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What to Expect from the Arrival of the Quantum 3D Microscope

WHITE PAPER

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Abstract

Forensic firearm and toolmark identification has been widely accepted in the courts since its inception in the early 20th century. Recently though, it has faced some significant challenges due to court concerns about reliability and a lack of a statistical foundation for the conclusions offered by forensic firearm examiners. The arrival of the **Quantum 3D Microscope™** provides examiners with a powerful tool that can support their conclusions with data sufficient to alleviate the concerns of the court. Furthermore, it will help address other issues that have existed in the discipline, including work efficiency and the lack of standardization of samples for training, and competency and proficiency testing.

Introduction

Firearm and toolmark identification is a discipline of forensic science that has, as a major focus, the comparison of toolmarks to determine if they share a common source. Most often, the toolmarks with which examiners are concerned are those left behind on bullets, cartridge cases, and shotshells by the various parts of a firearm when a cartridge is fired.

As a bullet is fired down a barrel, the toolmarks on the inner surface of the barrel created during the manufacturing process of that barrel scratch the surface of the bullet, leaving a pattern of scratches on its surface. These individual characteristics, which serve as the basis for common source determinations, are highlighted by the ovals in **Figure 1** and consist of a series of microscopic scratches on the surface of the bullet.

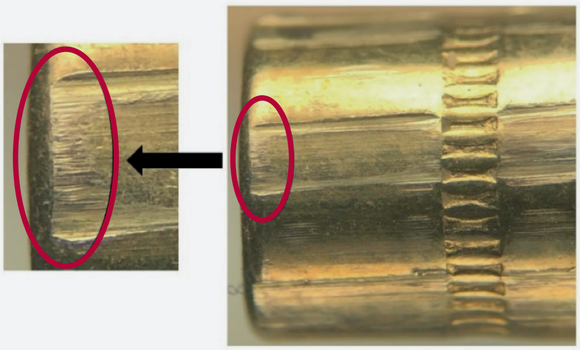

Figure 1 › .25 ACP caliber bullet

When attempting to determine if two bullets were fired from the same firearm, examiners will compare the patterns of individual characteristics on the two bullets (see **Figure 2**). The conclusion that is offered by the examiner is based on the level of pattern correspondence that is observed between them.

Figure 2 › Comparison of two .380 ACP caliber bullets

The currently accepted guiding principles used by firearm and toolmark examiners when making common source determinations is the AFTE Theory of Identification as it Relates to Toolmarks.[1] This published statement by the Association of Firearm and Tool Mark Examiners (AFTE) provides guidance for when a common source determination may be made, and makes two statements that are particularly relevant.

1 AFTE Committee for the Advancement of the Science of Firearm and Toolmark Identification, 2011. Theory of Identification as it Relates to Toolmarks: Revised. AFTE Journal 43(4):287.

1. Currently, the interpretation of individualization/identification is subjective in nature, founded on scientific principles, and based on the examiner's training and experience.
2. The statement that "sufficient agreement" exists between two toolmarks means that the agreement of individual characteristics is of a quantity and quality that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility.

These statements have been the focus of criticisms from several different avenues, including different research committees in the United States[2,3] and, most recently, court decisions that have limited the scope of the testimony that can be provided by firearm and toolmark examiners.[4,5,6] While the details of the criticisms differ, the main elements consist of two primary concerns regarding the reliability of the conclusion that two toolmarks share a common source—the subjective interpretation of the pattern correspondence and the lack of a statistical basis.

These concerns, and many more, are addressed using the the latest technological innovation from Ultra Electronics Forensic Technology—the Quantum 3D Microscope. This 3D virtual comparison microscope builds on the success of **IBIS®** (Ultra Electronics Forensic Technology's Integrated Ballistic Identification System). The 3D acquisition technology developed for IBIS was adapted to make the Quantum 3D Microscope possible.[7]

In addition to providing a platform for more-standardized comparative examinations, measurements from the 3D topography of objects feed correlation algorithms and statistical models to support expert conclusions with objective confidence levels and error rates. The *Daubert* decision[8] designated the judge as "gate keeper" for the admissibility of expert witness testimony. Part of the criteria for admissibility is the error or potential error rate of the method used to draw conclusions. Having become increasingly discontent with examiners speaking of a likelihood so remote as to be considered a practical impossibility, the courts have been seeking a solution to this problem for many years. The Quantum 3D Microscope is the beginning of that solution—it is combined with a software package that allows for the powerful and quantifiable discrimination between bullets fired from the same firearm and bullets fired from different firearms.

