



TopMatch-3D

High Capacity

3D Imaging and Analysis System
for Firearm Forensics.

True 3D



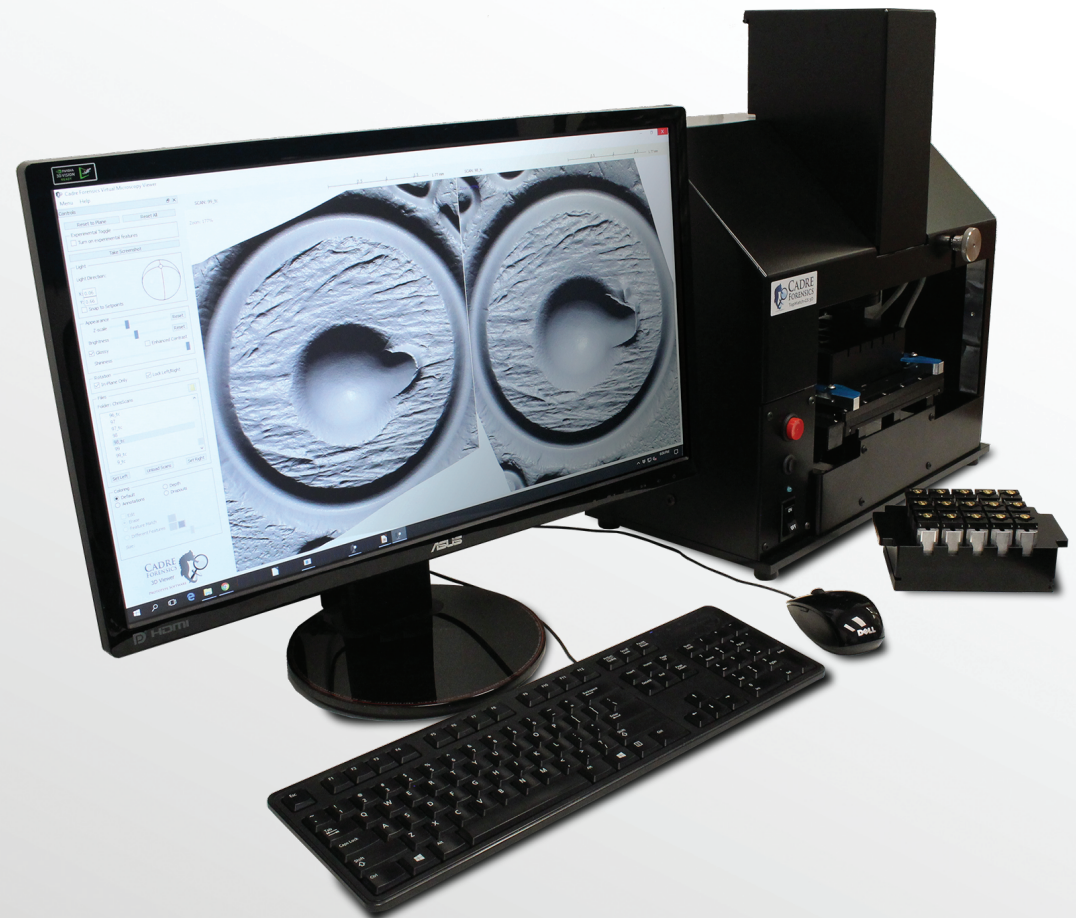


3D Imaging and Analysis System for Firearm Forensics

True 3D

The TopMatch-3D High-Capacity Imaging and Analysis System consists of the patented High-Capacity 3D Scanner and the TopMatch Analysis Software.

- Fast, Accurate, High-Resolution Scan Capture
- Database Search and Automated Comparison
- Interpretable Scoring Function with Highlighted Regions of Interest
- 15-Holder Tray for Batch Scanning
- Scan, Save, and Share 3D Measurements in ISO Standard X3P Format
- Remote Viewer Software allows Database Access and 3D Viewing on Examiner Workstations
- Data Sharing between Locations via Cadre Nexus
- Software Designed by and for the Forensic Community

