs: 84AF -> udta Ofcs: 84D3 -> meta Ofcs: 84DF -> hdlr Ofcs: 84EB -> mdir Ofcs: 8501 -> ilst Ofcs: 8511 -> mean Ofcs: 8519 -> com.apple.iTunes Ofcs: 8519 -> com.apple.iTunes Ofcs: 8520 -> name Ofcs: 8548 -> data Ofcs: 8548 -> data Ofcs: 857C -> @too Ofcs: 8584 -> data Ofcs: 8584 -> data Ofcs: 8590 -> com.apple.VoiceMemos Ofcs: 85AE -> iPhone (null) Ofcs: 85B5 -> (null)) Ofcs: 85E8 -> mdat Ofcs: C3B4 -> mdat Ofcs: FF55 -> mdat Ofcs: 141C4 -> mdat Ofcs: 1802E -> mdat Ofcs: 18DC2 -> mdat Ofcs: 1FC92 -> mdat Ofcs: 24137 -> mdat Ofcs: 27FCB -> mdat Ofcs: 28E01 -> mdat Ofcs: 2FA28 -> mdat Ofcs: 3386C -> mdat Ofcs: 379F5 -> mdat Ofcs: 3B7A3 -> mdat Ofcs: 3D8FF -> moov Ofcs: 3D907 -> mvhd Ofcs: 3D973 -> trak Ofcs: 3D97B -> tkhd Ofcs: 3D907 -> mdia Ofcs: 3D90F -> mdhd Ofcs: 3D9FF -> hdlr Ofcs: 3DA08 -> soun Ofcs: 3DA1B -> Core Media Audio Ofcs: 3DA30 -> minf Ofcs: 3DA38 -> smhd Ofcs: 3DA48 -> dinf Ofcs: 3DA50 -> dref Ofcs: 3DA60 -> urll Ofcs: 3DA6C -> stbl Ofcs: 3DA74 -> stsd Ofcs: 3DA84 -> mp4a Ofcs: 3DA08 -> esds Ofcs: 3DA08 -> stts Ofcs: 3DAF3 -> stsc Ofcs: 3DC5F -> stsz Ofcs: 3F333 -> stco Ofcs: 3F3EB -> udta Ofcs: 3F40F -> meta Ofcs: 3F41B -> hdlr Ofcs: 3F427 -> mdir Ofcs: 3F43D -> ilst Ofcs: 3F44D -> data Ofcs: 3F44D -> data Ofcs: 3F479 -> mean Ofcs: 3F481 -> com.apple.iTunes Ofcs: 3F481 -> com.apple.iTunes Ofcs: 3F495 -> name Ofcs: 3F480 -> data Ofcs: 3F480 -> data Ofcs: 3F4E4 -> @too Ofcs: 3F4EC -> data Ofcs: 3F4EC -> data Ofcs: 3F4F8 -> com.apple.VoiceMemos Ofcs: 3F516 -> iPhone (null)) Ofcs: 3F51D -> (null)) Ofcs: 3F528 -> free Ofcs: 3F540 -> data Ofcs: 3F540 -> data Ofcs: 3F574 -> @too Ofcs: 3F57C -> data Ofcs: 3F57C -> data Ofcs: 3F588 -> com.apple.VoiceMemos Ofcs: 3F5A6 -> iPhone (null)) Ofcs: 3F5AD -> (null))	Ofcs: 4 -> ftyp Ofcs: 8 -> M4A Ofcs: 10 -> M4A Ofcs: 14 -> isom Ofcs: 18 -> mp42 Ofcs: 20 -> mdat Ofcs: 7F63 -> mvhd Ofcs: 7FCF -> trak Ofcs: 7FD7 -> tkhd Ofcs: 8033 -> mdia Ofcs: 803B -> mdhd Ofcs: 805B -> hdlr Ofcs: 8067 -> soun Ofcs: 8077 -> Core Media Audio Ofcs: 808C -> minf Ofcs: 8094 -> smhd Ofcs: 80A4 -> dinf Ofcs: 80AC -> dref Ofcs: 80BC -> urll Ofcs: 80C8 -> stbl Ofcs: 80D0 -> stsd Ofcs: 80E0 -> mp4a Ofcs: 8104 -> esds Ofcs: 