Evaluation of the Vision X Comparison Microscope to Share Digital Images of Bullets and Shell Casings and the Potential Impact on the Firearms and Tool Marks Community

Final Summary Overview of Contract 2016-DN-BX-K006

A. Purpose of the Project

- **Goal #1** – Assess the current ability of Firearms and Tool Marks examiners to share microscopic imaging data on both an inter-lab and an intra-lab basis.
    - **Objective #1** – Quantify the number of inter-laboratory NIBIN hit confirmations to date and the time required to travel between laboratories to perform the confirmatory process.
    - **Objective #2** – Quantify the percentage of Firearms and Tool Marks comparisons analyzed by the MSP-FSD's FATMU since 2009 that resulted in an inconclusive conclusion. Currently, all inconclusive conclusions require a verification process, but prior to 2016 inconclusive conclusions were not verified. Search the associated case files to evaluate the roles that case type, examiner experience, and verification requirements played in issuing an inconclusive conclusion.
- **Goal #2** – Assess the impact of Vision X technology on the ability of Firearms and Tool Marks examiners to share microscopic imaging data on both an inter-lab and intra-lab basis.
    - **Objective #1 –** Measure the time and accuracy rate associated with external examiners performing comparisons and verifications on common sets of shell casings of known origins using the Vision X Collaboration Station versus the existing practice of in person comparisons of the physical evidence on the same comparison microscope system.
    - **Objective #2** – Measure the time and accuracy rate associated with MSP examiners performing comparisons and verifications on common sets of shell casings of known origins using the Vision X Collaboration Station versus the existing comparison microscope system without Vision X technology. Evaluate the data to determine if there is a significant improvement in efficiency and quality associated with using the Vision X Collaboration Station and whether there are significant differences associated with the experience level of the examiners involved.

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B. Project Design Objectives, Purposes, Analyses and Project Findings

Goal 1 Objective 1

1. G1O1 – Project Objective

1.1. Quantify the number of inter-laboratory NIBIN hit confirmations to date and the time required to travel between laboratories to perform the confirmatory process.

2. G1O1 – Purpose

2.1. Report on the confirmation of NIBIN Hits and the travel distance and time incurred by FSD-FATM Unit Examiners.

3. G1O1 – Data Analysis and Results

3.1. A total of 9 FSD-FATM Unit examiners traveled to external locations for confirmation of 8 NIBIN hits. Travel by FSD-FATM Unit examiners to locations were mostly alone, but once was performed by a pair of examiners.

3.2. The overall average distance per round trip was approximately 72 miles and the average time traveling to and from that location was approximately 90 minutes.

4. G1O1 – Findings and Observations

4.1. While there was no way of calculating the time spent interacting with firearms examiners from the other locations in order to confirm the hits, the fact that 90 minutes in travel were needed demonstrates that significant time could be saved through performing remote confirmations using Vision X technology.

Goal 1 Objective 2

1. **G1O2 – Project Objective**

1.1. Quantify the percentage of Firearms and Tool Marks comparisons analyzed by the MSP-FSD's FATMU since 2009 that resulted in an inconclusive conclusion. Currently, all inconclusive conclusions require a verification process, but prior to 2016 inconclusive conclusions were not verified. Search the associated case files to evaluate the roles that case type, examiner experience, and verification requirements played in issuing an inconclusive conclusion.

2. **G1O2 – Purpose**

2.1. Report on the verification of Elimination or Inconclusive decisions by FSD-FATM Unit Examiners.

3. G1O2 – Data Analysis and Results

3.1. There were 219 cases from 2012-2016 in which FSD-FATM Unit Examiners performed analysis using comparison microscopes.

3.2. Of the total 219 cases, 71 (32.4%) resulted in an elimination or inconclusive decision. Of the 71 cases, 27 (38.0%) were found not to have been verified by a second examiner.

3.3. The type of crime associated with the examinations that resulted in the 27 elimination or inconclusive determinations not being verified by a second examiner included 9 homicides, 5 attempted homicides, 4 firearm violations, 1 assault, 1 reckless endangerment, 1 shooting, 1 robbery, and 5 others.