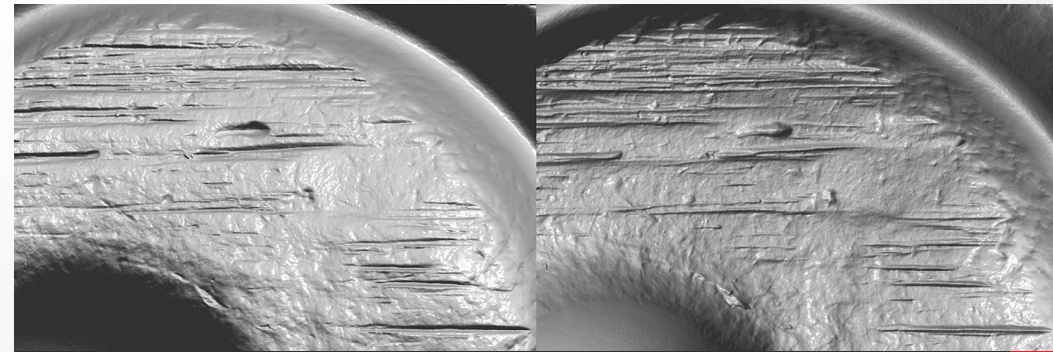


With TopMatch-3D High Capacity only one computer workstation is required for 3D image capture, visualization, analysis, and database search. Additional workstations can be added for remote viewing and collaboration.

3D Visualization and Virtual Comparison Microscopy

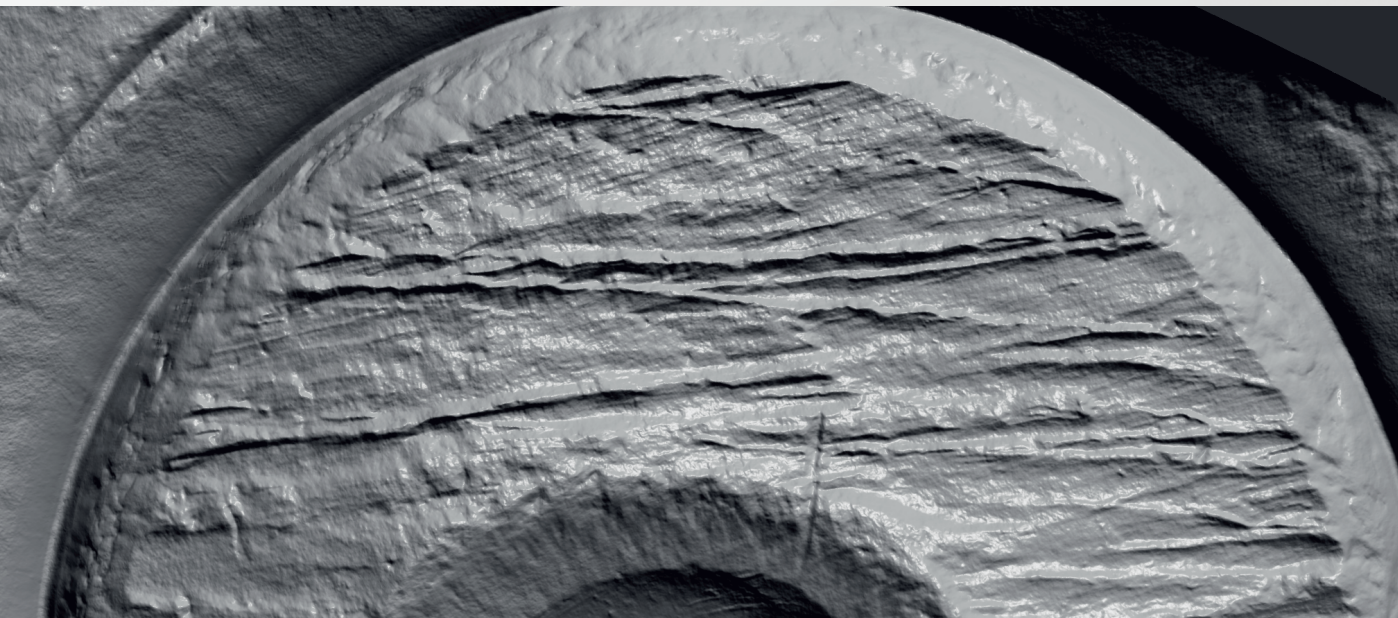
When you visualize a scan using TopMatch *3D Virtual Comparison Microscopy (VCM)* you are seeing its true high-resolution 3D surface topography. The detail provided via TopMatch 3D VCM often exceeds that visible with a traditional comparison scope.

