The Response of the Association of Firearm and Tool Mark Examiners to the National Academy of Sciences 2008 Report Assessing the Feasibility, Accuracy, and Technical Capability of a National Ballistics Database[1] August 20, 2008

By AFTE Committee for the Advancement of the Science of Firearm & Toolmark Identification

Keywords: AFTE response to the 2008 NAS report; Daubert; NAS Report; National Research Council (NRC); National Academy of Science

ABSTRACT

This response was written mainly to comment on three conclusions made in a March 2008 report issued by a National Academy of Sciences Committee whose main function was to study ballistics imaging technology. These conclusions addressed: 1) whether or not the validity of the fundamental assumptions of the uniqueness and reproducibility of firearms related toolmarks has been demonstrated; 2) whether additional general research on the uniqueness and reproducibility of firearm related toolmarks should be done; and 3) whether conclusions drawn in firearms identifications should be stated to imply the presence of a firm statistical basis. With regard to: conclusion 1; AFTE feels that the fundamental assumptions of the uniqueness and reproducibility of firearms related toolmarks has been demonstrated: conclusion 2; AFTE feels that while continuing research and empirical testing is a fundamental part of any scientific forensic discipline, sufficient basis currently exists to warrant conclusions of toolmark identification; and conclusion 3; while AFTE agrees with the conclusion that absolute statements of toolmark identification, "to the total exclusion of all other tools" is unwarranted, the implication that there is no statistical basis for toolmark identification is also unwarranted.

Introduction

The discipline of firearm and toolmark identification has recently come under increased scrutiny as a result of the report published by the National Academy of Science Committee to Assess the Feasibility, Accuracy, and Technical Capability of a National Ballistics Database. While there is much in the report that is accurate and with which practitioners within the discipline agree, there are concerns raised by this Committee that appear without basis and indeed have been addressed and answered on a number of occasions[2] by well-respected practitioners within the field of firearm and toolmark identification in response to other critics of the discipline.

The purpose of this position statement is to examine those concerns expressed by the Committee and to identify and clarify how the discipline has already addressed those concerns. In doing so, the following will be presented:

•Background information to which this statement is directed

•A review of the charge and constitution of the NRC Committee Panel responsible for the NRC report of March 2008

•The qualifications and role of the Association of Firearm and Tool Mark Examiners (AFTE) for the purpose of responding to certain conclusions in the NRC/NAS report of March 2008

Date Received: September 5, 2007
Peer Review Completed: September 17, 2007

[1] The Committee for the Advancement of the Science of Firearm and Tool Mark Identification. Committee members include: John Murdock (Chair), Andy Smith, Brandon Giroux, Lucien Haag, James Hamby, Ph.D., and Pete Striupaitis.

[2] Most currently by Ronald Nichols in: "Firearm and Tool Mark Identification: The Scientific Reliability and Validity of the AFTE Theory of Identification Discussed Within the Framework of a Study of Ten Consecutively Manufactured Extractors." *AFTE Journal*, Vol. 36, No. 1, Winter 2004, pp. 67-88; "The Scientific Foundations of Firearms and Tool Mark Identification – A Response to Recent Challenges," *CACNews*, 2nd Quarter 2006, 8-27; and "Defending the Scientific Foundations of the Firearms and Tool Mark Identification Discipline: Responding to Recent Challenges." *Journal of Forensic Sciences* 52(3), May 2007, 586-594.

•A basic review of firearm and tool mark identification to include the critical and fundamental issues of toolmark uniqueness and interpretation

•AFTE's response to specific issues and concerns raised in the NRC/NAS report of March 2008

•Concluding remarks

Background Information

The National Research Council (NRC), working under the National Academy of Sciences (NAS) on a project sponsored by the National Institute of Justice (NIJ) undertook a lengthy study of the current ballistic imaging technology commonly known as IBIS and NIBIN as it might apply to a proposed national database of computerized images of bullets and/or cartridge cases from all new firearms sold in the United States. This mission is embodied in the NRC committee's title- *The Committee to Assess the Feasibility, Accuracy, and Technical Capability of a National Ballistics Database.* The efforts of this committee covered the period from 2004 to the issuance of their report in March of 2008[3] . The ultimate conclusion of this committee was given in a single sentence on page 4 of the Executive Summary- *"A national reference ballistic image database of all new and imported guns is not advisable at this time."* The Association of Firearm and Tool Mark Examiners (AFTE) has no quarrel with this conclusion as it appears to be the end result of careful consideration. At the same time, it is quite apparent the NRC committee felt strongly about wanting to be understood as *having not gone on record against* the use of forensic firearm identification as a legitimate forensic science discipline based on the following quotations from the report:

"…this study is neither a verdict on the uniqueness of firearm related toolmarks generally nor an assessment of the validity of firearms identification as a discipline" (Chapter 1, p. 5).

"…some readers may attempt to infer from this review a stance by this committee, for or against the validity of firearms identification generally. From this perspective some may argue that our narrow focus on the uniqueness of ballistic images amounts to missing the proverbial elephant standing in the room: that is, we should extend any conclusion on the strength or weakness of ballistic image evidence to infer the strength or weakness of ballistic toolmark evidence more globally. We reiterate that no such conclusion is intended by this report" (Chapter 1, pp. 5 – 6).

"The proposal for this study explicitly precluded the committee from assessing the admissibility of forensic firearms evidence in court" (Chapter 1, p. 6).

"We do not in any way offer a determination of whether ballistics evidence should or should not be admissible in court proceedings" (Chapter 1, p. 7).

