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The Advancement of Forensic Technology has Increased the Effectiveness of Documenting Evidence and Producing More Investigative Leads

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Abstract

The efficiency of investigations, crime scene processing, and evidence documentation have all been greatly improved by developments in forensic technology. This study assesses the effects of integrated databases like the National Integrated Ballistic Information Network (NIBIN), Automated Fingerprint Identification System (AFIS), and Combined DNA Index System (CODIS), as well as contemporary tools like the Foster and Freeman DCS-5 Camera, Crime-lite Auto, Leica RTC 360 Scanner, M-Vac System, and Cellebrite UFED. Twenty-two forensic professionals and law enforcement officers responded to a quantitative exploratory survey that was conducted online. Participants evaluated the correctness, dependability, and research results of conventional and contemporary approaches. According to the findings, most respondents believe that modern technologies are more effective and efficient, citing increases in processing speed, evidence accuracy, and the creation of investigation leads. Nonetheless, common issues were noted, such as inadequate training, a lack of funds, and limited access to new tools. The study emphasizes how crucial technology innovation is to the advancement of forensic science, but it also highlights how ongoing training and resource investments are necessary to fully utilize these capabilities.

Keywords: Forensic Technology, Crime Scene Investigation; Automated Fingerprint Identification System; Combined DNA Index System; National Integrated Ballistic Information Network; Leica RTC 360; Cellebrite UFED; M-Vac System

Abbreviations: AFIS: Automated Fingerprint Identification System; ALS: Alternate Light Source; ATF: Bureau of Alcohol, Tobacco, Firearms, and Explosives; CODIS: Combined DNA Index System; DCS-5Foster and Freeman; DCS-5: Camera System; DSLR: Digital Single-Lens Reflex; JFSCI: Journal of Forensic Sciences & Criminal Investigation; MP: Megapixel; M-Vac: Microbial Vacuum; DNA Collection System; NIBIN: National Integrated Ballistic Information Network; RTC 360: Leica RTC 360: 3D Laser Scanner; UFED: Universal Forensic Extraction Device; UV: Ultraviolet

Introduction

The advancement of forensic technology has increased the effectiveness of documenting evidence and

producing more investigative leads. Forensic technology has developed tools such as Foster and Freeman DCS- 5 Camera, Foster and Freeman Crime-lite Auto, Leica RTC 360 Scanner, M-Vac System, and Cellebrite. These tools have changed the world of forensics by providing accessibility for more thorough and efficient evidence processing and documenting. Intergraded data systems are responsible for increase of solved crimes due to the accessibility of the systems throughout the criminal justice network. Forensic networks include the National Integrated Ballistics Information Network (NIBIM), Automated Fingerprint Identification System (AFIS), and Combined DNA Index System (CODIS). These networks have also contributed to developing faster investigative leads. The new forensic technologies have contributed to the advancement of many forensic disciplines including DNA analysis, trace evidence examination, digital forensics, latent fingerprint examination and processing, firearm and tool mark examinations, bloodstain pattern analysis, crime scene reconstruction, and general crime scene processing.

Forensic sciences, which are cumulative techniques for creating and examining tangible evidence from crime scenes, were created out of that idea. The meticulous collection of that evidence, which is then examined at a crime laboratory, is a component of crime-scene investigation, which is frequently carried out by professionals known as crime-scene investigators. The only indisputable evidence offered at trial in some situations is evidence collected by crime scene investigators and examined by forensic specialists.

Crime scene investigators gather evidence from crime scenes that the suspects may have touched or "contaminated". That evidence is examined under a microscope in attempts to locate trace evidence.

Additionally, crime scene investigators collect fiber, dust, soil samples, and many other forms of tangible

evidence. Agencies generally document crime scenes using digital photography. Detailed notes, sketches, and meticulous measurements are also all recorded by crime scene investigators to document the crime scene. Evidence is gathered and meticulously categorized. Lasers and other light sources that can disclose latent fingerprints, stains, hairs, fibers, and other trace evidence have been developed because of scientific and technological advancements [1].