The use of VCM has the potential to greatly enhance the speed and accuracy of *remote collaboration*. For example, by exchanging digital 3D scan data (via *X3P* or the Cadre *Nexus*), two labs can compare evidence without having to physically ship the specimens between labs. This allows multiple labs to examine the same specimen at the same time and simplifies chain of custody documentation.



Adjusting the virtual light highlights different surface features just as if the physical object was in front of you.

- Maneuver scanned cartridge cases in full rendered 3D
- Adjust a virtual light to visualize all surface features
- Save high-resolution images for use in other software and reports
- Share full resolution scans both locally and remotely
- Annotate surfaces to highlight relevant regions



Experience the detail yourself.
Take a test drive with Cadre's
free X3P viewer at

www.CadreForensics.com



Fast. Accurate. High-Resolution Scan Capture

The TopMatch GelSight sensor can measure toolmark surfaces with micron-scale lateral and depth resolution. Unlike other imaging technologies, the TopMatch system can measure steeply sloped surfaces and has an extremely short scan acquisition time.

Because the true high-resolution 3D surface geometry is captured, examiners can manipulate a virtual light within the software to bring out individual features for visual comparison.

Fast scan acquisition optimizes an examiner's productivity and can reduce backlog.

LESS THAN

1

MINUTE PER
CARTRIDGE CASE
PRIMER SCAN



The TopMatch High Capacity tray holds up to fifteen cartridge cases and microscale references to automate and expedite scanning and QC checks. TopMatch's barcode interface allows tray, gel, and cartridge case barcoding to expedite the scan process and improve organization.



Interpretable Results

Heatmap Visualization for Hit Verification

Unlike other systems which provide little to no explanation on the detail of a match, the TopMatch system can display a heatmap to justify the computed match score. With a heatmap, the software uses a patented approach to color code the surface of the cartridge cases to indicate areas of geometric similarity. This visualization provides interpretability and facilitates communication of your findings to those who are not experts in firearm forensics.

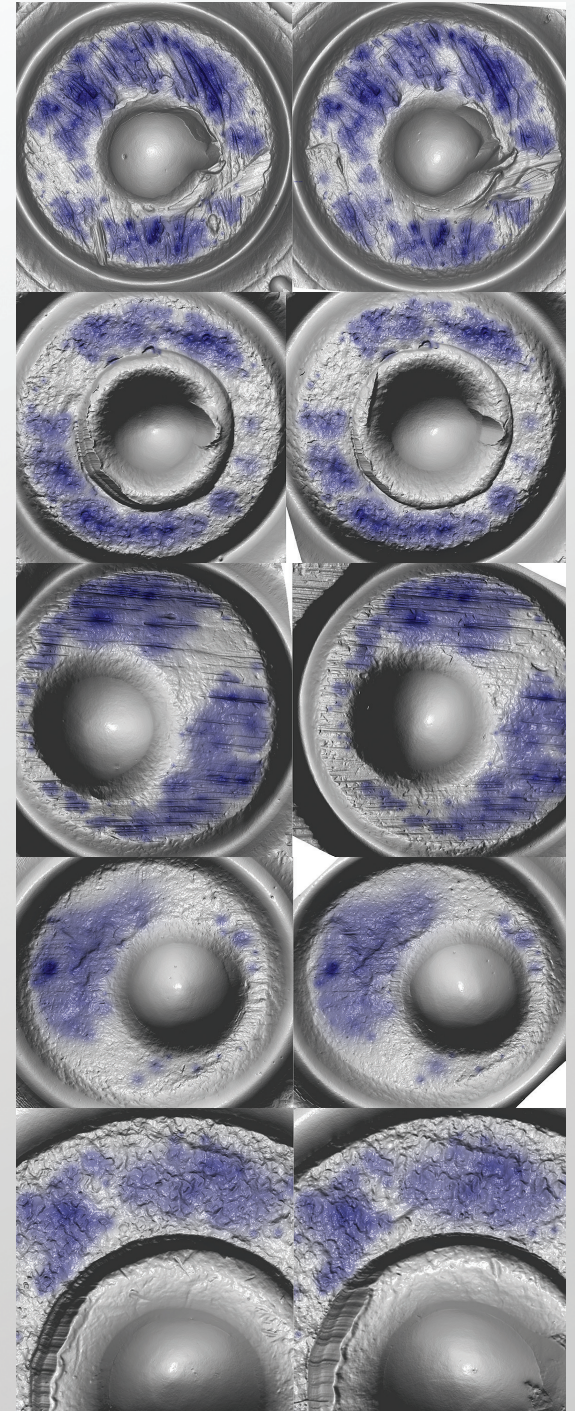
Meaningful Comparison Score

The TopMatch Software's similarity score is a number which reflects the underlying confidence in the comparison and the support for common origin. With TopMatch you no longer have to look endlessly down a long list of potential candidates.

