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Firearms and Tool Marks

Presented by:

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Core Team Members

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Disclaimer

Certain commercial equipment, instruments, or materials are identified in this presentation to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology (NIST), nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

Firearm and Tool Mark Identification

- Were the evidence tool marks produced by the same tool?
- Was an evidence mark produced by the evidence tool?

Firearm "tools"

- Revolver
- Pistol
- Rifle
- Shotgun

Source: SWGGUN

Common tool mark evidence

- Bullet
- Cartridge case

aegisacademy.com

Non-firearm tools

- Screwdriver
- Pry bar
- Wire cutter
- Pliers
- Lock pick

Source: SWGGUN

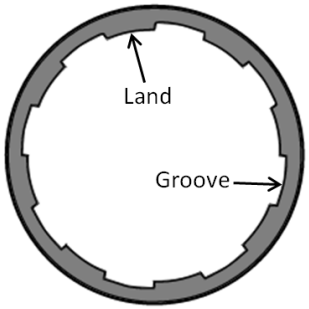
Common tool mark evidence

- Lock
- Safe
- Window still
- Wire

Bullets and Cartridge Cases – Regions of Interest

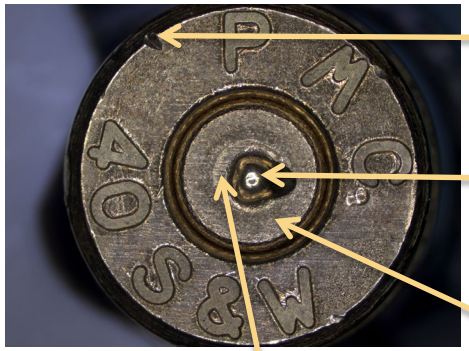
Bullets have striated tool marks from the barrel rifling.

From Centralia College – H. Ebiari



Land Engraved Areas (LEAs)

Cartridge cases have impressed and striated tool marks from various sources



Ejector mark

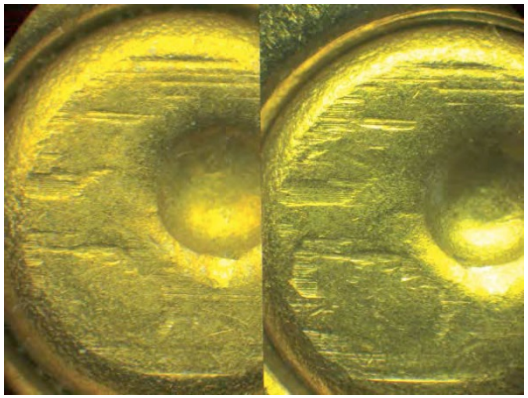
Firing pin impression

Breech face impression

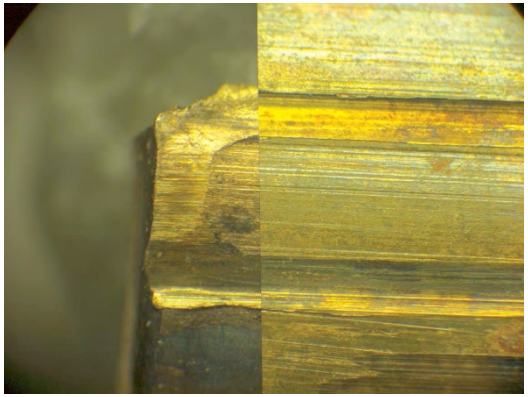
Aperture shear (striae)

Casings constitute over 90 % of the NIBIN national database entries for firearm identification.

Firearm Identification – Current Practice



Toolmarks on cartridge cases



Striated toolmarks on bullets

Compare class characteristics - Measurable features that indicate a restricted group source

Compare individualizing tool marks (subjective):

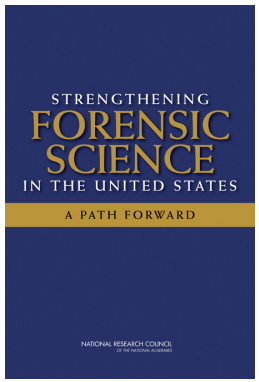
- Does the agreement exceed the best agreement demonstrated between tool marks from different tools?
- Is the agreement consistent with the agreement demonstrated by tool marks from the same tool?