In spite of their repeated statements to the contrary and their acknowledged limitations, the NRC/NAS Committee drew three conclusions regarding traditional forensic firearm identification issues. AFTE is not in agreement with the first of these statements because it does not appear to be the result of careful consideration or any in-depth search of the available literature. With the second statement, AFTE is in only partial agreement, and with the third, AFTE is in agreement.

NRC Conclusion #1:
"Underlying the specific tasks which the committee was charged is the question of whether firearms-related toolmarks are unique: that is, whether a particular set of toolmarks can be shown to come from one weapon to the exclusion of all others. Very early in its work the committee found this question cannot now be definitively answered" (Executive Summary, p. 3 and Chapter 3, p. 22).

NRC Conclusion #2:
"Additional general research on the uniqueness and reproducibility of firearm related toolmarks would have to be done if the basic premises of firearms identification are to be put on a more solid scientific footing (Chapter 3, p. 23).

NRC Conclusion #3:
"Conclusions drawn in firearms identification should not be made to imply the presence of firm statistical basis when none has been demonstrated. (Chapter 3, p. 23).

---

[3] Suggested citation: National Research Council. (2008). *Ballistic Imaging*. Committee to Assess the Feasibility, Accuracy, and Technical Capability of a National Ballistics Database, Daniel Cork; John E. Rolph; Eugene S. Meieran; and Carol V. Petrie, eds. Committee on Law and Justice and Committee on National Statistics, Division of Behavioral and Social Sciences and Education; National Materials Advisory Board, Division of Engineering and Physical Sciences. Washington, DC: The National Academies Press. Additional copies of this report are available from The National Academies Press, 500 Fifth Street, NW, Lockbox 285, Washington, DC 2005; (800) 624-3313 (in the Washington metropolitan area); Internet. http//www.na.edu

The Purpose and Constitution of the NRC Committee Panel

To begin, it is important to understand the charge made to the Committee as well as the manner in which the Committee was constructed to meet the needs of the charge. In the Executive Summary, the report reads:

…the panel's charge is to:

(1) Assess the technical feasibility, through analysis of the uniqueness of ballistic images, the ability of imaging systems to capture unique characteristics and to parameterize them, the algorithmic and computational challenges of an imaging database, the reproducibility of ballistic impressions and the ability of imaging systems to extract reproducible information from ballistics impressions.

(2) Assess the statistical probabilities that ballistics evidence presented would lead to a match with images captured in a database, whether and how the base rate can be estimated for those crimes that present bullet or casing evidence that do in fact come from a gun that produced a database entry, and the probabilities and consequences of false positives and false negatives.

(3) Assess the operational utility of ballistics evidence in criminal investigations – that is the extent to which it is used or can be used to identify crime guns and suspects and to solve specific crimes.

(4) Assess the sources of error in ballistic database matching (from examination, digitization, computer matching, chain of custody, documentation of tests, and expert confirmation), how they may be quantified, and how these errors interact (Executive Summary, p. 2).

In the Committee's own words, the task was focused on the issue of "ballistic images" and related ancillary issues. Immediately it is important to understand that the issue of ballistic images and the evidence with which a qualified firearm and toolmark examiner works and on which he or she bases opinions are not the same thing. At best, ballistic images represent a second generation of the actual evidence. Indeed, that is the reason for the existence of the NRC/NAS Committee – to determine whether or not this second generation of ballistic images is suitable for the intended task – as a nationwide search program to identify potential links between shootings.

As important as understanding what the Committee was supposed to do, it is also important to understand what the Committee itself recognized as limitations, specifically, "What the Committee Study Does Not Do." Though they comment on the issue of toolmark uniqueness, at the very outset they state that it was not part of the charge *nor considered as an issue* when seeking to construct the Committee. Specifically,

"First, and most significantly, *this study is neither a verdict on the uniqueness of firearm-related toolmarks generally nor an assessment of the validity of firearms identification as a discipline…*The uniqueness of firearm-related toolmarks is a much broader question – and a very important one – but it is not one that our committee was **constituted** [emphasis added] to address" (Chapter 1, p. 5),

In the Preface of the report, the Committee identified the decision not to include an active firearm and toolmark examiner on the committee. AFTE Past-President Ann Davis approached the NAS Committee in February of 2004 offering the assistance of nine (9) qualified scientists in the discipline of firearm and toolmark identification to assist the committee as subject matter experts[4]. To date, this *ad hoc* committee formed by Past-President Davis was never approached for technical assistance or to facilitate the understanding of the multi-faceted factors that influence and affect the discipline of firearm and toolmark identification. They do indicate they had the counsel of AFTE member Lawden Yates though they do not describe the extent to which he was consulted. They also indicate contacting examiners for the purpose of discussing micro-stamping but, apparently, none of the more seminal issues of the discipline. Finally, they identified two recognized forensic scientist practitioners in the review of the final report, only one of which is a firearms examiner.

For the purpose of the charge, "to focus on 'the uniqueness of ballistics images' – that is, on the uniqueness and reproducibility of the markings (toolmarks) left on cartridge cases and bullets as they are recorded or measured by various technologies (e.g., photography or surface metrology)" (Chapter 1, p. 5) it appears that the manner in which the NRC committee was constituted was arguably appropriate. For the purpose of discussing toolmark uniqueness and the evolution of close to one hundred years worth of research and study into the foundations of firearm and toolmark identification and the uniqueness of toolmarks, it appears that the committee was neither well constituted nor gave sufficient consideration to practitioners within the field.