In reference to the history of photography, the earliest pinhole camera, the camera obscura, is where the

history of forensic imaging starts. Although there may be disagreements among writers over who was the first to describe the camera obscura, Hassan bin al Haitham, an Arab scholar, is most likely the one who described it around 1038. As is well known, scientists used these early pinhole cameras to study the sun, and artists used them to sketch. Some sources also claim that Leonardo da Vinci in 1490 and Roger Bacon in 1267 were the first to describe the camera obscura.

A finding made by Sir William Herschel in 1800 would prove crucial for police enforcement photographers in the future. Herschel discovered the invisible infrared zone with a simple experiment. When he put a thermometer near the red end of a white light source where no color of light was visible, he utilized a beam splitter to separate the light into distinct hues. He found the infrared portion of the electromagnetic spectrum in this way.

Black-and-white films' color sensitivity was enhanced into the red region of the visible light spectrum in 1873 by Dr. Hermann Wilhelm Vogel's invention of dye-sensitizing technology. That was the next significant advancement in the development of photographic film emulsion. This important finding paved the way for the creation of contemporary black-and-white panchromatic cinema.

Polaroid Polacolor instant print film was introduced in 1963. Super 8mm film technology was released in 1965 and was popular with consumers until video camcorders took its place. Fully automatic electronic flash units for still photography were introduced in the same year. The 1990s and the first decade of 2000 witnessed numerous noteworthy advancements in crime scene processing and technology for courtroom presentations, in addition to advancements in digital still photography [2].

Some would argue the most important tool of a crime scene investigator is the digital camera. Camera technology has advanced tremendously. Using a digital camera is like using a computer. Older camera technology had many limitations, one being storage. Newer digital cameras almost have unlimited storage. Not only can newer digital cameras capture more images, but the devices capture photos quicker.

While capturing photos with a digital camera, the operator can edit and adjust photos. Present cameras also take tremendously higher quality photos, than past camera technology. Newer cameras are also more portable and have easier set-up capabilities. Digital Cameras have advanced to the stage of containing major editing software, within the device, and incorporating alternate light sources in the photograph processing. An example of this technology is the Foster and Freeman Crime Lite-Auto and DCS-5.

The Foster and Freeman DCS-5 Camera and Crime-lite Auto have integrated a combination of Alternate Light Source processing and forensic photography. The DCS-5 is a specially designed Nikon D6 camera with a Pro- Grade 20.8 MP DSLR camera that has been altered for Ultraviolet-Infrared photography. It produces amazing images in all light levels. A comprehensive imaging system, the DCS 5 can identify, record, and enhance almost any type of fingerprint on any surface or background. To enhance the visibility of all fingerprint types, whether latent, polluted, or chemically altered, precise wavebands of illumination from Ultraviolet to visible to infrared are offered. The Foster and Freeman Crime-lite Auto is a full-spectral imaging tool for evidence identification, search, and collection. The device has a 20MP camera, LED lighting, and a clever motorized filter selection system. More evidence may be found faster because of the Crime-lite Auto's ability to investigate the full forensic spectrum [3].

Alternate light sources (ALS) make evidence easier to gather, record, and process by improving its visualization of evidence that is not immediately visible to the unaided eye. The technology increases the contrast between the evidence and background by using light emitted at a specific range of wavelengths. Different light sources that produce visible light in the electromagnetic spectrum between 400 and 700 nanometers can produce fluorescence, which allows for the visualization of several kinds of evidence. Throughout the years, tools such as Foster and Freeman Crime-lite Auto have become portable and easily accessible for transport to crime scenes. This allows the investigator to bring an entire spectrum of alternate light sources to a crime scene in an instant [4].

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To demonstrate the evolution of photography technology a sample fingerprint was photographed. The sample was a fingerprint on a clear plastic bag, processed with polycyano. The first photograph was captured with a Kodak PixPro FZ53. The Kodak is an older model of a "point and shoot" digital camera. To visualize the fingerprint, an Ultra-Violet Labino light was also utilized. To capture the photograph, the Labino light was handheld over the sample, to visualize the fingerprint, while the Kodak camera digitally captured the photograph.