Background/Problems

The ultimate question that firearm and toolmark examiners are attempting to answer, "Was this toolmark created by this tool?", is not as simple as it appears. The reason is because two different issues are involved, each of which can be summarized by a question. The first is, "Do different tools produce different toolmarks?" The second question is, "If the answer to the first question is yes, that different tools do produce different toolmarks, then can trained examiners discern these differences to make accurate common source determinations?"

Ideally, the answer to the first question would have been determined without involving the subjectivity of an examiner and then the second question could have been addressed separately. However, this was not possible. The first question could not be answered without introducing an examiner to compare the toolmarks created by different tools, assess the similarities and the differences, and interpret those similarities and differences to determine if different tools produce different toolmarks. When comparing toolmarks made by the same tool, they no doubt observed similarities as well as differences. When comparing toolmarks made by different tools, they no doubt observed differences and maybe some similarities. They reported as such. However, what was the criterion that they used to declare that bullets fired from different firearms, and those fired from consecutively manufactured barrels, could be differentiated? Whether the toolmarks were on bullets, cartridge cases, or other tools, what was generally concluded was, "They are different, therefore, the method is valid." Maybe the method was valid, but was the criterion by which they declared them to be different valid? With a couple of exceptions, the criterion was never defined.

2 National Research Council, 2009. Strengthening Forensic Science in the United States: A Path Forward. The National Academies Press, Washington, DC.
3 President's Council of Advisors on Science and Technology, 2016. Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods.
4 United States v. Adams, 2020 U.S. Dist. LEXIS 45125.
5 United States v. Tibbs, 2019. D.C. Super. LEXIS 9.
6 United States v. Davis, 2019. U.S. Dist. LEXUS 155037.
7 There is an important distinction to be made between the Quantum 3D Microscope and IBIS. The purpose of IBIS is to find links in a large database of candidates. Its greatest utility is as an investigative tool to provide investigators with links between shooting incidents that may not have otherwise been developed. The purpose of the Quantum 3D Microscope is to compare specific toolmarks, one with the other, enabling the examiner to provide definitive common source determinations with respect to those toolmarks.
8 Daubert v. Merrell Dow Pharm., Inc., 1993. 509 U.S. 579.

Without a defined criterion guiding the assessment, the research described above can be rightly criticized as having significant weaknesses. Chief among them is the inherent subjectivity in the final interpretation of the results in the studies. It was the individual researcher who was concluding that differences in toolmarks created by different tools were sufficiently different. It was the same individual researcher who was concluding that similarities in toolmarks created by the same tool were sufficiently similar. Each of these conclusions was based on the individual researcher's training and experience, which, as mentioned earlier, is subjective in nature.

Furthermore, because of the design of the studies, it could easily be argued that the studies were subject to bias. In many instances, when making toolmark comparisons, the researcher knew that the toolmarks were in fact made by different tools. Therefore, it would have been natural to look for differences, no matter how slight they might be. This presents a challenge because when conducting comparisons in casework, examiners are typically looking for patterns of similarity. They do not typically look for differences because differences are to be expected. So, when there are differences, albeit slight, would an examiner in a casework situation dismiss those differences as "expected differences" when in fact they could be the key to determining that the toolmarks were made by different tools?

Prior to the 1990s, the two questions mentioned at the beginning of this section were merged into one question, based on necessity—there simply was no other way to accomplish the needed research.[9] However, with the development of machine-based technology and algorithms with which to process the measured topographies, the discipline is provided with clear, objective, quantifiable data indicating that different tools produce different toolmarks. Over 30 machine-based studies have been published dealing with bullets, cartridge cases, and other objects with toolmarks, and they all show separation between data from same source comparisons and data from different source comparisons. When considering the cumulative data, there are close to one million data points, if not more, that clearly support the primary premise of firearm and toolmark identification—that different tools produce different toolmarks.[10]

The issue of course is that machine-based technology is not used in performing visual comparisons of toolmarks. Furthermore, error rates relevant to machine-based technology and algorithms cannot be applied to examiners using comparative microscopy. Therefore, there remains the issue of whether examiners, using accepted processes and procedures, can accurately make common source determinations. Fortunately, this has been assessed by over 20 different studies that have examined an examiner's ability to accurately make common source determinations.[11] There are limitations to some of these studies but overall, they demonstrated that trained examiners could accurately make common source determinations with a low rate of error. But, like the machine-based studies, these studies do not provide for a discipline-wide error rate. While this low error rate should allay some of the concerns the courts have with reliability, the courts do not appear sufficiently persuaded. Furthermore, there is still a concern with the certainty with which common source determinations can be made. These studies do not offer that certainty.