[4] Ms. Davis formed the NAS Advisory Committee of technical experts and provided all contact information to Daniel Cork and Carol Petri after Ms. Davis' first address to the NAS Feasibility Committee.

This concern is only heightened when the Committee itself asserted, "it is possible to speak meaningfully about ballistic image database performance without first fully accepting or concluding the fundamental uniqueness of toolmarks" (Chapter 1, p. 6). This heightens the concern because without a need to accept the "fundamental uniqueness of toolmarks," there is also not a need to investigate it as fully as would otherwise be the case.

Simply put, for the purposes for which it was charged, the Committee appears to have been constituted well enough. When it extended beyond that charge to comment on the issue of toolmark uniqueness, the Committee was neither constituted appropriately enough nor did it have the necessary resources or motivation to investigate that issue to the depth necessary to adequately comment on it. That is the context within which the concerns expressed by the NRC/NAS Committee have been made. Answering these concerns will necessitate introductory statements demonstrating first AFTE's qualifications to respond and second, a basic introduction into firearm and toolmark identification.

AFTE as the Relevant Community to Respond to Certain NRC Conclusions

In 1969 a dedicated group of forensic scientists came together for the first time to form the Association of Firearm and Tool Mark Examiners – a professional organization now most commonly known by its acronym AFTE. At its inception, its membership was essentially, if not exclusively, composed of examiners employed in municipal, state and federal crime laboratories in the United States. Presently its membership is international and includes members in Canada, the United Kingdom (England, Northern Ireland and Scotland), France, Belgium, Germany, the Netherlands, Finland, Denmark, Norway, Greece, Italy, Israel, Saudi Arabia, the United Arab Emirates, South Africa, Australia, New Zealand, the Philippines and Japan. In addition, many private examiners are currently represented among AFTE's membership of approximately 920 individuals. These private examiners are available to criminal defense attorneys who wish to have the findings of any government laboratory re-evaluated. AFTE members specialize in the study and examination of the various markings produced by firearms and other tools on the objects with which they come in contact. In the case of firearms, these are bullets and cartridge cases.

The founders of AFTE recognized the need for the exchange of information and methods, the development of standards, and the furtherance of research in this specialized area of forensic science. This has always been particularly true in the case of firearms as new products and new manufacturing methods frequently appear. Over the last 39 years, AFTE has accomplished these purposes through conducting and sponsoring annual training seminars involving the theory and practice of firearm and toolmark examination and identification, by fostering the exchange of information between crime laboratories for the improvement, standardization and documentation of firearm and toolmark identification and evidence examination techniques. These same goals have also been sought through publication of a peer-reviewed quarterly journal, the *AFTE Journal*. AFTE has adopted a comprehensive ethics code and enforcement procedure and has published a Training Manual, a Procedures Manual and a Glossary of terms and definitions associated with this specialized area of forensic science and adopted the AFTE Standardization for Comparison Documentation[5] and the Theory of Identification (first adopted in 1992) as it pertains to the comparison of toolmarks to include those on fired bullets. The cumulative result and ultimate objective of these measures is to provide the criminal justice system with the most reliable and well documented findings regarding such frequent questions as the nature and operability of a firearm and the relationship, if any, between fired ammunition components and a particular firearm. This latter aspect of a forensic firearms examiner's work is commonly referred to as *firearms identification.*

The principles and techniques utilized in forensic firearms identification have been used internationally for nearly a century by the relevant forensic science community to both identify and exclude specific firearms as the source of fired bullets and cartridge cases. It should be remembered that the inception of crime laboratories in the United States began with firearms identification as a result of the efforts of Calvin Goddard (the father of firearms identification in the United States) and his work in the 1929 St. Valentines Day Massacre in Chicago. A number of textbooks have been written on the subject of firearms identification with dates of publication extending back to the 1930's. Moreover, numerous studies of both a statistical nature and a practical nature have been conducted over the years that support the proposition that a properly trained and experienced forensic firearms examiner can correctly associate a fired bullet or cartridge case with the specific firearm that discharged it.

From the foregoing it should be clear that the Association of Firearm and Tool Mark Examiners is the relevant and most

[5] First adopted by the voting membership in May, 2004 and revised by the voting membership in June, 2005, AFTE Journal, 38(1), Winter 2006, pp. 72-73.

knowledgeable community to address and comment upon the statements in the NRC/NAS Ballistic Imaging Report.

Firearm and Toolmark Identification

Forensic firearm identification has been a forensic science discipline in the United States since the 1930's. Firearms identification is a subset of the broader forensic science discipline known as toolmark identification. Toolmark examiners are trained to examine the marks left by tools on any variety of surfaces in an attempt to associate a toolmark to a particular tool that produced the mark. Firearms are simply a subset of tools that impart marks on bullets and cartridge cases. The approach to examining toolmarks of any and all types is the same whether the toolmarks were generated by a screwdriver tip, a pry bar or the bore or breechface of a firearm.
Firearm and toolmark identification is based upon two propositions:

Proposition #1:

Toolmarks imparted to objects by different tools (known non-matches) will rarely if ever display agreement sufficient to lead a qualified examiner to conclude the objects were marked by the same tool. That is, a qualified examiner will rarely if ever commit a false positive error (misidentification).