The next photograph was from the same sample. The photograph was captured by the Crime-Lite Auto. To visualize the fingerprint, the Crime-Lite Auto was set to the ultra-violet setting. The combination of the

internal ultra-violet light source, internal filter, and camera system made capturing the photograph below an efficient process. The last photographs are from the same sample. Those photos were captured by utilizing the DCS-5. The camera used a 1:4 Ultraviolet-Visible-Infrared Apo Macro lens. To visualize the fingerprint, an ultra-violet lighting with the crime-lite 82s ultra-violet. After the photo was captured, the photo was enhanced with foster and freeman software. The enhancement software is like Adobe Photoshop, but extremely easier to use. The photograph was converted to gray scale. The image can also be both manually or automatically adjusted by changing the image's brightness, contrast, and gamma. The combination of high-quality camera and Foster and Freeman software provided high quality examination photographs for examiners. Another great function of the software is that it provides a processing record of how the image was enhanced. It also provides the original photo with all the separate enhanced photographs.

Even though forensic photography is an important skill set, it is not the only type of crime scene documentation. Another type of crime scene documentation is mapping. Mapping allows the investigator to create an accurate scene sketch, there must be supporting documentation that defines the size of the scene and where the scene's various items are. For the best part of the history of modern crime scene investigation, this was accomplished using manual measuring techniques. The image below is an example of a digital crime scene sketch, of a fatal collision. This sketch was created after documenting the scene with measurements and digital photography.

A manual crime scene mapping approach also depends on the physical conditions the technician discovers at the location. In some situations, some approaches are more realistic. Rectangular coordinates, triangulation, baseline coordinates, and polar coordinates are the most often utilized mapping techniques.

The rectangular-coordinates approach and the baseline method of fixing evidence are extremely similar.

Although it can be utilized indoors, the baseline works best in outdoor situations with no obvious landmarks. A datum point, from which the baseline will expand, is where the baseline starts. Triangulating an exterior scene to a group of neighboring landmarks establishes the datum.

An older method for mapping outdoor scenes when the data was widely dispersed over a rather broad area is the polar-coordinate method. It was frequently employed in cases of plane crashes, dispersed remains, or even bombing sites, where bomb remnants are extensively dispersed. When line-of-sight was restricted by dense vegetation or other obstructions, the polar-coordinate approach was not appropriate.

Manual mapping has become a less-used method. New technology such as total stations and 3D- Laser Scanners are taking the place of manual mapping methods. The Laser Scanning captures not only measurements but also visuals of the area that was scanned [5]. The most used 3D Laser scanner in crime scene work is the RTC Leica 360 Scanner.

The Leica RTC 360 Scanner has combined digital imaging and measuring. Laser scanning has increased the speed of documenting crime scenes considerably. Scanning is not only fast but very accurate. Compared to hand measurement tools, the accuracy and precision of measurements made with a scanner are far higher. The range of the Leica Geosystems scanner is above 100 meters, and its stated precision at 50 meters is plus or minus 6 millimeters. When compared to any realistic evaluation of accuracy related to the usage of tape measures or roller wheels, this degree of precision and accuracy is unthinkable. It speeds up the process and ability needed to provide a presentation that is accurate, lucid, and timely for interested parties [3]. The device shoots a beam of light and then measure the time it takes for a reflection to return. Plotting the individual laser light returns in a simulated three-dimensional space is made possible by the scanner's ability to precisely orient the beam's projection in both azimuth and elevation. Depending on the area of interest, the several scan resolutions can be changed. The ability to mix many scan positions to create expansive, seamless, virtual crime scenes is an even bigger benefit. Once data is collected with the scanner, the data is inserted into the Leica Cyclone Registration. That software manages the scan data projects. It allows the user to process the data stored and create a three-dimensional demonstrative for viewing. The images below demonstrate the product produced by a Leica RTC 360 Scanner.

