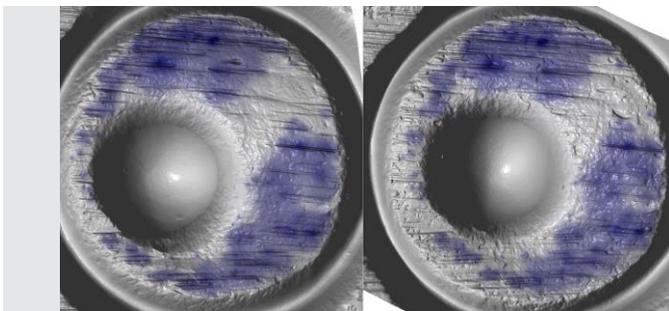




SUCCESS STORY

NIJ and Cadre Forensics:

Advancing 3D Virtual Microscopy for Firearm Forensics



“High-resolution 3D surface topographies coupled with advanced software analysis are providing firearm examiners unprecedented new tools for micro-surface examination.”

-Dr. Ryan Lilien, Chief Scientific Officer, Cadre Forensics

Synopsis of the Problem and Solution

Examining bullets and cartridge cases from crime scenes can help link crimes, moving investigators one step closer to identifying a suspect. Firearm forensic analysis can also link recovered evidence to a seized firearm, based on the impression pattern that the gun leaves on the cartridge case or bullet during firing.

The predominant method used to compare firearm evidence is the century-old technique of comparison microscopy (essentially a split-screen optical microscope) to determine whether an evidence cartridge matches a test-fired cartridge. This method is highly dependent on variable lighting conditions and examiner subjectivity and requires that the two pieces of evidence be in the same place at the same time. In recent years, forensic laboratories have become interested in applying more advanced imaging techniques. These permit the digital capture of an accurate 3D representation of the topography of the surface being examined. This yields more reliable, reproducible images for examiners¹ and points the way toward establishing an objective, quantifiable foundation for forensic firearm analysis, as recommended by the National Research Council (NRC)².

Cadre Forensics, led by Dr. Ryan Lilien, with support from Todd Weller, Pierre Duez, and Dr. Marcus Brubaker, developed the TopMatch-3D system for imaging of firearms evidence. Cadre based their hardware on a patented imaging technology that employs a thin elastomeric gel to accurately measure microscopic surface features. Dr. Lilien and the team also developed specialized image-matching algorithms to automatically detect and compare the 3D impression features observed on a surface with one or many other possible matches. When used for virtual comparison microscopy (VCM), the

system can allow firearm examiners to more accurately and efficiently reach conclusions without having to wait for the physical exchange of evidence. Further in-lab validation studies are being conducted to quantify the performance of the system under casework conditions.

Key Benefits of TopMatch-3D

- ▶ Increases accuracy, repeatability, and reproducibility of firearm forensics while offering an economical alternative to other 3D imaging technologies.
- ▶ Captures 3D images and allows easy sharing of data through the open source [X3P file format](#), streamlining collaboration and simplifying blind verification. Cadre also offers a free X3P viewer to encourage the free and easy exchange of data among laboratories.
- ▶ Unlike many other 3D imaging systems, TopMatch-3D was designed specifically for firearm forensics; both hardware and software were developed with forensic examiners in mind.

National Institute of Justice (NIJ) Research

NIJ grant support enabled Cadre to develop and validate a 3D topography system for firearm forensics. Initial grants supported the development of system hardware and software; subsequent grants contributed to (1) expansion of evidence types analyzed, and (2) feature development and validation (e.g., novel algorithms for surface comparisons). With NIJ support, Cadre is performing a black-box study for examiners on algorithms using 3D topographies to build foundational validity.

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More Information

To learn more about the research presented in this success story, please contact:

Ryan Lilien, PhD/MD
 Chief Science Officer
 420 W Huron St,
 Chicago, IL 60654
www.cadreforensics.com
forensics@cadreforensics.com

To learn more about the FTCoE and the impact of NIJ research, please contact:

John Morgan, PhD
 Director, FTCoE
 RTI International
jmorgan@rti.org

Gerald LaPorte, MSFS
 Director, Office of Investigative and Forensic Sciences
 National Institute of Justice
gerald.laporte@ojp.usdoj.gov

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Resources

[1] Forensic Technology Center of Excellence (2016). Forensic Optical Topography - A Landscape Study. U.S. Department of Justice, National Institute of Justice, Office of Investigative and Forensic Sciences.

[2] Committee on Identifying the Needs of the Forensic Sciences Community, National Research Council (2009). Strengthening Forensic Science in the United States: A Path Forward. Retrieved from <https://www.ncjrs.gov/pdffiles1/nij/grants/228091.pdf>

[3] Duez, P., Weller, T., Brubaker, M., Hockensmith, R. E. and Lilien, R. (2018), Development and Validation of a Virtual Examination Tool for Firearm Forensics. *J Forensic Sci*, 63: 1069-1084. doi:10.1111/1556-4029.13668

Bringing Research to Practice

- ▶ The TopMatch-3D desktop scanner is on the market and actively used in casework in multiple agencies, including the FBI's Firearms/Toolmarks Unit. The FBI now uses the system as part of their standard workflow including the analysis of mass shooting events.
- ▶ Based on forensic practitioner feedback, Cadre has developed an autosampler scanning tray that accepts up to 15 cartridge cases at a time.
- ▶ The Royal Canadian Mounted Police collaborated with Cadre Forensics to investigate examiner error rates as part of a VCM pilot study. Findings from the pilot study were recently published in the *Journal of Forensic Sciences*³.
- ▶ Collaborative Testing Services (CTS) has partnered with Cadre to offer a VCM [proficiency test](#) for training purposes.
- ▶ Cadre Forensics representatives have presented their work at forensic science conferences, including the Association of Firearm and Tool Mark Examiners (AFTE) national and regional meetings, the European Network of Forensic Science Institutes (ENFSI), California Association of Criminalists, and Tulane University. In 2018, Ryan Lilien led a [workshop](#) at the NIJ [Impression, Pattern, and Trace Evidence Symposium](#).

The Future

Cadre continues to enhance and drive the adoption of its Cadre Nexus software, a cloud-based platform that allows data sharing and search among laboratories. The team is working to improve its hardware by expanding the capabilities of its TopMatch-3D system to allow scanning of bullets as well as cases. Cadre recently released the TopMatch-3D Portable Scanner, a hand-held system that can be used for triage or prescreening at the crime scene to help select the highest priority evidence for further analysis. The company will continue to drive validation studies and further evaluation of the systems within crime laboratories. Near-term plans include exploring how image resolution impacts examiners' ability to reach accurate conclusions.



Cadre's TopMatch-3D Desktop Scanner

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