Proposition #2:

Most manufacturing processes involve the transfer of rapidly changing or random marks onto work pieces such as barrel bores, breech faces, firing pins, screwdriver blades, and the working surfaces of other common tools. This is caused principally by the phenomena of tool wear and chip formation or by electrical/chemical erosion. Microscopic marks on tools may then continue to change over time from further wear, corrosion, normal use or abuse.

Examiners are trained to recognize three types of markings, known also as "characteristics," which are often imparted onto bullets and cartridge cases: (1) class characteristics; (2) subclass characteristics; and (3) individual characteristics.

• Class characteristics are predetermined during the manufacturing process. As they relate to fired bullets and firearms, they include such features as caliber, number of lands and grooves, the widths of the lands and grooves and the direction of twist of the rifling. For a fired cartridge case, class characteristics are typically limited to the firing pin impression on the primer, which can appear in various shapes, including circular, rectangular, hemispherical, and elliptical. The general type of machining process used to form the breechface or breech block may be thought of as a class characteristic, e.g., vertically parallel finishing marks, circular cutter marks, etc. Class characteristics may also include the location and spatial orientation of an extractor and ejector particularly in the case of semi-automatic firearms.

• Individual characteristics consist of microscopic, random imperfections along the length of the bore of a firearm created by the manufacturing process, wear, corrosion, erosion, normal use over time and/or abuse. For firearm barrels, these unintended characteristics are initially caused by changes in the tool as the bore of each barrel is produced on the production line. They typically undergo slow modification and change with the passage of time and repeated use of the firearm.

• Subclass characteristics occupy a position between class and individual characteristics. These characteristics can exist within a particular production run in the manufacturing process and occasionally arise from: (1) imperfections in a machine tool that persist during the production of multiple firearm components; (2) extreme hardness differences between the machine tool and the work pieces; or (3) particular manufacturing processes such as casting or molding. Qualified examiners are trained to distinguish subclass characteristics from individual characteristics, because identifications cannot be made from subclass characteristics. However, they may be useful in placing a discharged bullet or cartridge case in a limited source subset.

As stated previously, the contacting surfaces of a firearm will change over time from wear and thus leave different marks on bullets and cartridge cases discharged at some later time and usually after considerable use. As microscopic similarities diminish, the likelihood of an inconclusive result increases when comparing bullets or cartridge cases but the likelihood of a false positive remains unchanged.

A number of studies have been performed that have supported the concept that toolmarks are indeed unique and can serve as a means by which the responsible tool can be identified. Many of these studies were performed with tools that were manufactured in consecutive sequence. Consecutively manufactured tools demonstrate the most rigorous challenge to the theory that tool surfaces will leave unique toolmarks because it is expected that two tools that are consecutively manufactured will exhibit the greatest amount of subclass correspondence. These studies have demonstrated that even under these rigorous conditions, tools may leave unique toolmarks.

There is the potential for subclass characteristics, especially

in consecutively manufactured tools. However, studies have demonstrated that 1) they are not the norm and 2) the presence of subclass markings is predictable based on knowledge of manufacturing methods and how tools interact with substrates. Therefore, examiners are trained to evaluate which of the manufacturing methods may leave subclass characteristics, how to evaluate tool working surfaces for their presence, to consider the designed working action of the tool and to properly interpret unknown toolmarks in light of the potential for the presence of subclass characteristics. With this knowledge and training, qualified examiners are able to recognize the potential of subclass characteristics, identify them when present, and be conservative when interpreting correspondence when subclass characteristics are present.

Since the inception of firearm and toolmark identification as a forensic discipline, firearm examiners have been using a method known as "pattern matching" to determine whether sufficient similarity exists between firearm-generated toolmarks to warrant a conclusion that two bullets or two cartridge cases came from the same firearm. These "patterns" consist either of arrays or groups of consecutively matching striae in the case of striated toolmarks, such as found on fired bullets, or corresponding (matching) impression toolmarks, such as those found in a firing pin impression on a fired cartridge case.

Currently the final step in the individualization/identification process is subjective in nature but is founded on scientific principles and based on the examiner's training and experience. This final process is preceded by a number of objective measurements/observations that greatly narrow the possible source firearms. These objective measures include caliber determination, the land and groove count, the widths of the lands and grooves, the shape of the firing pin, the general type of finish on the breechface and the spatial relationship between the extractor and ejector in semi-automatic firearms.

In 1992, the Association of Firearms and Tool Mark Examiners (AFTE) memorialized the Theory of Identification in order to explain the basis of opinions of common origin in toolmark comparisons:

1. The Theory of Identification as it pertains to the comparison of toolmarks enables opinions of common origin to be made when the unique surface contours of two toolmarks are in "sufficient agreement."

2. This "sufficient agreement" is related to the significant duplication of random toolmarks as evidenced by a pattern or combination of patterns of surface contours. Significance is determined by the comparative examination of two or more sets of surface contour patterns comprised of individual peaks, ridges and furrows. Specifically, the relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges and furrows within one set of surface contours are defined and compared to the corresponding features in the second set of surface contours. Agreement is significant when it exceeds the best agreement demonstrated between toolmarks known to have been produced by different tools and is consistent with agreement demonstrated by toolmarks known to have been produced by the same tool. The statement that "sufficient agreement" exists between two toolmarks means that the agreement 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. *(NOTE: Thus it can be clearly seen that the AFTE Theory of Identification calls for positive toolmark identifications in a practical sense, and not in an absolute sense. This will be critical in further discussion.)*

The AFTE Theory of Identification articulated traditional principles of pattern matching that have been broadly accepted within the forensic firearms community for decades. Today, traditional pattern matching is practiced by firearm and toolmark examiners in forensic laboratories throughout the world. These patterns can take the form of arrays or areas of reproducible striae caused by the dynamic action between the bullet and the bore of a firearm or a sliding or shearing motion between a firearm and a cartridge case. Alternatively, they may take the form of patterns or arrays of impressed marks in one or more areas on a fired cartridge case as a result of the impact of the firing pin and/or breechface due to the extremely high pressures reached during the firing process.