3.4. The experience level of the examiner associated with the examinations that resulted in the 27 elimination or inconclusive determinations not being verified by a second examiner included 10 (37.0%) by examiners with more than 5 years of experience and 17 (63.0%) by examiners with less than 5 years of experience.

4. G1O2 – Findings and Observations

4.1. While the FSD-FATM Unit has modified its policy in recent years to require verifications of elimination and inconclusive determinations, other agencies still may not have such requirements. The fact that of the 27 elimination or inconclusive determinations found without verifications, 14 (51.9%) were associated with homicides or attempted homicides shows the serious nature of the casework that could be impacted. Furthermore, the fact that often it is less experienced examiners making elimination and inconclusive determinations may suggest that the less experienced examiners lack confidence to implicate an individual and therefore could benefit from a verification process.

4.2. If the verification process could be made less cumbersome by using Vision X technology, then there may be more buy in to requiring verifications of all elimination and inconclusive determinations.

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Goal 2 Objective 1

1. **G2O1 – Project Objective**
    1.1. Measure the time and accuracy rate associated with external examiners performing comparisons and verifications on common sets of shell casings of known origins using the Vision X Collaboration Station versus the existing practice of in person comparisons of the physical evidence on the same comparison microscope system
2. **G2O1 – Purpose**
    2.1. Report on how performing remote verifications using Vision X technology between agencies separated by physical distance impacts time and accuracy of the verification process.
3. **G201 – Data Analysis and Results**
    3.1. The ability to complete the inter-lab experiments associated with Goal 2 Objective 1 is dependent on the manufacturer making needed software modifications identified during the completion of the intra-lab experiments associated with Goal 2 Objective 2.
    3.2. While the time table for the software modifications is out of our control, we will attempt to address this objective by demonstrating the ability to remotely connect 2 Vision X comparison microscopes located at agencies separated by physical distance.
4. **G2O1 – Findings and Observations**
    4.1. At this time, we have been unable to establish a remote connection between a FSD FATM Unit Vision X comparison microscope and a Vision X comparison microscope located at another agency. Delays have occurred due to the security requirements of our IT Division and the need to obtain certain documentation from the external agency. Efforts continue to resolve the security issue so that proof of concept can be established before the end of the grant period.

Goal 2 Objective 2

1. **G2O2 – Program Objective**
    1.1. Measure the time and accuracy rate associated with MSP examiners performing comparisons and verifications on common sets of shell casings of known origins using the Vision X Collaboration Station versus the existing comparison microscope system without Vision X

technology. Evaluate the data to determine if there is a significant improvement in efficiency and quality associated with using the Vision X Collaboration Station and whether there are significant differences associated with the experience level of the examiners involved.

2. G2O2 – Purpose

2.1. Report on how performing remote verifications using Vision X technology within a single agency impacts time and accuracy of the verification process

3. G2O2 – Data Analysis and Results

3.1. The use of the Vision X comparison microscopes within the FSD FATM Unit required an initial performance check on the Vision X comparison microscope.

3.1.1. The performance check of each of the Vision X Comparison Microscope instruments were conducted for the purpose of microscopic forensic comparison of evidence such as toolmarks, bullets, and cartridge cases. The optical lenses and lens strengths were tested for accuracy and repeatability in order to determine if the microscopes are working properly and are suitable for casework purposes.

3.1.2. All objective lenses performed as expected. No differences were found over the three days the checks were performed.

3.1.3. The attachments for right and left holders of each microscope were found to operate as expected. Each microscope was able to work with annotations and measurements as expected based on the observation of the performance check. Annotations and measurements were added to the measurement photographs.

3.1.4. The difference in values for the averages can be attributed to the measuring scales and measuring devices. The Starrett micrometer is limited to $\pm$ 0.0005 in. The Vision X has a measuring capacity of $\pm$ 0.000001 in., a difference of up to 100 times more sensitive but the incremental units at 32x magnification was .00023 in. making the Vision X only twice as sensitive as the Leica.

3.1.5. Some differences between measurements were noticed because of the different measuring systems. The Starrett Micrometer airgap method and the Vision X computerized measurement system were determined similar and results were within standard deviations.