TopMatch's unique comparison algorithm includes several methods for analyzing topographic features. Cadre's approach identifies geometric structures similar to those considered by a trained examiner.

Color intensity corresponds to the number of matched features.

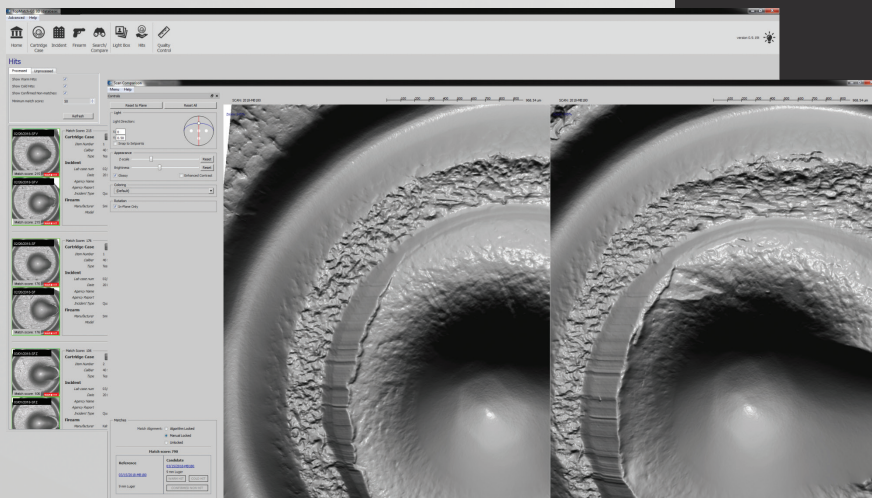
Darkly shaded regions have a higher degree of similar surface geometry than lightly shaded or unshaded regions.





TopMatch Search, Comparison, and Visualization

- Organize scans, firearms, and case files in a hierarchical database.
- Multiple Virtual Comparison Microscopy visualization, comparison, and search modes. Compare cartridge cases one-to-one, one-to-many, or many-to-many.
- Advanced feature-based topography matching algorithm is more accurate than traditional correlation methods.
- Search runs on the desktop workstation or Nexus. No large rack-mount hardware or server room required.
- Export Images and Reports (MS Word compatible).
- Intuitive Incident Analysis screen enables intra- and inter-incident comparisons.



True 3D from Acquisition through Matching.

Cadre Nexus

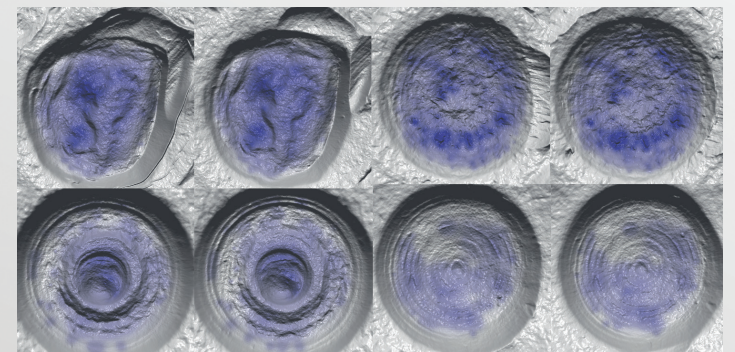


Cadre's suite of acquisition and analysis software can all be linked to the Cadre Nexus. The Nexus is a secure cloud-based platform that allows for the storage, retrieval, and search of topographic data.

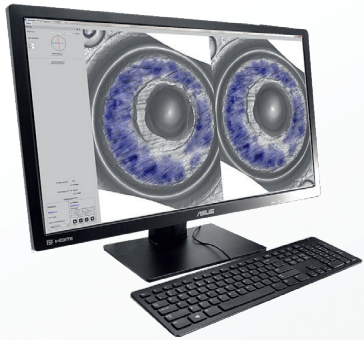
- User, Lab, and Region specific access rights
- Access your scans with unique specimen ID
- Share scans with others for teaching and collaboration
- 256-bit encryption secures your data
- Upload and download in X3P format

Firing Pin Impressions

Use of a proprietary gel pad improves the resolution of steep slopes allowing high resolution imaging of firing pin impressions. Cadre's optional flattened view improves visibility of individual characteristics.