Render an opinion:

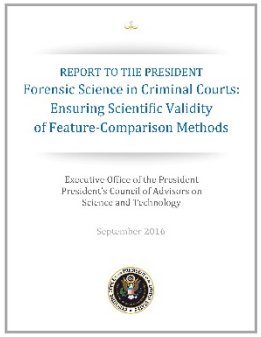
- Identification
- Exclusion
- Inconclusive
- Unsuitable

AFTE Theory of Identification, AFTE Journal – Volume 43, Number 4, Page 287, 2011.

Current Practice is Under Scrutiny



- NAS 2009 "..the decision of the toolmark examiner remains a **subjective decision** based on unarticulated standards and **no statistical foundation for estimation of error rates**."



- PCAST 2016: "PCAST finds that firearms analysis currently falls short of the criteria for foundational validity, because there is only a single appropriately designed study to **measure validity and estimate reliability**."

- PCAST 2016: "A second – and more important – direction is … to convert firearms analysis **from a subjective method to an objective method**…"

- The National Research Council, "Strengthening Forensic Science in the United States—A Path Forward", Washington DC, 2009.
- President's Council of Advisors on Science and Technology, "Forensic science in criminal courts: Ensuring scientific validity of feature-comparison methods", Washington DC, 2016.

NIST Firearms and Tool Marks Focus Area

Goals:

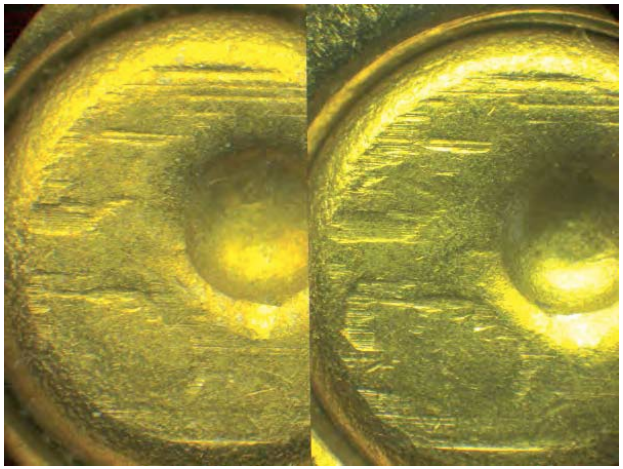
- Metrology infrastructure for objective firearm and tool mark examination
- Scientifically-justified protocols to quantify the weight of the evidence.

Focus:

- Measurement methods, quality assurance, and standards.
- Objective comparison metrics and algorithms
- Knowledge base for similarity and variability of tool marks
- Quantitative expressions for the weight of evidence.