There are other ancillary concerns with which the discipline is challenged. One is the black box process used by examiners. This refers to the fact that between the initial examination of the specimens and the final interpretation with respect to common source, many decisions are made that are not necessarily reflected in the case report or even the notes. The AFTE Theory of Identification as it Relates to Toolmarks states that the interpretation of comparisons is subjective in nature. However, this can be misleading as there is an interplay of objectivity and subjectivity throughout the entire comparison process. There are decisions regarding lighting that can impact how the toolmarks are visualized. There are constant decisions made with respect to correspondence that is and is not observed, thereby causing the examiner to shift the images. Every time the examiner shifts one or more of the images, a subjective assessment is made about the objective data that is being observed at that moment. Therefore, even though examiners are dealing with objective data, subjectivity is inherent in the on-going evaluation of that data during the comparison process.

Another concern is the current status of the training of new firearm and toolmark examiners. AFTE has published a Training Manual that many laboratories use as the foundation of their training programs for new examiners. Overall, the manual provides excellent direction and uniformity with respect to what should be done and the references that should be consulted. However, what is not standardized are the toolmark samples, including those on bullets and cartridge cases, that individuals are provided to develop their comparative analysis skills. And it is these samples upon which an examiner's identification criterion is developed and built.

9 Prior to machine-based studies, consecutive matching striations (CMS) were studied, hoping to provide examiners with a more objective criterion for concluding that two striated toolmarks shared a common source. During these studies, there was a demonstrable, quantifiable difference between striated toolmarks produced by the same tool and striated toolmarks produced by different tools. The reason was that toolmarks created by the same tool demonstrated a consecutiveness of striations while toolmarks created by different tools did not show that same consecutiveness. While valuable, this research still involved the human element and could be subject to similar criticisms as other, earlier studies.

10 Nichols, R. Firearm and Toolmark Identification: The Scientific Reliability of the Forensic Science Discipline, 2018. London: Academic Press. See chapter 4, State of the art for a summary of many of these studies.

11 Nichols, R. Firearm and Toolmark Identification: The Scientific Reliability of the Forensic Science Discipline, 2018. London: Academic Press. See chapter 7, Validating the criteria for identification for a summary of many of these studies.

One more prominent concern is the lack of standardization of the toolmark samples used in competency and proficiency testing. Strong efforts have been made to minimize differences between test samples, but there can be variation between samples that can impact test performance.

IBIS or Quantum

IBIS has been used in building and searching regional and national ballistic networks for over two decades. This has resulted in hundreds of thousands of links between firearm-related incidents. Instrumental in the success of these networks has been the technology along with the processes and people behind the technology.

While it uses some adapted IBIS technology, the Quantum 3D Microscope has a much different purpose. In IBIS, standard acquisition protocols are essential for effectively searching ballistic networks. Using the Quantum 3D Microscope, examiners have much more flexibility in what they acquire for the specific comparison at hand.

The Solution—The Quantum 3D Microscope

The Quantum 3D Microscope offers solutions to many of the issues that examiners face in the courts as well as the primary and ancillary concerns that have been mentioned. The following topics will be discussed in turn:

- Movement toward a more objective casework approach
- Enhancement of the ability of examiners to process evidence and casework
- Reinforcement of the primary premise of firearm and toolmark identification through community-wide validation
- Standardized remote training, and competency and proficiency testing
- LIMS (Laboratory Information Management System) integration and data management issues

Movement Toward a More Objective Casework Approach

Virtual Comparison Microscopy

There are two ways in which the use of the Quantum 3D Microscope facilitates a movement toward a more objective approach in firearm and toolmark examinations. The high quality, 3D topography capture allows for measurements, and consequently, allows for the use of computer-based methods for common source determination and large-scale statistical analysis. The widely successful IBIS® technology provided the foundation upon which the Quantum 3D Microscope was developed. The 3D data acquisition is reproducible and traceable to international measurement standards, thus permitting accurate comparisons.