Firearm and toolmark identification involves some degree of subjectivity during the final phase of the examination protocol when the examiner evaluates the degree of correspondence in patterns between two toolmarks with similar class characteristics. This is neither fatal to the identification process nor unique to firearm and toolmark identification. At the most fundamental level it is somewhat analogous to the manner in which we recognize friends and relatives in everyday life. When we see a friend or relative amid a large crowd we are able to make an identification based upon patterns of features that match our memories. While none of us will ever view the face of every living individual in the world, we can easily agree that we would be confident that we have specifically identified our friend or relative. The firearms examiner learns to recognize the 'face of the submitted firearm' through the careful study of test-fired bullets or cartridge cases from that firearm. This 'face' takes the form of reproducible patterns or arrays of striae on fired bullets and any number of striated or impressed marks on fired cartridge cases. Once he or she is

satisfied that these patterns are reproducible and are comprised of individual characteristics, the examiner's attention is turned to the evidence specimen. This only occurs after the evidence specimen cannot be excluded on the basis of class characteristics. The trained eye of the firearms examiner is conditioned to recognize corresponding toolmarks on bullets and cartridge cases. The visual side-by-side comparison, made on the comparison microscope, of toolmarks is an objective process that precedes the final step: the subjective evaluation of the significance of the extent of agreement/disagreement objectively observed.

It should be noted that virtually all sciences involve some element of subjectivity. Even an analytical chemist comparing two matching infrared spectra of a standard (known) sample of a pure organic compound and an unknown compound will see small differences between one or more absorption bands in the two spectra. For those not familiar with analytical chemistry, an infrared spectrum is analogous to the molecular fingerprint of a specific compound. Examining and comparing infrared spectra of standard and unknown compounds is a long recognized method of identifying unknown compounds such as drugs, explosives, plastics or any other pure organic substance. These small differences between a standard spectrum and that of the previously unknown compound do not preclude or even detract from the correct identification of the unknown substance because the analytical chemist knows through his or her training and experience that small variations in absorption peak intensities or shapes do occur from sample to sample of the same material. Even with these small variations, spectral database libraries are commonly used to narrow an analysis to just a few potential candidate compounds. Indeed, if two spectra were ever found to match exactly and in every detail throughout the spectrograms, the viewer of such spectra would be correct to consider the results with caution or skepticism. Firearms identification is no different insofar as areas of dissimilarity are concerned. Areas on bullets or cartridge cases that do not take up firearm-generated markings well, or in a reproducible manner, will vary from bullet to bullet or cartridge case to cartridge case. It is through the examination and study of test fired specimens under the forensic comparison microscope that the trained and experienced examiner comes to know the 'face' or signature of the submitted firearm as expressed on bullets or cartridge cases. This acquired knowledge is then applied to the evidence specimen. In some cases, even without a firearm, it is possible to reach meaningful comparative conclusions with a series of fired bullets or cartridge cases. This is usually possible when these fired evidence specimens are marked in a very reproducible way.

Forensic odontology provides us with another example of subjectivity in action within a well-established scientific discipline. Forensic odontologists, through their training and experience, are able to specifically identify deceased individuals from dental records. This is not the same as bite mark analysis in which an examiner attempts to link a bite mark to teeth, but rather is the identification of deceased individuals from dental records as might occur in a scenario involving a burned or otherwise decomposed body. The varied shapes, sizes and orientations of an individual's teeth (as shown in archived dental x-ray records) are a part of the basis of the forensic odontologist's evaluation and are compared with x-ray films taken of a deceased individual. Perhaps more important in the identification process are the location and shapes of radio-opaque fillings. Our common sense tells most of us that these combined features cannot occur in another individual yet no statistical or numerical evaluation of these features is known or presently possible. When sufficient quantity and quality of characteristics are found, however, this lack of statistical or numerical evaluation does not preclude the trained and experienced forensic odontologist from establishing the unique identity *(to the exclusion of all other individuals in the world)* of the decedent who is often burned, disfigured and/or decomposed. Moreover, there often is no scale in the same plane as the images and the forensic odontologist is limited to an x-ray image of the teeth and any fillings, not the actual items themselves. Neither the courts nor the public question this acquired skill in pattern recognition and unarticulated probability.

Issues and Concerns Raised in the NRC/NAS Ballistic Imaging Report of March 2008

Earlier, the scope and constitution of the NRC/NAS Committee was discussed. It was shown that while arguably appropriate for the purpose with which they were charged, the constitution of the NRC/NAS Committee was not appropriate for their comments with regard to non-ballistic image related issues. Furthermore, it was shown that the motivation to investigate these seminal issues to the extent necessary to comment on them was not present. Several concerns regarding forensic firearms identification raised in the March 2008 NRC/NAS Report were clearly those of individuals lacking practical experience in this specialized area of forensic science. It is apparent that there was a lack of basic understanding regarding the principles and practices involved in examining firearms evidence and the numerous studies and research efforts that have been carried out over the last half-century.