Using a 3D scanner at the scene of a gunshot occurrence has many significant advantages. First, a vastly larger volume of data is gathered. At a modest crime scene, an investigator may take a few hundred measurements using tape measures before leaving the area. A 3D laser scanner may record millions of data points at the same place, making it appear as though the investigator is taking the data with him when he departs. This is useful when a physical relationship between items becomes significant due to later, unanticipated remarks or developments. Certain things might not have been precisely located in the scene using human

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tape measure techniques, but with laser scanning, all objects in the instrument's field of view will have been recorded. Additionally, using 3D laser scanning, all item position recording is done hands-off. A scanner rotates silently on its tripod, gathering the necessary data, rather than the shooting reconstructionist traipsing in, over, or around blood, casings, shoe prints, or other delicate evidence while brandishing a tape measure. After scanning a shooting scene, a direct presentation of the raw data can be produced in a matter of minutes. It may take days or weeks to compile the raw data from tape measurements into a presentation-ready figure. Even in those situations, the product is often two-dimensional. In just a few hours, scan data can be transformed into a three-dimensional product that allows viewpoint positioning in any location. In just a few days, more thorough and streamlined presentations can be created.

Three-dimensional laser scanning is so effective at depicting both simple and complex trajectories, that it is especially interesting to shooting incident reconstructionist. It is very valuable to be able to show bullet trails in three dimensions as soon as one leaves a scene. Scanner data has been used to create a wide variety of presentations, from highly stylized animated computer animations to raw data. Trajectory rods work in the same basic way; one scans the probes and extrapolates the path. Nevertheless, several more sophisticated methods, such as multilayer scanning and a connect-the-dots procedure, have been created [3]. Digital forensics has changed the way detectives and investigators process crime scenes. Digital evidence has become the most desired evidence from investigators. The rise of digital forensics has enabled investigators to extract and analyze data from electronic devices such as computers, smartphones, and servers. This can include recovering deleted files, tracing online activity, and analyzing communications, which can be critical in solving crimes. Most forensic evidence answers the investigative questions of who, what, where, and when the crime in question occurred. Digital evidence answers all those questions and most of the time answers the questions of why the crime occurred. Digital forensic technology has had the most advancements of all the forensic technologies. Just the software in the devices used for forensic extractions has monthly software updates.

In digital forensics, the Cellebrite Universal Forensic Extraction Device (UFED) is a potent instrument for obtaining and examining data from mobile devices. UFED was first developed in the early 2000s to solve the problems of data extraction and analysis from the growing number of mobile devices. Cellebrite has expanded UFED's capabilities through ongoing research and development, incorporating features like touchscreen functionality, intuitive user interfaces, and superior data processing algorithms. These enhancements have strengthened UFED's standing as a top mobile device forensics tool. It provides vital evidence while maintaining forensic integrity, making it an essential tool for law enforcement, corporate security, and forensic specialists today.

Due to its unparalleled data extraction capabilities, Cellebrite UFED stands out as a leader in the mobile

device forensics sector. Call logs, text messages, emails, photos, videos, and app-related data are just a few of the many types of data it can obtain from various mobile devices. Forensic experts can access locked devices and retrieve data that would otherwise be unreadable due to its capacity to go over security measures like encryption and passcodes. With support for both iOS and Android, Cellebrite UFED provides flexibility in managing a range of situations. It is a dependable and effective tool for forensic experts performing in-depth investigations because of its user-friendly interface and strong extraction algorithms. Investigators can recover information such as call records, text messages, emails, and social media activities that have been erased or buried. The tool's sophisticated reporting features and algorithms assist investigators in effectively presenting their findings, supporting both criminal investigations and court cases [6].

While the application of digital forensic tools has improved electronic evidence recovery and analysis, developments in collection of biological evidence, such as the M-Vac System, have similarly improved collection of physical traces in crime scenes. Prior to the M-Vac System, there were not many ways for forensic practitioners to collect DNA without swabbing a substrate or submitting the entire object to a DNA laboratory for processing. The M-Vac System collects DNA material using the wet-vacuum technique. This technology is accessible to smaller crime laboratories and provides a more thorough way to collect evidence [7].