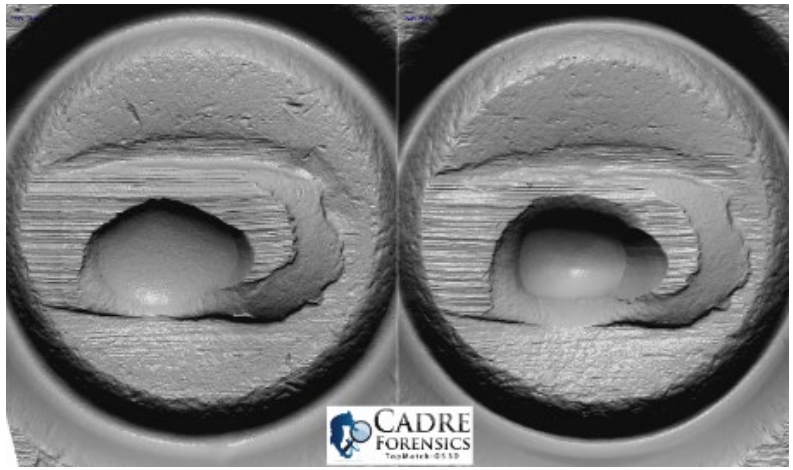
From 2D to 3D

2D reflectance microscopy images



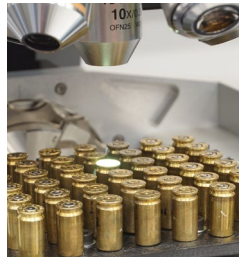
Comparison microscopy

3D topography images



Virtual comparison microscopy

- Higher reproducibility and focus on actual topography
- Measure once, compare often
- Well suited for numerical analysis
- Already common for database search
- Virtual comparison microscopy is ready for case work

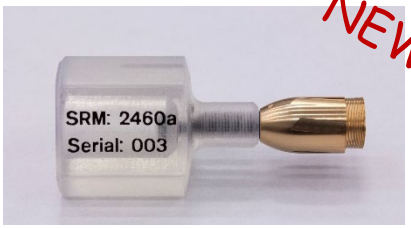


Physical Standards for Measurement Traceability and Quality control

- Provide SRM bullets and cartridge cases.
- Provide reference images for comparison.
- Laboratories regularly check their measurements with the reference.

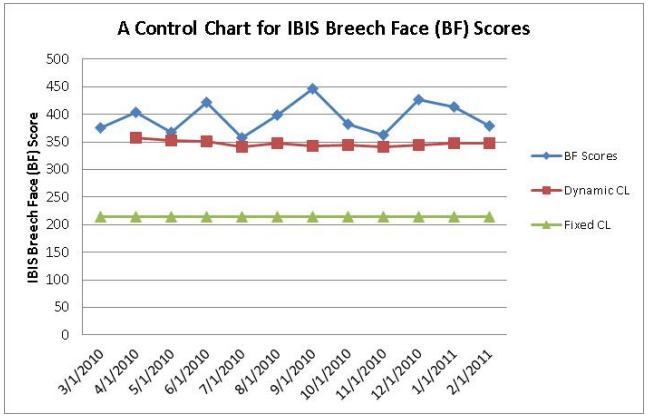
SRM 2460 Standard Bullet

NEW



SRM 2460a
Standard Bullet Replica

Enter measured image into NIBIN



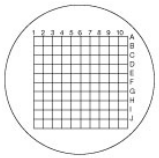
Track similarity score with reference image

SRM 2461 Standard
Cartridge Case

T. Vorburger, et al., "The Second National Ballistics Imaging Comparison (NBIC-2)," J. Res. Natl. Inst. Stand. Technol., 2014.

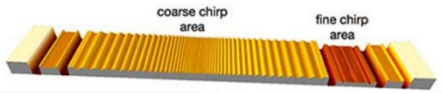
Standards for Individual Error Sources and Measurement Uncertainty Evaluation