Most, if not all of their concerns and criticisms have been answered in one recent article by AFTE member Ronald Nichols that appeared in the May 2007 issue of the *Journal of Forensic Science* entitled "Defending the Scientific

Foundations of the Firearms and Tool Mark Identification Discipline: Responding to Recent Challenges" (*J Forensic Sci,* 52(3), May 2007, pp. 586-594). This comprehensive publication includes 65 references. It should also be noted that this journal has a stringent and daunting peer review process. The pages that address the Theory of Identification are pages 586-588. The issue of the permanence of toolmarks can be found on page 588 and the matter of mathematical/ statistical validation of firearms (and non-firearm toolmark) identification can be found on pages 591-592. This article is available on line at www.blackwell-synergy.com or from the author at ronald.nichols@atf.gov.

Those who would preclude the testimony of a forensic firearms examiner often seize upon the subjective element associated with the final step in the identification process, recognized in the Theory of Identification. Nichols effectively addresses the objective-subjective issue on pages 589-590 of his previously cited 2007 article. He concludes that if the subjective component of the identification process were a problem, it would be exposed in our error rates. Yet, that is not the case based on the following evidence:

•Error rates in controlled studies: In the validation studies reported to date, the error rate (defined as the rate of identifications of a toolmark to the wrong tool) has not exceeded one percent and that was in a study of consecutively manufactured knives. The error rates, again, defined as the rate of identifications of a toolmark to the wrong tool, in validation studies involving firearms and firearms related evidence has not exceeded zero.

•Error rates inferred from proficiency testing[6]: Although having some recognized limitations, proficiency tests can provide to the end-user a good estimate of how often examiners, using accepted methods and controls, will make an error of identifying a toolmark to a tool other than the one which produced it. Based on more recent calculations and tests, the error rates are approximately 1% for firearms and approximately 1.3% for toolmarks.

It is recognized that the practice of forensic firearms identification is not and cannot be completely free from error. Infallibility is neither possible nor required in any sector of forensic science or the criminal justice system. But reasonable estimates of error rates *can* be and have been determined and they have been found to be quite low in the case of firearm and toolmark identification. Where errors do occur, it is usually due to the misapplication of the methodology or the competency of the examiner. It is difficult to claim that the science of firearms identification is flawed, unsound or unproven when it is the correct application of this very science by trained and experienced examiners that detects these infrequent errors.

NRC Conclusion #1:

This is the main conclusion in the NRC report that has caused the most consternation within the profession of firearm and toolmark examiners. It has also precipitated legal challenges to the admissibility of firearm and toolmark identification. The "finding" appears on page 3 of the *Executive Summary* and is presented here along with the two preceding sentences to put the finding in the proper context:

"Underlying the specific tasks which the committee was charged is the question of whether firearms related marks are unique: that is, whether a particular set of toolmarks can be shown to come *from one weapon to the exclusion of all others.* Very early in its work the committee found that this question cannot now be definitively answered"

"Finding:
The validity of the fundamental assumptions of uniqueness and the reproducibility of firearms related to marks has not yet been fully demonstrated."

This "finding" can be interpreted in two ways when the preceding two sentences are considered. One way is to include the conclusion, *"…. from one weapon to the exclusion of all others"* as an integral part and prerequisite to the "finding". Considered in this way, the finding is not unreasonable. More is said about this in the response to NRC Conclusions #3.

---

[6] Thompson, in reviewing the CTS reports after the Peterson and Markham study (Peterson, Markham P. "Crime Laboratory Testing Results, 1978-1991, II: Resolving Questions of Common Origin *J Forensic Sci* 1995;40(6):1009-29), derived the false identification percentage in the same manner as the Peterson and Markham data; the number of false identifications compared to all of the comparisons reported by the responded laboratories. For the years 1978 to 2002 the false identification rate for the firearm proficiency tests is 1.0 %, and for the years 1981 to 2002 the false identification rate for the toolmark proficiency tests is 1.3% (toolmark proficiency tests started in 1981). Grzybowski, R.; Miller, J.; Moran, B.; Murdock, J.; Nichols, R.; Thompson, R. "Firearm/ Toolmark Identification: Passing the Reliability Test Under Federal and State Evidentiary Standards." *AFTE Journal*, 35(2), Spring 2003, pp. 209 – 241. The CTS data for 2003 to 2007 has not been summarized but the data for each of these years is available on the CTS website.

If, however, this "finding" is considered without the *"…..to the exclusion of all others*[7,8]*"* phrase, it clearly misrepresents years of empirical research summarized by Nichols. This research has conclusively shown that sufficient individuality is often present on tool (firearm tools or non-firearm tools) working surfaces to permit a trained examiner to conclude that a toolmark was made by a certain tool and that there is no credible possibility that it was made by any other tool working surface. Toolmark identifications are made to a practical certainty, not to an absolute certainty. Dr. John Thornton, quoted extensively in the NRC/NAS report, makes these observations about absolute certainty: "… absolute certainty is not a goal that is or can be achieved anywhere in the forensic sciences, or just about anywhere else for that matter. If the expectation is absolute certainty, we will all be forever disappointed. With DNA, we say that a particular suite of alleles could be expected at a rate of one in a squillion; we don't say that there is no possibility whatsoever of a chance replication, i.e., that the denominator is infinity[9]" . In the context of a scientific conclusion, practical certainty occurs when an examiner can affirm all of the following necessary conditions:

1) He or she believes the conclusion to be true and accurate;

2) He or she has rational grounds for believing the conclusion is true and accurate; and

3) He or she acknowledges that, in the abstract, it is not possible to achieve absolute certainty for results flowing from a scientific theory or technique.