Freely Exchange Your Data



X3P XML 3D Surface Profile

Free to Export It's your data

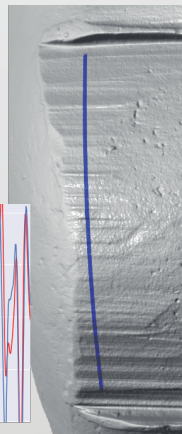
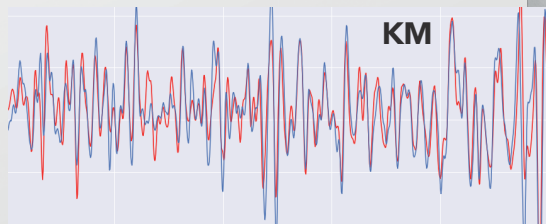
TopMatch allows you to export scans to share with other labs.

Open File Format

Cadre is a founding member of OpenFMC (Open Forensic Metrology Consortium), a group of government, academic, and private institutions pioneering the use of the open X3P file format for the exchange of surface topography data. Systems supporting X3P are compatible with each other and can easily exchange data.

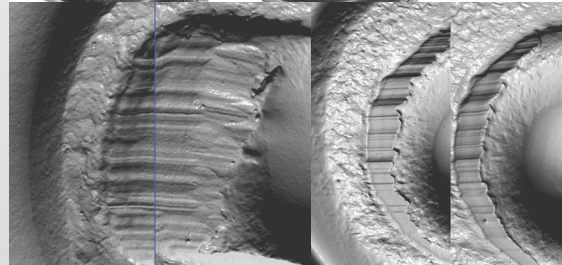
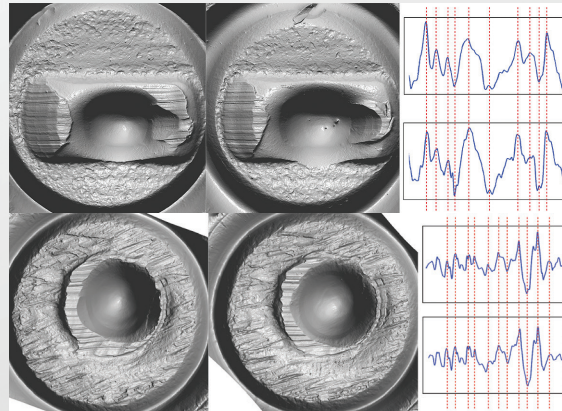
Bullets

TopMatch's bullet tray allows scanning of land and groove areas. Submicron depth sensitivity allows matching of striation profiles.



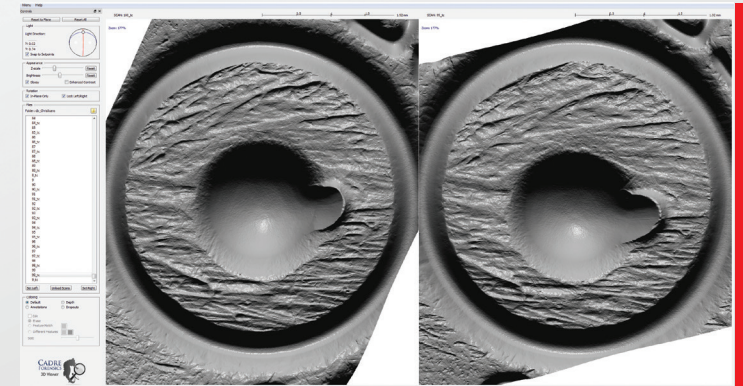
Shear Extraction and Matching

Aperture Shears are extremely useful when comparing two cartridge cases. As a striated mark, shears are correctly compared by measuring the similarity of their linear profiles. The TopMatch-GS 3D scanner can accurately measure aperture shears and the system's robust profile extraction algorithm can characterize a shear's linear profile even when it's distorted. Shears can be compared independently or combined with the breech-face impression to give an overall confidence of match.