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3.1.6. Based on the results determined, the two microscopes' comparison of total bullet land and groove impression width measurements are relatively consistent. Individual larger caliber width measurements provided larger measurements and greater variation. Fewer samples of bullets also increased the variation. Yet all are within standard deviation and differences in measurement are within acceptable statistical variation ($P \geq .01$). Therefore, The Vision X Comparison Microscope passed the performance check and is suitable for casework purposes.

3.2. The use of the Vision X comparison microscopes within the FSD FATM Unit required an initial performance check on the Vision X software.

3.2.1. This performance check of each of the Vision X Comparison Microscopes was conducted for the purpose of validating specified operating parameters for the Vision X software functions and features. This validation study tested the specified operation parameters to determine compliance to that stated in the Operating Manual.

3.2.2. The following parameters were examined and measured: Operating the Vision X Software, Capturing an Image in Acquisition Mode, Capturing a Comparison Image in Acquisition Mode, Manipulation of Images, and Creating Reports.

3.2.3. Based on the results, the land and groove impression width measurements are within described capacities. The Vision X software is capable of acquisition and comparison of images of objects, storing as photographs, movies, and data, annotating and measuring the objects, manipulation of images, and creating reports are all functional and as described. Therefore, The Vision X Comparison Microscope software passed the performance check and is suitable for FATM Unit use.

3.3. After the performance checks were completed, three projects were completed to compare the Vision X and Leica UFM 4 Comparison Microscopes within the FSD FATM Unit. Project 1 evaluated each system's ability to provide measurements and characteristics of fired bullets from 26 handguns.

3.3.1. From each handgun a total of 154 measurements were taken resulting in an average land distance of .112 and .115 inches for the Leica and Vision X, respectively. Results found for

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the average groove distance were .072 and .073 inches for the Leica and Vision X, respectively. The standard deviation for these averages indicated that measurements were essentially the same ($P \geq .01$).

3.3.2. Based on the results, the two microscopes' comparison of bullet land and groove measurements are identical. Minor differences in measurement are within acceptable statistical variation ($P \geq .01$).

3.3.3. Observational use of the two comparison microscopes favors the ease of the Vision X microscope. The Vision X essentially eliminates need for physical handling of the bullet and focusing required on the Leica microscope. The motorized platform, focusing ability, and lens of the Vision X allow for much finer manipulation and positioning of the bullets. While the binocular lenses and cameras in each microscope system provide images of high resolution, the computer software of the Vision X is more advanced than that of the Leica and eliminates the need for a separate micrometer.

3.4. Project 2 evaluated the ability of MSP-FSD FATM Unit examiners to become as proficient with the Vision X comparison microscope as with the Leica UFM4 comparison microscope.

3.4.1. All examiners were able to correctly identify matched cartridge casings in a random blind proficiency-style test. Testing indicated that the more experienced examiner took far less time to adapt to the Vision X technology. After the final trials the difference for making decisions between the two microscopes was reduced to 5 minutes.

3.4.2. After 16 trials the difference in time spent examining cartridge cases dropped from 27 minutes initially to 5 minutes which should not make an impact on an examiner's efficiency or performance.

3.4.3. Following the final trials and second training session, the examiners reported in a questionnaire that they were more comfortable with the Vision X although they still had some lighting and clarity issues and preferred the Leica. One examiner felt it was complicated to use because it was just very different than every other microscope since all of the controls were automated and many features may not be used. One said she liked the touch synchronized magnification change and various lighting options. The fine focusing

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was easier with experience while the joy sticks and split screen hair line controls still moved too fast.

3.4.4. It is possible that new or less experienced examiners who could be initially trained on the Vision X and who have been exposed to more complex and integral computer graphics and games in their lifetimes may be more open to the enhancements provided in the Vision X. Trainees, who had less than 2 years' experience and were trained on both the Leica and Vision X at the same time preferred the Vision X to the Leica.