NRC Conclusion #2:

"Additional general research on the uniqueness and reproducibility of firearm related toolmarks would have to be done if the basic premises of firearms identification are to be put on a more solid scientific footing." (Chapter 3, p. 23)

In general, we agree with this conclusion. A true science is characterized by continuing research efforts. In the case of firearm and toolmark identification, these efforts over the past 100 or so years have centered on the individuality and permanence of toolmarks, and on the criteria for the identification of both striated and impressed toolmarks. These research efforts have been summarized by Nichols in his part 1 and 2 papers already cited, as well in his 2007 *JFS* paper. Indeed the AFTE Theory of Identification[10] is just that, a theory. Theories are by definition subjected to continual testing and AFTE members take this responsibility seriously, as evidenced by basic research articles that continue to appear not only in the *AFTE Journal* but other peer-reviewed journals including the aforementioned *Journal of Forensic Sciences*.

The potential volatility or lack of permanence of toolmarks imparted to bullets also seemed to be of concern to the NRC Ballistic Imaging Committee. That the internal surfaces of a gun barrel can change with time and usage is well known to forensic firearms examiners. If the bore of a gun used in a crime were to change between the time of the incident and the submission of the firearm to the laboratory, no "match" is going to be found. The caliber and general rifling characteristics would still be in agreement but the individual characteristics are not likely to show sufficient agreement in quality and quantity to allow the examiner to conclude that he or she was in possession of the responsible gun. Such a situation would lead to an inconclusive finding, e.g., t*he submitted firearm could neither be excluded nor identified as having fired the evidence bullet.* With the exception of deliberate tampering or modification, multiple studies have shown that these changes are gradual, requiring hundreds to thousands of cartridges to be fired before such changes become problematic and preclude an association between an earlier fired bullet or cartridge case and one or more test fired specimens.

Studies in this area have included highly deleterious conditions and firing a number of shots that would be considered excessive except under the most exceptional of circumstances. In those studies involving lead bullets, the reproducibility reduced after a number of shots because of the lead build-up in the barrel. This is not unexpected and has been a known phenomenon to the discipline for decades. However, in those instances in which jacketed bullets or cartridge cases are examined, there has been very good reproducibility of various firearm markings to support an identification even when the fired specimens are thousands apart in sequence.

In summary, tool surfaces will change. With that, the following need to be considered:

- More individual characteristics will develop

---

[7] Nichols R., Firearm and Toolmark Identification Criteria: a Review of the Literature. *J Forensic Sci* 1997; 42(3):466-74.
[8] Nichols R., Firearm and Toolmark Identification Criteria: a Review of the Literature- Part 2. *J Forensic Sci* 2003; 48(2):318-27.
[9] Personal communication with John Murdock, July 15, 2008
[10] *Theory of Identification, Range of Striae Comparison Reports and Modified Glossary Definitions –An AFTE Criteria for Identification Committee Report*, AFTE Journal 1992; 24(3):337

• The change is not rapid enough to de-value identification discipline

• The change is not significant enough to prevent an examiner's ability to make identifications

• The worse case scenario would be that an examiner would not be able to achieve an association

The NRC report also states (Chapter 3, p. 23) that "… it could be useful to study the level of agreement of marks generated by the whole system of parts that make up the firearm, rather than treating each mark type in isolation." AFTE asserts that this would not be useful. A firearm is made up of many parts/ tools that may contact a cartridge case or bullet. Each of these tools has its own working surface which must be evaluated individually for subclass and/or individual detail. Each of these tools must be considered individually, not collectively, as a group or system.

NRC Conclusion #3:

"Conclusions drawn in firearms identification should not be made to imply the presence of firm statistical basis when none has been demonstrated" (Chapter 3, p. 23).

While AFTE agrees with this conclusion, the implication that there is no statistical basis for toolmark identification is unwarranted. The study by Biasotti in 1959[11] was a statistical study relating to striated markings on fired bullets produced by the firearm that discharged them. This seminal study was the genesis for what is now known as the consecutive matching striation (CMS) approach to striated toolmark identification. Other studies employing CMS theory have followed to include at least one carried out by a statistician, Dr. David Howitt of the University of California at Davis and presented at the 2007 AFTE Seminar in San Francisco[12]. The CMS method allows for statistical treatments of data and statistical statements to be made regarding striated toolmarks. It is not a substitute for the traditional approach of pattern recognition and matching used by most examiners but is simply a way of: 1) defining the extent of agreement of an array or pattern of striae on a bullet (or any other toolmark comparison) and; 2) provides empirically based support for the conclusions reached by the examiner. This method is not in conflict with the traditional method of pattern matching and, in fact, can be applied to previously located areas of agreement (matching patterns of striae) as a supplemental test or method. The criteria for the identification of impressed toolmarks have recently received the attention of Stone[13] and Collins[14]. Both authors have made significant inroads into quantitatively defining this criterion.

Concluding Remarks:

The NRC/NAS Committee Panel provided a valuable service with regard to their investigation and recommendations of ballistic imaging for the purposes of a national database. Many of their observations and conclusions in this regard appear to be well thought out and not something with which practicing firearm and toolmark examiners would have quarrel. At the same time, the Committee made some comments and statements that they themselves viewed as more tangential to their primary charge and investigation with which the relevant scientific community has strong concerns. These comments were with regard to the uniqueness of toolmarks, the reproducibility of toolmarks and the subjectivity of the interpretation of toolmarks. These issues are fundamental for the firearm and toolmark discipline and as such have been studied since the seminal years of the discipline. They have been the subject of extensive research and development with significant scientific publication dating back nearly a century.