Virtual comparison microscopy (VCM) has many advantages over conventional comparison microscopy. Chief among them is the availability of data to be compared. With the 3D acquisition, the topography of both specimens is **directly measured** and reproduced. In conventional comparison microscopy, the topography is **observed** using lighting to cast highlights and shadows on the specimens. Therefore, what is observed is highly dependent on lighting and it is critical that lighting be as similar as possible for both specimens. In addition, it can be difficult to replicate lighting from sample to sample. With VCM, comparisons are reproducible and repeatable because of its direct topography measurement that cannot be accomplished with conventional comparison microscopy.

A second distinct advantage of VCM is remote collaboration—examiners in different laboratories can partner with one another. For example, in a laboratory system in which there is a single examiner at a location, evidence must be physically transferred to another site for verification and technical review. With VCM, such transfer of evidence is unnecessary. The images can be accessed remotely, and the verification processes easily handled.

VCM also allows for easy annotation during comparisons. With annotation, examiners can readily highlight areas that were relied upon for conclusions that were reached. This helps to reduce the black box concerns; concerns that the reasoning behind decisions are for the most part an unknown. When comparisons are reviewed, or, in some instances, questioned, it is now possible to "see" the thought process of the examiner who performed the documented comparison.

RBL Method Leading to a False Match Rate

In the Quantum 3D Microscope's RBL Method, two similarity measures are used. The first is the Pattern Matching Score which quantifies overall similarity using a combination of a cross-correlation function (CCF) and an absolute normalized difference. The CCF has been shown to be effective in measuring the similarity of bullet profiles. The second similarity measure is the Line Counting Score that analyzes consecutively corresponding peaks as well as consecutively corresponding valleys. The underlying logic is that there could be two corresponding peaks between two toolmarks, but the valleys in between those peaks could be misaligned. Therefore, the corresponding valleys provide additional and complementary information. When combined, the discriminating power of the Pattern Matching Score and the Line Counting Score is greater than the discriminating power of each of them individually. This method has been fully described elsewhere.[12]

Consider, as an example, five bullets fired from the same firearm. They were acquired and then analyzed using the RBL Method. For this set of five bullets, there are 10 possible known match pair combinations. **Figure 3** depicts an RBL Graph that could be generated after these 10 comparisons are conducted and analyzed.

Extending this example, let us say that there is an intact, relatively undamaged bullet from a crime scene that is to be compared against the five bullets test fired from the firearm with RBL Method results presented in Figure 3. There are two potential possibilities: the bullet was fired from that firearm or the bullet was not fired from that firearm. If it was fired from that firearm, then there should be five additional data points, from the comparison of that bullet with each of the five test-fired bullets, represented by blue dots, near the other data points in the upper right quadrant (see **Figure 4a**). If it was not fired from that firearm, then the five additional data points should be distanced from the group of known match data points, in the lower left of the RBL Graph representing low similarity scores (see **Figure 4b**).

Two things should be noted with respect to these hypothetical examples. The first is that the known matching data points can shift toward the lower left or nonmatching area when the bullets are not marked well. This is not a failing of the primary premise of firearm and toolmark identification, nor is it a failure of the technology. Some bullets are simply not well marked, and the RBL Method's results are consistent with the observable similarity. Also, it must be kept in mind that the Quantum 3D Microscope was designed to **support** the examiner, **not replace** the examiner.

IBIS Correlation or RBL Method

The correlation used in IBIS technology is designed to perform a search of an acquired specimen with a large database of like specimens. The purpose is to identify other specimens that may have a common source and bring those to the attention of the technician in the form of a list. In order to accomplish this rapidly and reliably, the algorithms must have wide search parameters.

In contrast, the Quantum 3D Microscope's RBL Method compares two specimens directly in more detail with no constraints on computing time, to provide objective and statistically meaningful results to support the examiner's conclusion, whether those specimens share a common source, have a different source, or if the results are inconclusive.