2D grid

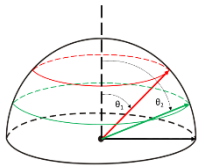


mirror

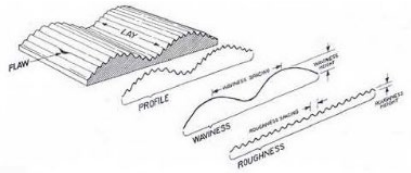
Chirped target



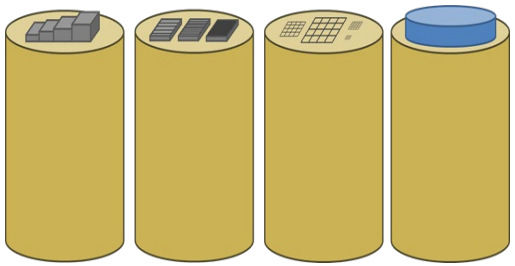
Half-sphere



roughness



Artifact Suite

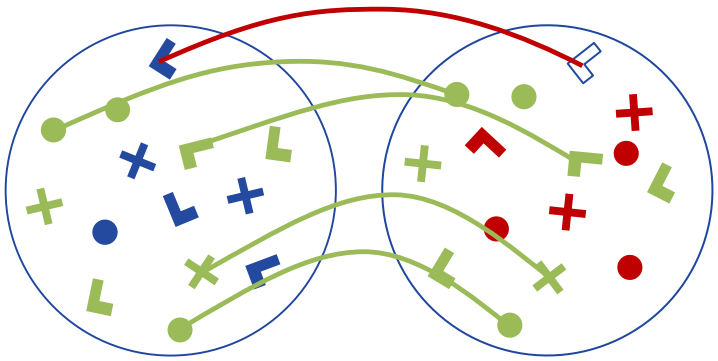


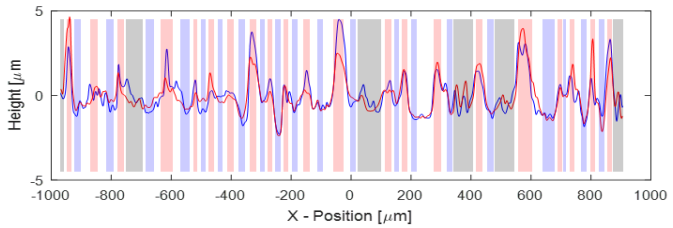
Results are applicable to a wider range of measurands and enable check of instrument specifications

Objective Similarity Metrics

Number/Quality of Matching Features

Reference Sample Questioned Sample

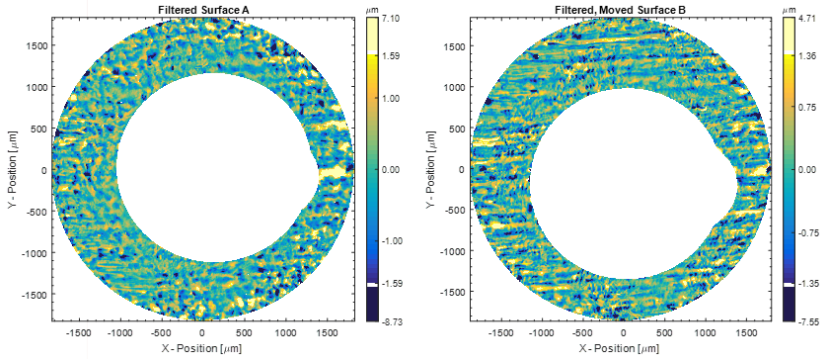


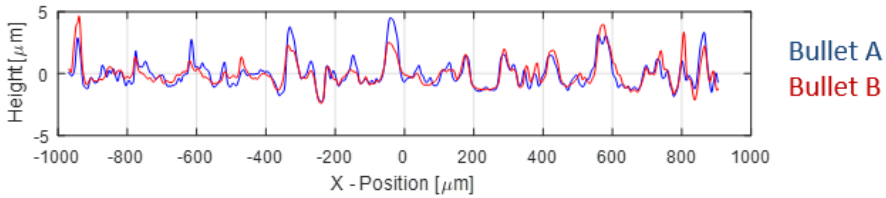


Congruent Matching Striae (*CMS*)

Area or Profile Similarity (e.g., correlation coefficient)