The M-Vac System is an effective tool when collecting touch DNA. Touch DNA is a trace left behind when human tissue or bodily fluid meets items at a crime scene. The term was first used in the early 2000s. Before touch DNA processing was developed, forensic experts depended on substantial quantities of human blood, semen, or other bodily fluids to identify people associated with a crime scene. With the advancements of both laboratory systems and collection tools, "Touch" DNA Analysis has become more sought out and a great asset when developing investigative leads.

Database integration is one way evidence and criminal cases are linked nationally. The integration of various forensic databases, such as those for DNA, ballistics, and fingerprints, allows for cross-referencing and more efficient data sharing across different jurisdictions and agencies, improving the chances of connecting evidence to suspects. The database used for cross-referencing DNA is the Combined DNA Index System (CODIS). The database for cross-referencing firearm evidence is the National Integrated Ballistic Information Network (NIBIN). The database for cross-referencing latent prints is the Automated Fingerprint Identification System (AFIS). Before AFIS, latent print cards and inked print cards had to all be manually compared from an agency

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file drawer that recorded the impressions. These databases often provide investigators with leads when the case goes cold.

The first scientific method for identifying criminals was the Bertillonage system created by Alphonse Bertillon. Bertillonage was swiftly copied by other criminal justice institutions in Europe and the United States due to its remarkable performance history. As additional law enforcement agencies started keeping Bertillon records, it became clear that the system was ineffective and only served as a temporary solution to the persistent issue of accurate criminal identification. The main issue was that measures made by several police were either close enough to identify two people as the same person or dissimilar enough to prevent further identifications.

As the newly appointed Inspector General of the Bengal District Police in India in the early 1890s, Sir Edward Henry was dealing with a prevalent issue of the time: the incapacity to correctly identify the indigenous population. He was certain that he could develop a sensible and useful system of fingerprint classification after reading Galton's Fingerprints, which would allow fingerprints to be the exclusive means of criminal and personal identification. After his return to England in 1894, Henry became friendly with Galton on both a personal and professional level. He received his own research material from Galton as well as Herschel's and Faulds'. Henry went back to India with this knowledge to tackle the fingerprint categorization issue. In 1896, he directed his police officers to start collecting fingerprints and anthropometric measurements of Bengali inmates, even in the absence of a classification system.

Despite their effectiveness in identifying repeat offenders, known-print categorization techniques could not help apprehend criminals by detecting latent prints found at crime scenes. Many single-fingerprint

classification systems were created to overcome this restriction. While some of these methods were entirely innovative, others were based on known-print classification schemes that already existed. New Scotland Yard's Detective Superintendent Fredrick Cherrill and Chief Inspector Henry Battley developed the most popular single-fingerprint classification technique [7].

Fingerprint technology has advanced by leaps and bounds. Criminals are now commonly identified by an AFIS search. With AFIS being a database used for cross-referencing latent prints, the system uses prints that were previously collected and entered the system. Among other things, law enforcement uses automated fingerprint identification systems (AFIS) to automatically search through massive databases of fingerprints for potential sources of latent prints from crime scenes. The databases that are search are local, state, and federal. The technology's matching performance is crucial to successfully identifying the origin of a latent print.

A new method for conducting database searches with the least amount of work has emerged in recent years. This method uses a feature extraction algorithm to automatically allocate minutiae to do the initial search. The idea behind this method is to use an AFIS feature extraction technique to automatically assign minutiae for fingerprints, replacing the manual process. The intricacies of fingerprint assignment can likewise be approached in a similar manner. The performance of manual and automatic minutiae assignments for fingerprints and fingermarks (latent or patent prints) can be compared using this test.