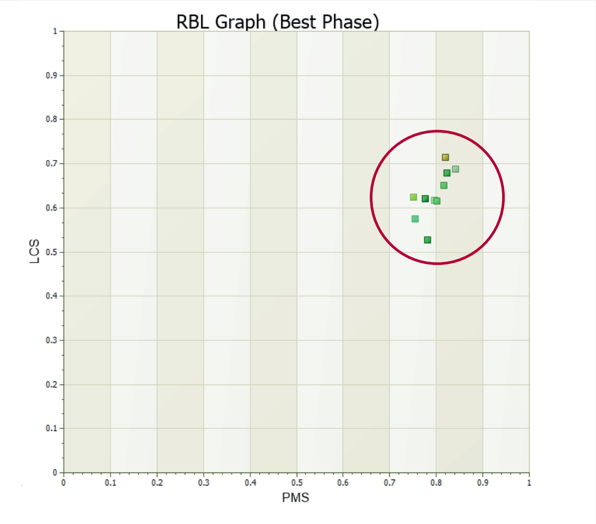

Figure 3 › RBL Graph with 10 known match pairs[13]

In Figure 3, the 10 data points within the red circle are the scores for the known matches. As can be observed, they are grouped together in the upper right which indicates consistency in the similarity of those test fires from the same firearm which marked well.

12 Roberge, D., Beauchamp, A., Levesque, S., 2019. Objective Identification of Bullets Based on 3D Pattern Matching and Line Counting Scores. International Journal of Pattern Recognition and Artificial Intelligence 33(11) DOI: 10.1142/S0218001419400214.

13 Results shown in RBL Graphs in this document are based on preliminary research data and may differ in the final product.

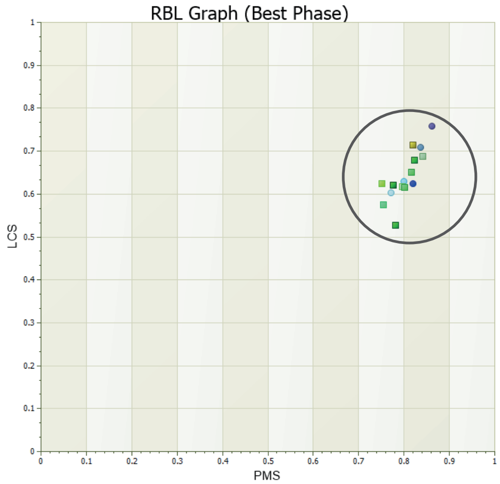

Figure 4a > RBL Graph of evidence matching test fires (blue dots)

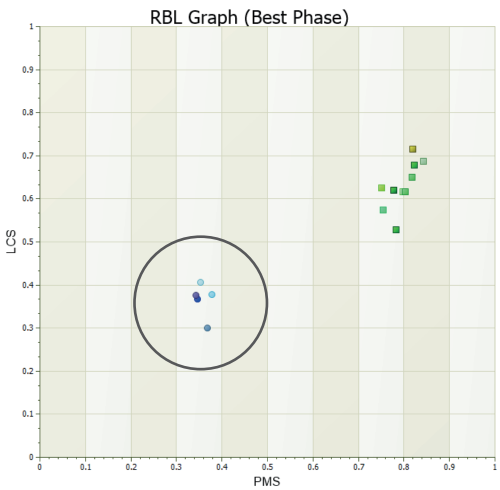

Figure 4b > RBL Graph of evidence not matching test fires (blue dots)

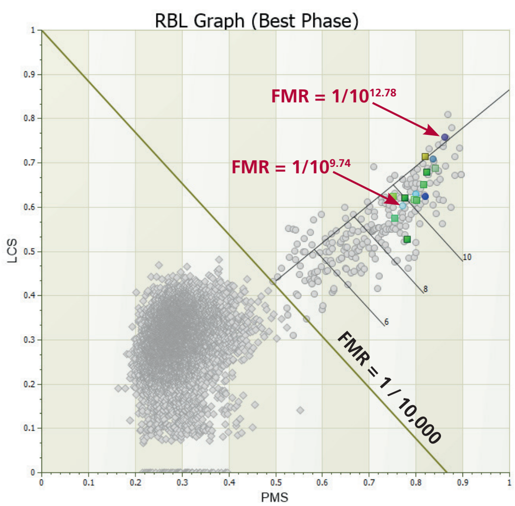

Figure 5 > RBL Graph with False Match Rate (FMR)

The second is related to the first. Even under ideal circumstances, bullets do not necessarily mark well on all land engraved areas. If all land engraved areas were included in the final score, it could artificially shift the scores toward the nonmatching score range when, in fact, there is sufficient correspondence on two land engraved areas to provide a common source determination. This situation gets more challenging when dealing with damaged bullets, a more frequent occurrence. For these reasons, it has been found that the RBL Method is optimized when the two best-scoring land engraved areas are used.