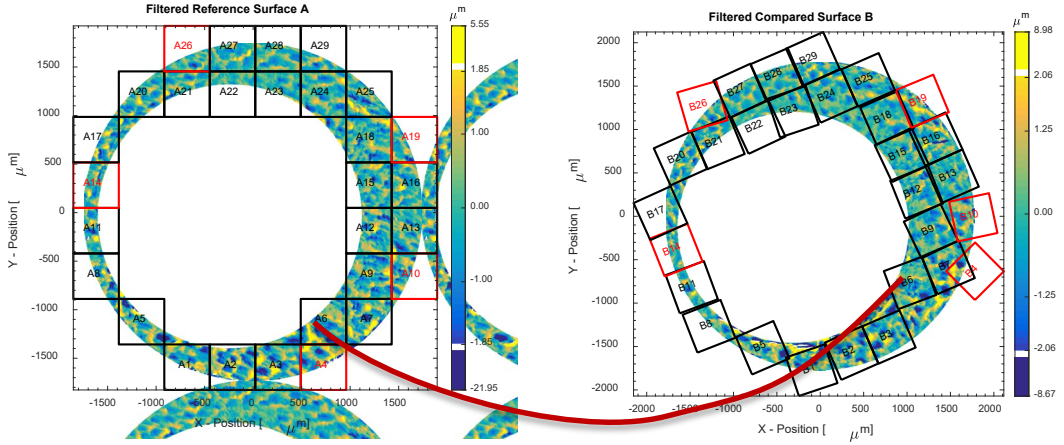
Reference Sample Questioned Sample





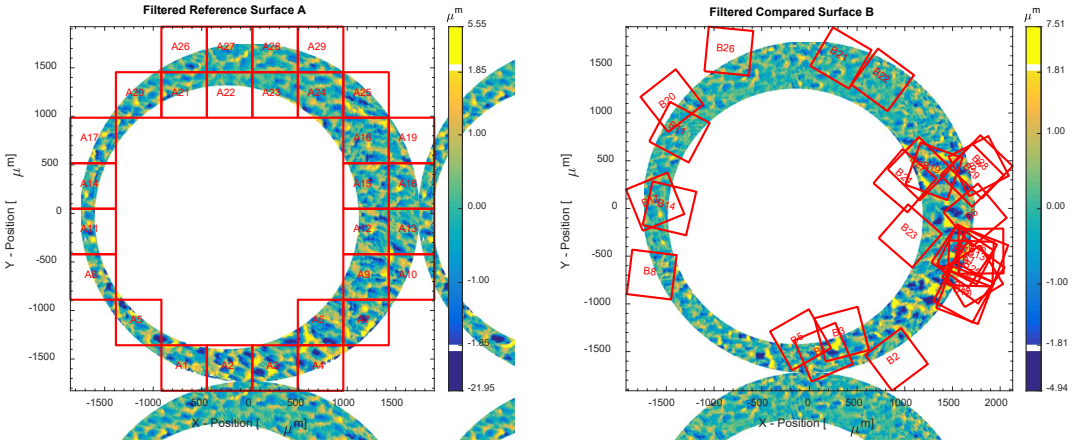
Congruent Matching Cells

Breech face impressions from the same firearm



24 CMCs

Breech face impressions from different firearms



0 CMCs

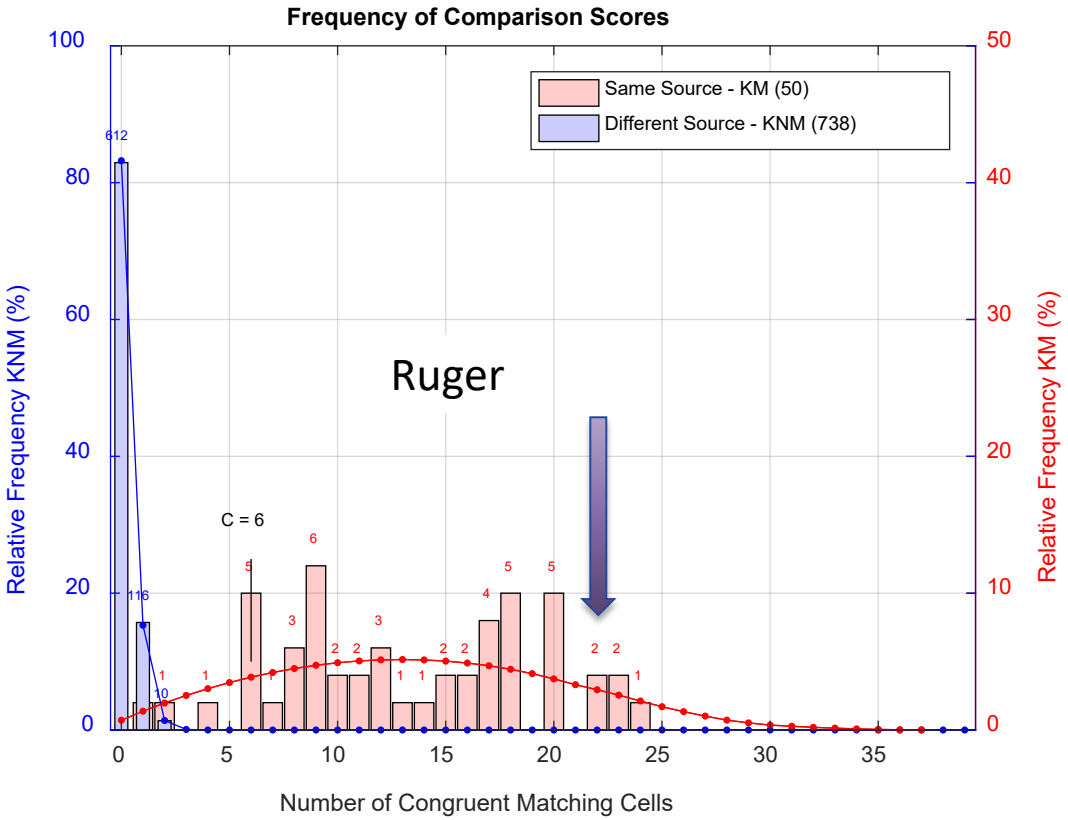
J. Song, "Proposed NIST Ballistics Identification System (NBIS) using 3D Topography Measurements on Correlation Cells", AFTE Journal, 45 (2), 184-194, 2013.

www.nist.gov/forensics/ballisticsdb

Open-access <u>research</u> database of firearm tool marks on bullets and cartridge cases:

- Firearms representing major class/subclass characteristics.
- Consecutively manufactured firearm components.
- Firearm firing many rounds (persistence/decay).
- Firearm firing different ammunition brands.
- Firearms known to present identification challenges.

