NIST Ballistics Toolmark Research Database

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Trace Evidence
Data Workshop
Improving Technology and
Measurement in Forensic Science

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 or the National Institute of Justice, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

Goal:

- Open-access <u>research</u> database of bullet and cartridge case toolmark data consisting of reflectance microscopy images and three dimensional surface topography data.

Motivation:

- Foster development and validation of methods, metrics, and uncertainty estimates for objective ballistics identification.

- Improve scientific knowledge base on the similarity of marks from different firearms and the variability of marks from the same firearm.

- Ease transition to application of 3D surface topography data.

- Remove the economic road block of acquiring large amounts of test fires and firearms.

Funding

- The NBTRD project was largely funded by the National Institute of Justice (2013-R2R-4843)

- Funding covered activities in 2014 and 2015.

Studies and test fires of interest

- Consecutively manufactured firearm components.
- Same firearm firing many rounds of ammunition (persistence/decay).
- Same firearm firing different brands of ammunition (pre-existing marks).
- Firearms known to present identification challenges.
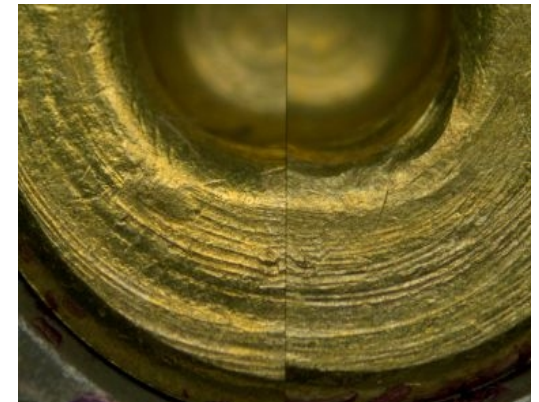- Firearms representing the major class/subclass characteristics.
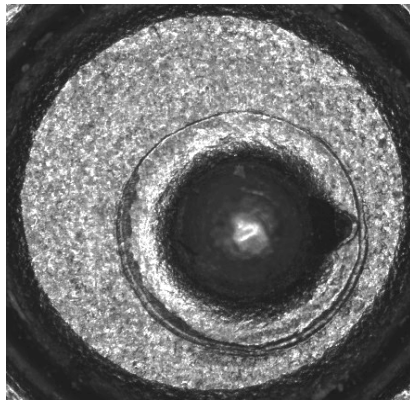
Random pattern of peaks and valleys
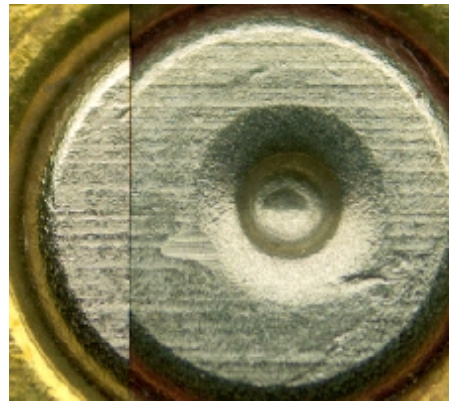
Source: AFTE

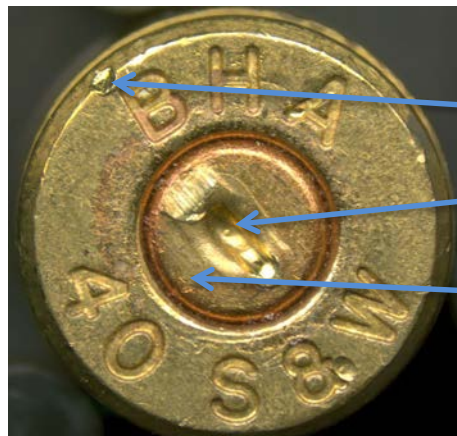Parallel lines

Source: AFTE

Concentric circles

Specimens and regions of interest

- Bullets (pristine): land engraving

Areas "engraved" by barrel lands

- Cartridge cases: breech face and firing pin impressions
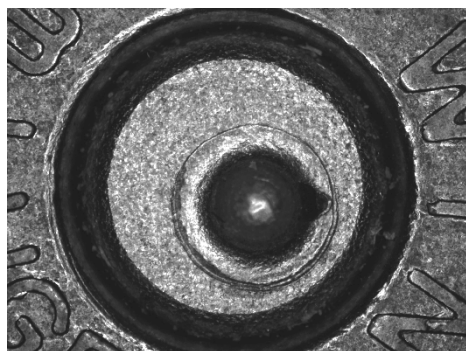