The NRC/NAS statements have helped to show that while very well qualified for the task with which it was charged, the committee lacked the expertise and information necessary for the in-depth study that would be required to offer substantive statements with regard to these fundamental issues of firearm and toolmark identification. The committee itself recognized these limitations. Furthermore, the committee itself identified a lack of necessity to accept these fundamental propositions to move forward in their charged task. Thus, they lacked not only the expertise necessary for an in-depth study of these issues, but also the motivation.

The Association of Firearm and Tool Mark Examiners

---

[11] Biasotti A. A statistical study of the individual characteristics of fired bullets. J Forensic Sci 1959; 4(1):340-50.

[12] Howitt D. The Statistical Significance of a Bullet Match. Presented at the 38th Annual AFTE Training Conference, May 27 – June 1, 2007, San Francisco, CA (Howitt concluded that it is possible to determine the probabilities for large numbers of consecutively matched lines on a bullet and to demonstrate that they are extremely unlikely to occur randomly.). Published as: Howitt D., Tulleners F., Cebra K., Chen S. A Calculation of the Theoretical Significance of Fired Bullets. J Forensic Sci. July 2008, 53(4):868–875.

[13] Stone R. How Unique are impressed toolmarks? AFTE J 2003; 35(4):376-83.

[14] Collins E. How Unique are impressed toolmarks? An empirical study of 20 worn hammer faces. AFTE J 2004; 37(4):252-95.

(AFTE) represents the relevant scientific community with regard to these issues. Although criticized more as a fraternal organization by some who do not understand its origins and mission, AFTE is a body of firearm and toolmark examiners that exists for the purpose of the furtherance of the science of firearm and toolmark identification. The primary purpose of this organization is to insure as much as possible that the criminal justice community at large can have faith in the work and conclusions of practitioners within the discipline. In an effort to do so, the organization is a forum for scientific research, development and exchange not only through yearly training seminars but also the publication of a peer reviewed journal. Members of the organization regularly review general laboratory practices and work at identifying ways in which these practices can be improved. This is done through individual efforts as well as partnering with organizations such as the Scientific Working Group for Firearms and Toolmarks (SWGGUN), the National Firearm Examiners Academy (NFEA), and the NFSTC/NIJ in the development of a Firearms Analyst Training Program. Furthermore, the organization has a strong code of ethical conduct that is enforced[15]. In addition, the organization has responded to concerns of individual examiner credibility by offering a comprehensive certification process of which examiners can avail themselves.

It is with this background that AFTE has responded to concerns addressed and inadequately researched by the NRC/NAS Committee Panel. Against the backdrop of a discussion of basic firearm and toolmark identification, this position statement identifies how the concerns of the committee have already been addressed by the firearm and toolmark discipline. The issues of toolmark uniqueness and reproducibility have been vigorously studied with the scientific method serving as the model for the systematic investigation of these fundamental questions. It has been repeatedly demonstrated that even under the most rigorous testing conditions of consecutively manufactured tools, once subclass characteristics (if any) are taken into account, toolmarks are unique and can be correctly identified to the tool that made them by a qualified examiner using appropriate procedures and techniques. It has also been demonstrated that the subjectivity involved in these evaluations is a minimized component such that scientific reliability can be expected discipline-wide. Furthermore, it has been demonstrated in repeated studies that toolmarks are generally persistent and reproducible, even under extreme circumstances. Finally, the concern with exclusive identifications has been clarified as it is a common misinterpretation of the standard published and recognized by AFTE which clearly speaks of identification in a practical sense and not an absolute sense.

It is interesting to note, and worthy of pointing out, that the very mission of the NRC/NAS Ballistic Imaging Committee involved an in-depth study of the IBIS ballistic imaging technology and its suitability to handle a large national database of scanned ballistic images. That the IBIS/NIBIN systems can search a large database and locate high confidence candidates (known as "hits") suitable for closer study by a trained examiner and among which are often bullets fired from the same gun, demonstrates that there is a gun-specific "signature" there among the multitude of striae present on the bearing surface of the bullet. Moreover, within the design of the IBIS/NIBIN system, it is recognized that the imaging component has functional limitations and differs from the human element. To be effective, the system requires the support of a trained and experienced firearms examiner to obtain the final conclusion.

In closing, the NRC/NAS Committee report states "The committee agrees with the basic point: statements on toolmark matches (including legal testimony) should be supported by the work that was done in the laboratory, by the notes and documentation made by examiners, and by proficiency testing or established error rates for individual examiners in the field and in that particular laboratory, but should not overreach to make extreme probability statements" (Chapter 3, p. 23). AFTE agrees with this conclusion. AFTE fully supports the continued application of the procedures and techniques employed in forensic firearms identification when carried out by trained and experienced examiners. The alternative proposition, where the court decides that the findings of forensic firearms examiners are not admissible, would not only set aside a long history of an established technique in forensic science but also stands to preclude all future associations between crime scene bullets and cartridge cases and the firearms that discharged them. The "truths" revealed by the skillful evaluation of firearm and toolmark evidence would then not be available to assist those responsible for the administration of criminal and civil justice.

[15]As evidence by the recent court decision in California, Dougherty v. Haag et al, Superior Court Number 05CC06993, Fourth Appellate District of the State of California, Division Three, July 28, 2008.