So, as can be easily observed with the RBL Method and the resulting graphs, the opinions of examiners can be supported using objective data. This is tremendously helpful for one of the two main concerns that the courts have had with firearm and toolmark identification—the reliability of the examiner. However, the graphs alone do not answer the concern about the lack of a statistical basis for the conclusion that two toolmarks share a common source. That answer lies within the data shown in the graphs.

When presenting a statistical basis, there are two general approaches: a likelihood ratio (LR) and a false match rate (FMR). The LR is frequently used but it can be challenging because while there can be a large amount of known nonmatch data available, the amount of known match data tends to be much smaller. For example, 100 known match pairs of bullets generate almost 20,000 nonmatch comparisons, but only 100 match comparisons. However, an FMR does not consider the known match comparisons and is calculated based only on the known nonmatch data (of which there is plenty). Provided that there is enough nonmatch data, it is possible to develop an FMR for that data. The Quantum 3D Microscope currently provides an FMR but could include an LR in the future. Examples of FMRs are shown in **Figure 5.**

Known visual matching pairs and known nonmatches are generally separated by a line corresponding to an FMR value of 1/10,000. While it appears that the FMR could be considered a decision criterion, distinguishing a common source from a different source, this is not the appropriate interpretation because it is possible that bullets fired from the same firearm could fall below that line. The FMR for a given similarity score represents the probability that two bullets that were not fired from the same firearm would generate a higher similarity score.

Enhancement of the Ability of Examiners to Process Evidence and Casework

The Quantum 3D Microscope enhances the ability of examiners to process evidence and casework in many ways. The first is the potential segregation of duties. The ease of data acquisition means that trained technicians can be responsible for acquisition so that examiners can focus on the comparative aspects of the work (which require greater levels of training and expertise). Even damaged bullets and fragments can be mounted and acquired with relative ease. Therefore, examiners are no longer spending a significant portion of their time mounting specimens and positioning lighting to optimize the marks to be observed. Instead, when the images are ready to be compared, they are sitting comfortably at a computer evaluating images on-screen instead of looking through an eyepiece which, even with the best, ergonomically designed comparison microscopes, can be tiring.

The second is that the Quantum 3D Microscope provides for enhanced comparative examination because the actual topography of the marks is measured and collected during acquisition. This is unlike conventional comparison microscopy where that topography is perceived using and adjusting lighting to cast highlights and shadows. Therefore, there is a greater opportunity for the visualization and observation of marks that would have otherwise been a challenge when using conventional comparison microscopy.

Finally, in those instances in which it would be necessary to physically transfer evidence to another site for verification and technical review, Quantum could be used to electronically "ship" the measured data in lieu of the evidence. As previously mentioned, examiners in satellite laboratories could have their work verified by colleagues in their laboratory system without having to ship the evidence. In the event that an investigator requests a comparison of bullets be conducted with bullets recovered from another jurisdiction, it is possible that rather than shipping the evidence, the images could simply be shared electronically. In both these instances, there are tremendous time savings that enable examiners to provide quicker results to their colleagues and clients.

Reinforcement of the Primary Premise of Firearm and Toolmark Identification Through Community-Wide Validation

There is a wealth of machine-based data that supports the basic premise that different tools produce different toolmarks. Using the Quantum 3D Microscope, that premise can be reinforced continually, and not just by a single researcher. 3D microscopy can be used to capture and share data globally. The RBL Method visually demonstrates quantifiable differences between matching and nonmatching conditions. This data sharing allows for on-going, community-wide validation of the basic premise of firearm and toolmark identification using standardized processes and procedures, much like crowdsourcing does for software.

As mentioned earlier, 100 known match pairs of bullets can give rise to almost 20,000 known nonmatching comparisons upon which the FMR is based. Provided that examiners are using standard methods and protocols for acquiring the data, it is easy to conceive that 50 laboratories, providing 20 pairs of bullets each, could result in a dataset of 1,000 known match pairs, in turn resulting in nearly 2,000,000 data points.