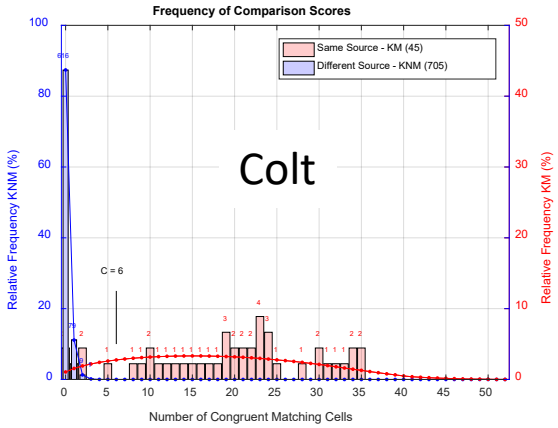
Characterizing the Weight of Evidence

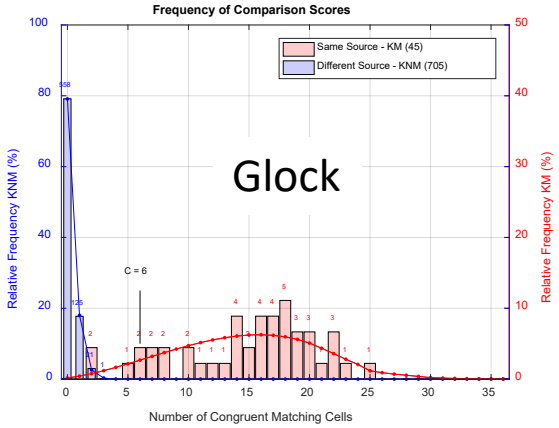


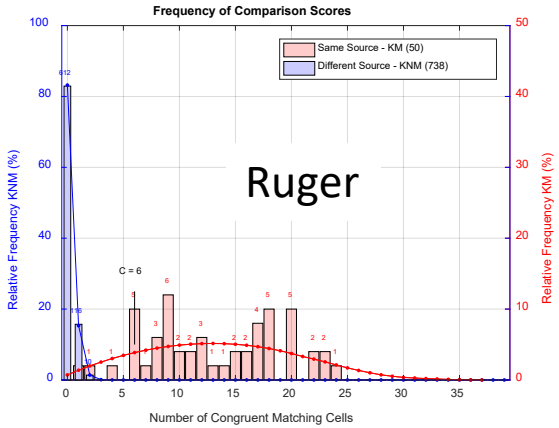
- Characterize score distributions for known matching and known non-matching comparisons
- Characterize the weight of evidence for a particular score
  - Error rates
  - Likelihood ratio
  - ….

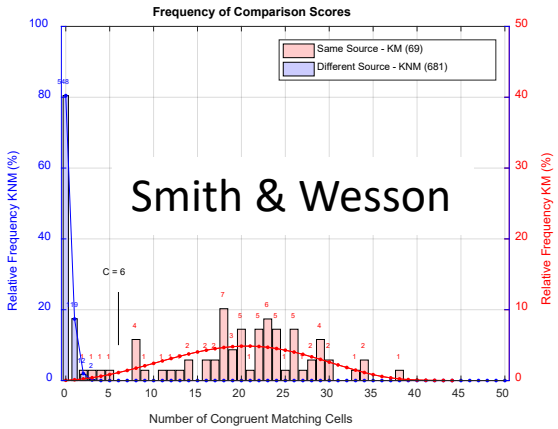
J.F. Song, et al., "Estimating Error Rates for Firearm Evidence Identifications in Forensic Science," Forensic Science International, Vol. 284, pp. 15-32, (March 2018)

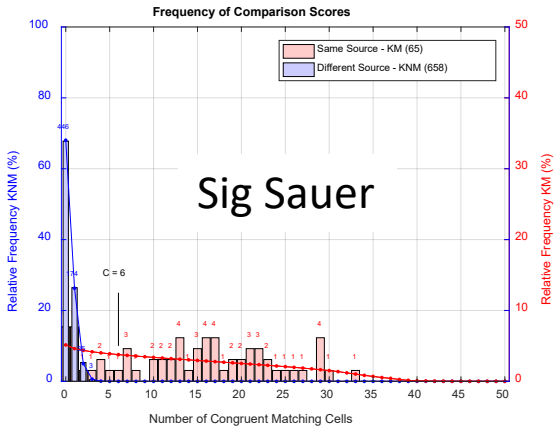
Initial Results “Population Study” (CMC Breech Face)







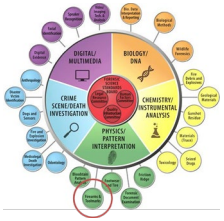


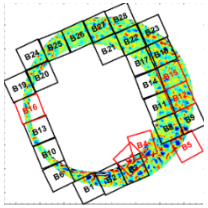


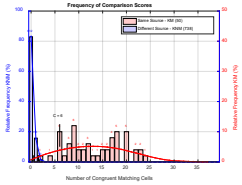
- **No sample triage.**
- **Consistent distribution of CMC scores for different-source comparisons.**
- **Results Indicate potential for low false positive error rates.**

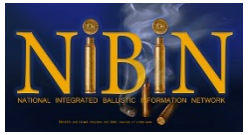
Major Activities

1. Quality assurance, reference artifacts, and documentary standards
2. Metrics and algorithms for objective identification
3. Tool mark database for research and validation
4. Quantitative evaluation weight of evidence
5. Specifications for NIBIN interoperability
6. Tool mark identification for non-firearm tools









ATF

Thank You

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