8137 -> stts Ofcs: 814F -> stsc Ofcs: 8177 -> stsz Ofcs: 848B -> stco Ofcs: 84AF -> udta Ofcs: 84D3 -> meta Ofcs: 84DF -> hdlr Ofcs: 84EB -> mdir Ofcs: 8501 -> ilst Ofcs: 8511 -> mean Ofcs: 8519 -> com.apple.iTunes Ofcs: 8519 -> com.apple.iTunes Ofcs: 8520 -> name Ofcs: 8548 -> data Ofcs: 8548 -> data Ofcs: 857C -> @too Ofcs: 8584 -> data Ofcs: 8584 -> data Ofcs: 8590 -> com.apple.VoiceMemos Ofcs: 85AE -> iPhone (null)) Ofcs: 85B5 -> (null)) Ofcs: 85E8 -> mdat Ofcs: C3B4 -> mdat Ofcs: FF55 -> mdat Ofcs: 141C4 -> mdat Ofcs: 1802E -> mdat Ofcs: 18DC2 -> mdat Ofcs: 1FC92 -> mdat Ofcs: 24137 -> mdat Ofcs: 27FCB -> mdat Ofcs: 28E01 -> mdat Ofcs: 2FA28 -> mdat Ofcs: 3386C -> mdat Ofcs: 379F5 -> mdat Ofcs: 3B7A3 -> mdat Ofcs: 3D8FF -> moov Ofcs: 3D907 -> mvhd Ofcs: 3D973 -> trak Ofcs: 3D97B -> tkhd Ofcs: 3D907 -> mdia Ofcs: 3D90F -> mdhd Ofcs: 3D9FF -> hdlr Ofcs: 3DA08 -> soun Ofcs: 3DA1B -> Core Media Audio Ofcs: 3DA30 -> minf Ofcs: 3DA38 -> smhd Ofcs: 3DA48 -> dinf Ofcs: 3DA50 -> dref Ofcs: 3DA60 -> urll Ofcs: 3DA6C -> stbl Ofcs: 3DA74 -> stsd Ofcs: 3DA84 -> mp4a Ofcs: 3DA08 -> esds Ofcs: 3DA08 -> stts Ofcs: 3DAF3 -> stsc Ofcs: 3DC5F -> stsz Ofcs: 3F333 -> stco Ofcs: 3F3EB -> udta Ofcs: 3F40F -> meta Ofcs: 3F41B -> hdlr Ofcs: 3F427 -> mdir Ofcs: 3F43D -> ilst Ofcs: 3F44D -> data Ofcs: 3F44D -> data Ofcs: 3F479 -> mean Ofcs: 3F481 -> com.apple.iTunes Ofcs: 3F481 -> com.apple.iTunes Ofcs: 3F495 -> name Ofcs: 3F480 -> data Ofcs: 3F480 -> data Ofcs: 3F4E4 -> @too Ofcs: 3F4EC -> data Ofcs: 3F4EC -> data Ofcs: 3F4F8 -> com.apple.VoiceMemos Ofcs: 3F516 -> iPhone (null)) Ofcs: 3F51D -> (null)) Ofcs: 3F528 -> free Ofcs: 3F540 -> data Ofcs: 3F540 -> data Ofcs: 3F574 -> @too Ofcs: 3F57C -> data Ofcs: 3F57C -> data Ofcs: 3F588 -> com.apple.VoiceMemos Ofcs: 3F5A6 -> iPhone (null)) Ofcs: 3F5AD -> (null))

Figure 49. Axon Citizen Option C ‘Browse’ – AAC File Structure Mapping Comparison Chart

	Voice Memos – Audio (Compressed)	Axon Citizen Option C ‘Browse’ to Apple Files
Filename:	20220826-094530.m4a	Audio-1-10-lossless.m4a
File SHA-256:	fl2477f9ac4ed45fdda96a0040f05caca05543aeb2d8aedb4cd4e6461bddd029	fl2477f9ac4ed45fdda96a0040f05caca05543aeb2d8aedb4cd4e6461bddd029