Furthermore, because the Quantum 3D Microscope is not tied into a ballistic database, there is nothing preventing examiners from exploring its use for other toolmarks. It can be used to acquire toolmarks on the surfaces of other small objects, like those on the sides of pills for those laboratories investigating illicit pill manufacture. It can also be used to acquire firearm chamber marks on the sides of cartridge cases, but the acquisition might have to be more customized. For example, several bands, full or partial, of the cartridge case may have to be acquired to capture the relevant chamber marks.

Standardized Remote Training, and Competency and Proficiency Testing

One of the ancillary concerns mentioned was the lack of standardization of toolmark samples, including those on bullets and cartridge cases, that individuals are provided to develop their comparative analysis skills and to test their application of those same skills. Generally, when preparing toolmark samples, trainers have been restricted to what was available in their own laboratories. This has resulted in a discipline-wide lack of uniformity with respect to samples designed to build arguably the examiner's most important skill.

Having a centralized, uniform training base of samples from which to pull a training set would be especially useful for trainers. They would be able to provide trainees with examples of certain conditions, such as sub-class characteristics, for which they do not have samples because such occurrences can be rare. They could have access to toolmarks for which they do not have samples. Furthermore, such standardized training would help to bring more uniformity to the identification criterion examiners develop as a result of their training.

As effective as current proficiency testing is for the discipline, because the samples are not uniform, if an examiner reaches a conclusion that is outside the specifications of the test, it is unknown if the result is due to an examiner issue or to an issue with the samples that the examiner was provided. A training base from which uniform samples could be drawn for competency and proficiency tests would help to alleviate this concern.

This would aid in laboratory directors and quality control managers being able to better understand how their trainees and examiners are performing relative to others in the discipline.

LIMS Integration and Data Management Issues

The fact that the Quantum 3D Microscope is **not** integrated with any other system allows for an easy file-based management. What this means is that the workspace files (acquisitions, comparison viewer screenshots, RBL results, notes, etc.) will be handled by the users at the file level. Examiners and laboratories will be able to handle this data in whatever way they desire. This includes importation into existing LIMS, sharing with others, and protecting and encrypting pursuant to established quality guidelines at their individual laboratories.

Summary

Several concerns and problems were highlighted with respect to the current practice of firearm and toolmark examiners. Two of them, examiner reliability and a lack of a firm statistical foundation for examiners making a common source determination, are the primary concerns that the courts have with respect to the testimony of firearm and toolmark examiners. There are other ancillary concerns that the discipline has faced, including those related to standardized training and competency testing, the black box process of examiners, the verification of on-going proficiency of examiners, and on-going research. The Quantum 3D Microscope offers the most complete package to date—a solution that provides the ability to not only acquire, compare, and analyze toolmark data from small specimens such as bullets, but also provides false match rate probabilities for bullets.

Even with the great technological leap forward offered with the Quantum 3D Microscope, there is more to be accomplished. As discussed earlier, some of that can be accomplished by the community-at-large, providing and sharing data that will help strengthen the objectivity of the discipline. In addition, standardized remote training will be made possible. This will not only create repeatable and reproducible training, but it will allow for the maximization of training opportunities for new examiners while reducing on-going training costs as well.

Future Advancements

The technological innovation found in the Quantum 3D Microscope can also be similarly applied to impressed toolmarks on surfaces such as cartridge case heads and other objects with flat surfaces. Such surfaces include pipe fragments from improvised explosive devices along with wires and plastic-encased connectors used in electrical components of such devices. They also include casts showing pry marks from chisels, screwdrivers, and pry bars at the scenes of various crimes.

Given the success of IBIS® BRASSTRAX™ and now the Quantum 3D Microscope, a 3D microscopy solution is being developed for cartridge cases to include breech face marks, firing pin impressions, and ejector marks. This same solution will be adapted for use with other toolmarks, much like the first Quantum 3D Microscope model, specialized for bullets, can be adapted for use with striated toolmarks on other small objects.

The RBL Method will continue to be refined to optimize its utility in providing the best, most objective statistical foundation to support to the conclusions of firearm and toolmark examiners.

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