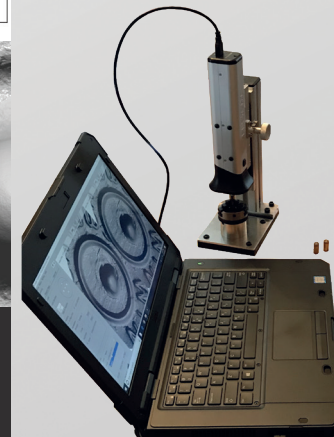
3D visualization and extracted shear profiles from a pair of Glock, Norinco, and Ruger test fires measured with the TopMatch system.

Virtual Comparison Microscopy



Cadre's Virtual Comparison Microscopy software is the industry-leading side-by-side comparison software for X3P topography files. Its use has been validated by a 2018 Journal of Forensic Sciences peer reviewed publication [4] as well as more recent studies by Cadre [5], the RCMP, and the FBI.

TopMatch-3D Portable



The TopMatch-3D Portable Scanner is designed to complement the desktop scanner for high-volume labs or labs which desire rapid or in-field measurements. The Portable scanner runs off a laptop and provides 3D topographies in just 5 seconds.

System Specifications

Imaging Sensor & Objective:	12 Megapixels; Telecentric Optics
Imaging Resolution:	Lateral: 0.9 - 1.8 microns per pixel. Typical operation 1.8. Depth: Better than 1 micron
Computer:	Multi-Core High-End Workstation with 28" 4K Display and Solid State Drive
Scanner Dimensions and Weight*:	19" (48.3 cm) wide x 10" (25.4 cm) deep x 21" (53.34 cm) tall; 48 lbs (22 kg) *(not including computer or monitor)
Power:	Standard North America 110V Power Outlet
Software:	TopMatch Workstation (Database, Analysis, Visualization, and Search); Lab Site License for Remote Viewer (Virtual Microscopy, Runs on Examiner Workstation)
Scan Storage Capacity:	30,000 (expandable)
X3P File Format Support:	Yes
System Support:	Full Phone and Email Support; On-Site when Required; Maintenance Package Covers all Hardware and Software

Cadre Forensics

The TopMatch-3D system is designed and developed by Cadre Forensics, an American company with headquarters in Chicago, Illinois. Beginning in 2013, recognizing the need for new technology within the forensic community, three PhDs and an experienced firearms examiner began development of the technology that would become the TopMatch system.

The project developed as an application of their research areas within computer science, engineering, and machine learning. The system's core imaging sensor is based on patented MIT research and is being further developed by GelSight Inc, a small business located in Massachusetts. The sensor utilizes a proprietary nondestructive gel to remove the influence of unwanted optical characteristics on the measurement process, ensuring accuracy, repeatability, and consistent performance.

Cadre continues the founders' academic tradition via ongoing collaboration with academic colleagues, dissemination of results with conference presentations, and publication of peer reviewed academic papers. Development also benefits from collaboration with local, state, and federal US firearms examiners as well as grants from NIST and NIJ.



[1] Johnson and Adelson, "Retrographic Sensing for the Measurement of Surface Texture and Shape", Proc. of the IEEE Conf. on Computer Vision and Pattern Recognition (CVPR), 1070-1077, 2009. [2] Johnson, Cole, Raj, and Adelson, "Microgeometry Capture using an Elastomeric Sensor", ACM Trans. on Graphics, Proc. of SIGGRAPH, 30(46:1-46:8), 2011. [3] Weller, Brubaker, Duez, and Lilien, "Introduction and Initial Evaluation of a Novel Three-Dimensional Imaging and Analysis System for Firearm Forensics", Association of Firearm and Toolmark Examiner Journal, 47(4):198-208, 2015. [4] Duez, Weller, Brubaker, Hockensmith II, and Lilien, "Development and Validation of a Virtual Examination Tool for Firearm Forensics", J. of Forensic Sciences, 63(4):1069-1084, 2018. [5] Chapnick, Meschke, Duez, Weller, Marshall, and Lilien, "Results of the 3D Virtual Comparison Microscopy Error Rate Study (VCMERS) for Firearm Forensics", (in preparation), 2019.

Note: Images in this document do not appear at full resolution. Parts of the TopMatch-GS 3D system and GelSight sensor are covered by granted and pending US Patents. GelSight is a trademark of GelSight Inc.

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