3.5. Project 3 evaluated peer-to-peer intra-laboratory collaboration to determine "matched" and "non-matched" breechface impressions on .40 caliber cartridge casings fired from consecutively manufactured slides by linked connection of two different Vision X comparison microscopes within the MSP-FSD FATM Unit's laboratory.

3.5.1. The two Vision X comparison microscopes were linked electronically where "known" cartridge casings were displayed live on one microscope and the "unknown" cartridge casings were examined against the "known" cartridge cases live on a different microscope. The examiners were able to correctly identify all "matched" breechface impressions of the cartridge.

3.5.2. The primary examiner could not rotate the cartridge on the secondary microscope and required communication between the two examiners to move the cartridges into various positions.

3.5.3. Due to software limitations, the examiners were not able to use the live images for comparison purposes and instead had to rely on still images.

3.5.4. Only the primary microscope would allow the left side edge of its image to be narrowed and aligned with the other image.

3.5.5. The gap between images where comparisons were made was larger than desired.

3.5.6. It was difficult to sweep across the surface of both cartridge breechfaces to get an overall impression of the markings.

3.5.7. The images on the monitors were not as sharp and detailed as those viewed through the binocular eyepiece lenses.

3.5.8. Both examiners pointed out that the terms “matched” and “unmatched” were not appropriate for this trial due to the inability to use live images. The best to that they would agree was that the images seen of “matched” cartridges were a “lead for further examination” or “inconclusive” for the “non-matched” cartridges. Both examiners would still require in-lab examination.

4. **G2O2 – Findings and Observations**

4.1. The Vision X was found to be comparable to the Leica in accuracy. Despite a steep learning curve, after extended practice using the Vision X the time to evaluate comparisons under the Vision X was found to be nearly comparable to the Leica. The fact that trainees, who had less than 2 years’ experience and were trained on both the Leica and Vision X at the same time, preferred the Vision X to the Leica suggests that the newer generation of examiners who have been exposed to more complex and integral computer graphics and games in their lifetimes may be more proficient with the Vision X.

4.2. While the remote capabilities of the Vision X software allowed for successful comparisons of evidence on different comparison microscopes within the FSD FATM Unit, the identified limitations of the software did not allow for confirmations to be declared by the examiners. These software limitations were communicated with the manufacturer who appreciated the feedback and said they would make the required improvements to the software. Further pursuit of using the Vision X remote capabilities will not occur until the updated software is released.

In addition to the original scope of the project, studies were performed to evaluate the ability to use the 3-dimensional Extended Depth of Focus (EDF) capability of the Vision X comparison microscope and associated software for making statistical comparisons between matched and non-matched cartridge cases by examining breechface impressions. Visual examination of the cartridge case primer and head surfaces showed a wide range of variability of markings on the cartridge head and primer. Comparative analysis of the data by Analysis of Variance (ANOVA) showed these variations among matched cartridges were not significantly different ($P \geq .05$). Comparative analysis of the data by ANOVA showed these variations among non-matched cartridges were significantly different ($P \geq .05$). Additional studies needs to be completed before this application can be reliably used in casework.

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C. Implications for Criminal Justice Policy and Practice in the United States

1. Risk of a false elimination or unnecessary inconclusive result can be mitigated by requiring verifications of all conclusions and not just for identifications. Advances in technology can help offset any negative impacts on efficiency that such a policy change could create.
2. Vision X is a powerful addition to the microscopic examination of cartridge cases, bullets, and toolmarks improving the tools available to the examiner for performing comparisons.
3. Vision X technology may be a preferred method of examination for the next generation of firearms examiners due to their familiarity with digital data systems such as video games, mobile devices, and algorithm based applications.
4. Further improvements in the Vision X remote live display has the potential to promote long distance live match determinations and inter-jurisdictional cooperation that could save significant time in the NIBIN hit confirmation process.
5. The implementation of inter-agency comparisons using Vision X technology is dependent on both agencies having the Vision X system as well as on both agencies having the IT authorization to transmit data between agencies.
6. Analysis of data by the Vision X software has the potential to advance the examination of cartridge cases to meet and exceed the AFTE “Theory of Identification as it relates to Tool Marks” by supplementing visual comparisons with statistically based findings.