Using five distinct performance tests, this study demonstrates to fingerprint examiners the importance of assessing AFIS systems' performance under circumstances. The findings highlighted the need to create and use performance tests for situations by demonstrating that the variations in performance for each condition were very significant. Numerous synthetic fingermarks made from six fingers served as the basis for the tests. Fingermarks should be made for a greater number of fingers to increase the dependability of performance measurements. The article advised it would be beneficial for performance testing research in the future to involve fingerprint examiners more in the test development process. Because these tests can provide them with a good idea of the opportunities and limitations of the system utilized at their institutions, fingerprint examiners should think about what kinds of exams are relevant to their everyday work [8].

NIBIN is the National Integrated Ballistics Information Network. The program automates ballistics evaluations and provides actionable investigative leads in a timely manner. NIBIN is the only interstate automated ballistic imaging network in operation in the United States and is available to most major population centers in the United States. This procedure was carried out manually by firearms examiners prior to the NIBIN Program, which was very time-consuming. Cartridge casing evidence is entered into the Integrated Ballistic Identification System (NIBIN) by firearms examiners or technicians. These images are correlated against the database. Law enforcement can look for evidence from other jurisdictions across the nation as well as from their own. This program is one investigative tool that law enforcement can use that makes it simple for us to cooperate and share information, which increases our effectiveness in resolving cases.

NIBIN captures the digital images of spent bullets and cartridge cases that were either found at crime scenes or test-fired from confiscated firearms and are included in the national database known as NIBIN. The Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) developed the system in 1997 and provides the equipment to crime laboratories around the country. ATF is also responsible for system maintenance and supervision. The expended cartridge cases are transformed into two- or three-dimensional digital photographs by a firearm examiner using ballistic imaging, which are then posted to the National Integrated Ballistic Information Network. It is feasible to scan NIBIN for potential matches, or other cartridge cases that might have come

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from the same gun because the cartridges have comparable tool marks. After a possible match, or "hit," has been identified, the crime laboratory gets the actual used cartridge cases and looks at them under a microscope to confirm the hit. Investigators are then given information regarding the hit by the lab. The hit report is a detailed report of the finding of correlations between fired cartridge cases in relation to a firearm. For law enforcement, there are numerous tactical and strategic applications for a NIBIN "hit" report. It can be used by law enforcement officers to connect crimes, which can aid in the identification of suspects.

Additionally, law enforcement can use it to comprehend gun crime trends like gun trafficking and sharing. Research was conducted on the National Integrated Ballistic Information Network by the National Institute of Justice Department. The researchers collected data on hits from all 150 NIBIN sites and more specific data on hits at 19 sites across the nation to understand how crime investigators use NIBIN. In-depth interviews with crime lab staff and investigators at ten NIBIN sites were also performed by the researchers, who also surveyed crime laboratories nationwide.

According to the researchers' results, the National Integrated Ballistic Information Network has a lot of unrealized potential for crime-solving. The researchers observed that many sites were not fully utilizing NIBIN at the time of the study, even though some sites made excellent use of it and considered it to be a very helpful tool in assisting in solving gun-related crimes. The researchers found that the time required to process ballistic data and find hits varied significantly across NIBIN sites, ranging from hundreds of days to days. Due to lengthy delays, it may be too late to assist with a specific investigation once a hit report has been forwarded from the crime lab to law enforcement.

Additionally, the researchers discovered that while some sites used NIBIN sparingly, those in the most gun- crime-prone areas entered the most evidence and produced the most hits. Nevertheless, hits frequently lacked information that could help investigators, such as the cartridge's location. These were small deficiencies with the published reports after NIBIN leads were established in a case [9]. Previous forensic technologies used for processing were slower. That technology also had a larger margin of error. With the advancement of technology, processing crime scene and evidence has become more efficient and effective technology. To assess how beneficial new technology has been in forensics and investigations research was conducted.

Material and Method

The method for the research was a survey method. The survey method was a quantitative research technique that used structured questionnaires or interviews to gather standardized data from a sample of people or groups. The research consisted of questionnaires. The specific type of survey was exploratory. Exploratory surveys are carried out when the amount of information available on a subject is small. Those surveys collect preliminary information to help formulate theories or direct further study. The delivery method of the survey was online surveys. Online surveys are conducted through the digital platform "Typeform" [10].