Format:	ALAC	ALAC
Frequency:	48000 Hz	48000 Hz
Channels:	1	1
	Ofs: 4 => ftyp Ofs: 8 => MAA Ofs: 10 => MAA Ofs: 14 => isom Ofs: 18 => mp42 Ofs: 20 => mdat Ofs: 1A157 => mvhd Ofs: 1A1C3 => trak Ofs: 1A1CB => tkhd Ofs: 1A227 => mdia Ofs: 1A22F => mdhd Ofs: 1A24F => hdlr Ofs: 1A25B => soun Ofs: 1A268 => Core Media Audio Ofs: 1A280 => minf Ofs: 1A288 => smhd Ofs: 1A298 => dinf Ofs: 1A2A0 => dref Ofs: 1A2B0 => url Ofs: 1A2BC => stbl Ofs: 1A2C4 => stsd Ofs: 1A31C => stts Ofs: 1A334 => stsc Ofs: 1A35C => stsz Ofs: 1A42C => stco Ofs: 1A450 => udta Ofs: 1A474 => meta Ofs: 1A480 => hdlr Ofs: 1A48C => mdir Ofs: 1A4A2 => ilst Ofs: 1A4B2 => mean Ofs: 1A4BA => com.apple.iTunes Ofs: 1A4BA => com.apple.iTunes Ofs: 1A4CE => name Ofs: 1A4E9 => data Ofs: 1A4E9 => data Ofs: 1A51D => @too Ofs: 1A525 => data Ofs: 1A525 => data Ofs: 1A531 => com.apple.VoiceMemos Ofs: 1A54F => iPhone (null) Ofs: 1A556 => (null) Ofs: 1A589 => mdat Ofs: 27E65 => mdat Ofs: 358C9 => mdat Ofs: 43088 => mdat Ofs: 50E74 => mdat Ofs: 600B8 => mdat Ofs: 6E858 => mdat Ofs: 78EDE => mdat Ofs: 8B25A => mdat Ofs: 98AB9 => mdat Ofs: A68DF => mdat Ofs: B3E5E => mdat Ofs: C1E38 => mdat Ofs: CF530 => mdat Ofs: DC7EB => moov Ofs: DC7F3 => mvhd Ofs: DC85F => trak Ofs: DC867 => tkhd Ofs: DC8C3 => mdia Ofs: DC8CB => mdhd Ofs: DC8EB => hdlr Ofs: DC8F7 => soun Ofs: DC907 => Core Media Audio Ofs: DC91C => minf Ofs: DC924 => smhd Ofs: DC934 => dinf Ofs: DC93C => dref Ofs: DC94C => url Ofs: DC958 => stbl Ofs: DC960 => stsd Ofs: DC988 => stts Ofs: DC900 => stsc Ofs: DC848 => stsz Ofs: D0138 => stco Ofs: D0204 => udta Ofs: D0228 => meta Ofs: D0234 => hdlr Ofs: D0240 => mdir Ofs: D0256 => ilst Ofs: D0266 => data Ofs: D0266 => data Ofs: D0292 => mean Ofs: D029A => com.apple.iTunes Ofs: D029A => com.apple.iTunes Ofs: D02AE => name Ofs: D02C9 => data Ofs: D02C9 => data Ofs: D02FD => @too Ofs: D0305 => data Ofs: D0305 => data Ofs: D0311 => com.apple.VoiceMemos Ofs: D032F => iPhone (null) Ofs: D0336 => (null) Ofs: D0341 => free Ofs: D0359 => data Ofs: D0359 => data Ofs: D0380 => @too Ofs: D0395 => data Ofs: D0395 => data Ofs: D03A1 => com.apple.VoiceMemos Ofs: D03BF => iPhone (null) Ofs: D03C6 => (null)	Ofs: 4 => ftyp