The questionnaire started with preliminary questioning to get a base of the respondents' general experience in forensics. The questionnaire contained questions to measure the experience and the capacity of the respondents who were involved in forensics. The survey then measured the respondents' knowledge of forensic disciplines. The survey also measured the respondents' knowledge of newer forensic technology. Lastly, the survey measured the respondents' experiences between older forensic technology and newer forensic technology.

The target respondents for the survey were individuals who either benefited from the results of forensic analyses or analysts who were forensic science practitioners. The survey consisted of fifty-nine questions. There was a total of twenty-two responses to the survey. Thirty-six of the fifty-nine questions were used to assess the opinions of the respondents on specific forensic technology. The results of those questions are provided at the end of this text using graph demonstratives.

Results

The purpose of the first section of questions was to gather information on roles, experience, and knowledge of forensic technologies. The average respondents were Crime Scene Investigators (64%), Forensic Analysts (27%), and Detectives (18%). A crime scene investigator is responsible for the documentation and collection of intangible and tangible evidence. The role of the detective is generally that of a case agent. Detectives are responsible for the overall case and normally benefit from the efforts of crime scene investigators and forensic analysts. Forensic Analysts are experts. Forensic Analysts review specific evidence to render an expert opinion on the provided evidence. An individual can be responsible for multiple, any combination of more than one role, or even all the roles. Results of the survey are provided in graph form below.

86 percent of the respondents had over two years of experience in forensics. 68 percent of respondents either always or frequently use new forensic technology for investigations. 95 percent of respondents use new forensic technology during criminal investigations. 95 percent of respondents agree that modern forensic technology is effective in solving or advancing criminal investigations. 91 percent of respondents agreed that the advancement in forensic technology has improved the accuracy and reliability of evidence collection. 80 percent of respondents agree that advancements in forensic technology have made a major contribution to solving cold cases. According to the

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respondents, the biggest technological challenges regarding forensic investigations are insufficient tools or software (43%), lack of training on new technology (43%), and data storage and management (14%).

The next portion of the questions was to gather information on the new technology in forensics and compare them with previous forensic tools. Those forensic technologies were the Foster and Freeman DCS-5 and Crime-lite Auto, RTC Leica 360 Scanner, Cellebrite, and the M-Vac System. 69 percent of respondents agreed that the Foster and Freeman Crime-lite Auto was effective in the enhancement of trace material and fingerprint evidence. 75 percent of respondents agreed that the Foster and Freeman DCS-5 was effective in the enhancement of trace material and fingerprint evidence. All respondents agreed that both the Foster and Freeman DCS-5 and Crime-lite Auto were quick to set up and analyze evidence. 56 percent of respondents agreed that prior to the Foster and Freeman DCS-5 and Crime-lite Auto analyzing trace evidence took a longer amount of time. An average of 90.5% of respondents agreed both the Foster and Freeman DCS-5 and Crime- lite Auto have assisted in solving or advancing forensic investigations.

97 percent of respondents were confident in the accuracy of data provided by the RTC Leica 360 Scanner. 76 percent of respondents agreed the RTC Leica 360 Scanner took less than 30 minutes to an hour to complete a scan to document a crime scene. Prior to the RTC Leica 360 Scanner, 76 percent of respondents agreed crime scene documentation took 1 hour or longer. 92 percent of respondents agreed the RTC Leica Scanner improved the efficiency and speed of documenting an investigation. 88 percent of respondents are confident that Cellebrite can extract and recover data from mobile devices. 57 percent of respondents believed that Cellebrite has significantly contributed to solving or advancing criminal investigations.

75 percent of respondents agreed the M-Vac System was effective in collecting biological DNA from difficult or porous surfaces. 90 percent of respondents agreed the M-Vac System contributed to advancing or solving criminal investigations. M-Vac System Collection more than 2 hours (33%), 1 to 2 hours (17%), and 30 minutes to an hour (50%). Collection prior to M-Vac System more than 2 hours (20%), 1 to 2 hours (60%), and 30 minutes to an hour (20%).

The next portion of the questions was to gather information on newer integrated data storage systems and their effectiveness in solving criminal investigations. Those integrated data systems were the Automated Fingerprint Information System (AFIS), Combined DNA Index System (CODIS), and National Integrated Ballistic Information Network (NIBIN). All respondents agreed AFIS provided correct matches. 93 percent of respondents agreed AFIS frequently or always produced leads in criminal investigations. 69 percent of respondents agreed that AFIS directly impacted the speed and resolutions of criminal cases. All respondents agreed CODIS provided correct matches. 80 percent of respondents agreed that CODIS frequently or always produced leads in criminal investigations. 67 percent of respondents agreed that CODIS directly impacted the speed of resolving criminal cases. 94 percent of respondents agreed NIBIN provided correct matches in identifying firearm evidence. 77 percent of respondents agreed that NIBIN frequently or always produced leads in criminal investigations. 94 percent of respondents agreed that NIBIN directly impacted the speed of resolving criminal cases.

Discussion

Most respondents agreed that new forensic technology is more efficient and effective in generating leads or solving criminal investigations. Most respondents also agreed that Foster and Freeman DCS-5 and Crime-lite Auto, RTC Leica 360 Scanner, and Cellebrite, were all more efficient and effective in generating leads or solving criminal investigations, than prior forensic tools. Most respondents agreed that AFIS, CODIS, and NIBIN are efficient and effective in generating leads or solving criminal investigations.

Although most respondents agreed that the M-Vac System contributed to advancing or solving criminal investigations, most respondents agreed that the M-Vac System takes more time to use than prior DNA collection methods. Previous known collection methods for DNA were to either swab the target area or cut out the target area and submit the entire source to a DNA laboratory. The M-Vac System, being a wet vacuum takes more time to set up and use but provides a more thorough collection method than swabbing or cutting out the target area.

There was a split response to the inquiry of the biggest technological challenges regarding forensic investigations. The split was insufficient tools or software at 43 percent, lack of training on new technology at 43 percent, and data storage and management at 14 percent. There are a variety of reasons for these responses. Most entities do not have the funds available to purchase new forensic tools when the tool is made available to law enforcement agencies. In the same token most entities do not have many resources to pay for training on the technology or to take an investigator out of rotation to attend the training. The lack of data storage and management is generally also due to the lack of available funds. Even digital storage costs money and with the advancement of technology, there is a bigger need for more digital storage. The common denominator is generally available funds allocated for the specific purpose of training and equipment.

Resulting from this research, it has become clear that modern forensic science plays a key role in enhancing law enforcement procedures. Respondents showed firm agreement with the efficiency, reliability, and promptness of forensic tools such as Foster and Freeman DCS-5, Crime-lite Auto, RTC Leica 360 Scanner, Cellebrite, and M-Vac System. These devices have improved the

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procedure of collecting evidence, documenting crime scenes, and establishing leads. Also, the use of integrated forensic databases such as AFIS, CODIS, and NIBIN has been associated with the quick solution of crimes. Funding for forensic databases is, however, insufficient despite the benefits associated with their application. The key challenge that respondents identified was the inability to access these tools and train personnel to use them. Funding and resource allocation are the challenges preventing full implementation of forensic science. In conclusion, while scientific investigations continue to provide an opportunity to determine the cause of crime, more investment should be made in the processes of providing equipment and training on how to use these devices to improve the effectiveness of forensic science.

Conclusion

Technological advancements have revolutionized tools and systems used in forensic science. The technology has also changed how to look at crime scenes. The introduction of the new forms of technology has helped to change how crime scenes are investigated. The modern ways of forensic analysis have improved the way of investigating crimes. There is more accurate evidence gathered, and it is now easier to access such evidence. The role of forensic science in criminal investigation has also evolved. This increase has influenced the work of crime scene investigators. The investigators are more reliant on the advancements in forensic science, as this newer technology helps investigators collect, document, and preserve evidence of crime more effectively and efficiently.

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