Ofs: 8 => MAA Ofs: 10 => MAA Ofs: 14 => isom Ofs: 18 => mp42 Ofs: 20 => mdat Ofs: 1A157 => mvhd Ofs: 1A1C3 => trak Ofs: 1A1CB => tkhd Ofs: 1A227 => mdia Ofs: 1A22F => mdhd Ofs: 1A24F => hdlr Ofs: 1A25B => soun Ofs: 1A268 => Core Media Audio Ofs: 1A280 => minf Ofs: 1A288 => smhd Ofs: 1A298 => dinf Ofs: 1A2A0 => dref Ofs: 1A2B0 => url Ofs: 1A2BC => stbl Ofs: 1A2C4 => stsd Ofs: 1A31C => stts Ofs: 1A334 => stsc Ofs: 1A35C => stsz Ofs: 1A42C => stco Ofs: 1A450 => udta Ofs: 1A474 => meta Ofs: 1A480 => hdlr Ofs: 1A48C => mdir Ofs: 1A4A2 => ilst Ofs: 1A4B2 => mean Ofs: 1A4BA => com.apple.iTunes Ofs: 1A4BA => com.apple.iTunes Ofs: 1A4CE => name Ofs: 1A4E9 => data Ofs: 1A4E9 => data Ofs: 1A51D => @too Ofs: 1A525 => data Ofs: 1A525 => data Ofs: 1A531 => com.apple.VoiceMemos Ofs: 1A54F => iPhone (null) Ofs: 1A556 => (null) Ofs: 1A589 => mdat Ofs: 27E65 => mdat Ofs: 358C9 => mdat Ofs: 43088 => mdat Ofs: 50E74 => mdat Ofs: 600B8 => mdat Ofs: 6E858 => mdat Ofs: 78EDE => mdat Ofs: 8B25A => mdat Ofs: 98AB9 => mdat Ofs: A68DF => mdat Ofs: B3E5E => mdat Ofs: C1E38 => mdat Ofs: CF530 => mdat Ofs: DC7EB => moov Ofs: DC7F3 => mvhd Ofs: DC85F => trak Ofs: DC867 => tkhd Ofs: DC8C3 => mdia Ofs: DC8CB => mdhd Ofs: DC8EB => hdlr Ofs: DC8F7 => soun Ofs: DC907 => Core Media Audio Ofs: DC91C => minf Ofs: DC924 => smhd Ofs: DC934 => dinf Ofs: DC93C => dref Ofs: DC94C => url Ofs: DC958 => stbl Ofs: DC960 => stsd Ofs: DC988 => stts Ofs: DC900 => stsc Ofs: DC848 => stsz Ofs: D0138 => stco Ofs: D0204 => udta Ofs: D0228 => meta Ofs: D0234 => hdlr Ofs: D0240 => mdir Ofs: D0256 => ilst Ofs: D0266 => data Ofs: D0266 => data Ofs: D0292 => mean Ofs: D029A => com.apple.iTunes Ofs: D029A => com.apple.iTunes Ofs: D02AE => name Ofs: D02C9 => data Ofs: D02C9 => data Ofs: D02FD => @too Ofs: D0305 => data Ofs: D0305 => data Ofs: D0311 => com.apple.VoiceMemos Ofs: D032F => iPhone (null) Ofs: D0336 => (null) Ofs: D0341 => free Ofs: D0359 => data Ofs: D0359 => data Ofs: D0380 => @too Ofs: D0395 => data Ofs: D0395 => data Ofs: D03A1 => com.apple.VoiceMemos Ofs: D03BF => iPhone (null) Ofs: D03C6 => (null)

Figure 50. Axon Citizen Option C ‘Browse’ – ALAC File Structure Mapping Comparison Chart