Ejector mark

Firing pin impression
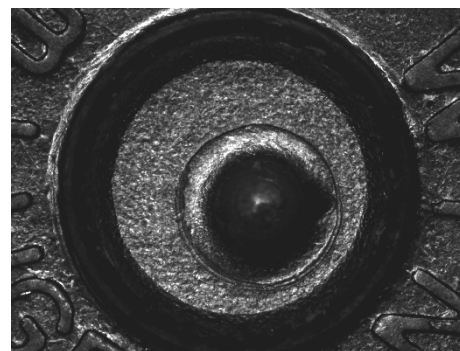
Breech face impression

Source: AFTE

NIST measurements: reflectance microscopy
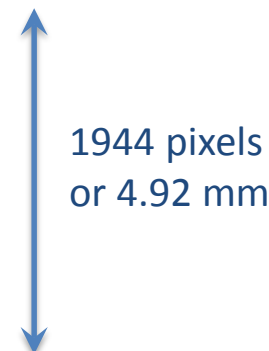
Forensic comparison Microscope

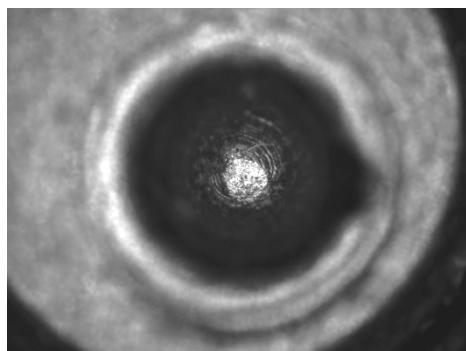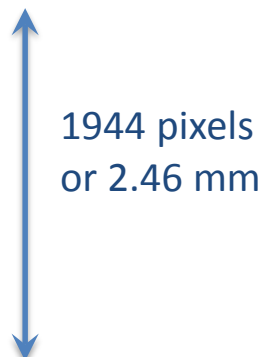- Breech face impression (2X objective, 2.53 µm mean pixel size).

Ring light illumination

6 o'clock side light illumination

1944 pixels
or 4.92 mm

- Firing pin impression (4X objective, 1.265 µm mean pixel size)

Ring light illumination

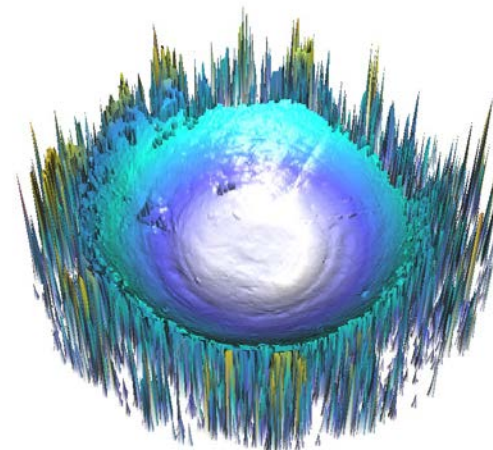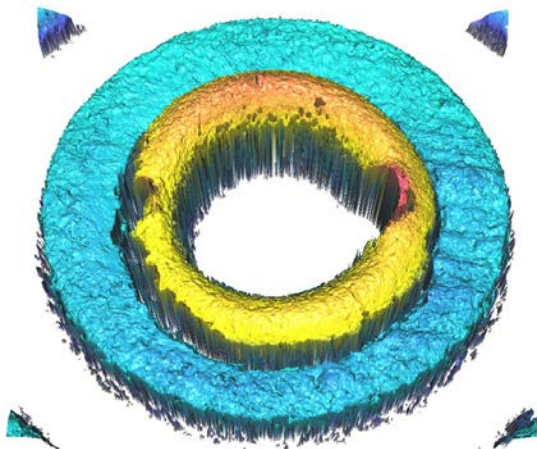1944 pixels
or 2.46 mm

Source: Leica

NIST measurements: 3D surface topography

Disc scanning confocal microscope

- Bullet land engraving (20X objective, 1.563 µm mean pixel size).

- Breech face impression
  (10X objective, 3.125 µm mean pixel size)

- Firing pin impression
 (20X objective, 1.563 µm mean pixel size)

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OpenFMC

- The Open Forensic Measurement Consortium is a group of researchers, instrument manufacturers, and practitioners.

- The goal of this group is to establish and implement a standard file exchange format for the exchange of 3D forensic topography measurements.

- Ensure interoperability between different instruments, algorithms, and agencies.

- Membership is open to interested parties, please contact Alan Zheng (alan.zheng@nist.gov)

Data transfer (measurement data)

Measurement data is provided as raw data (no trimming, leveling, form removal, filtering etc.):

Database user
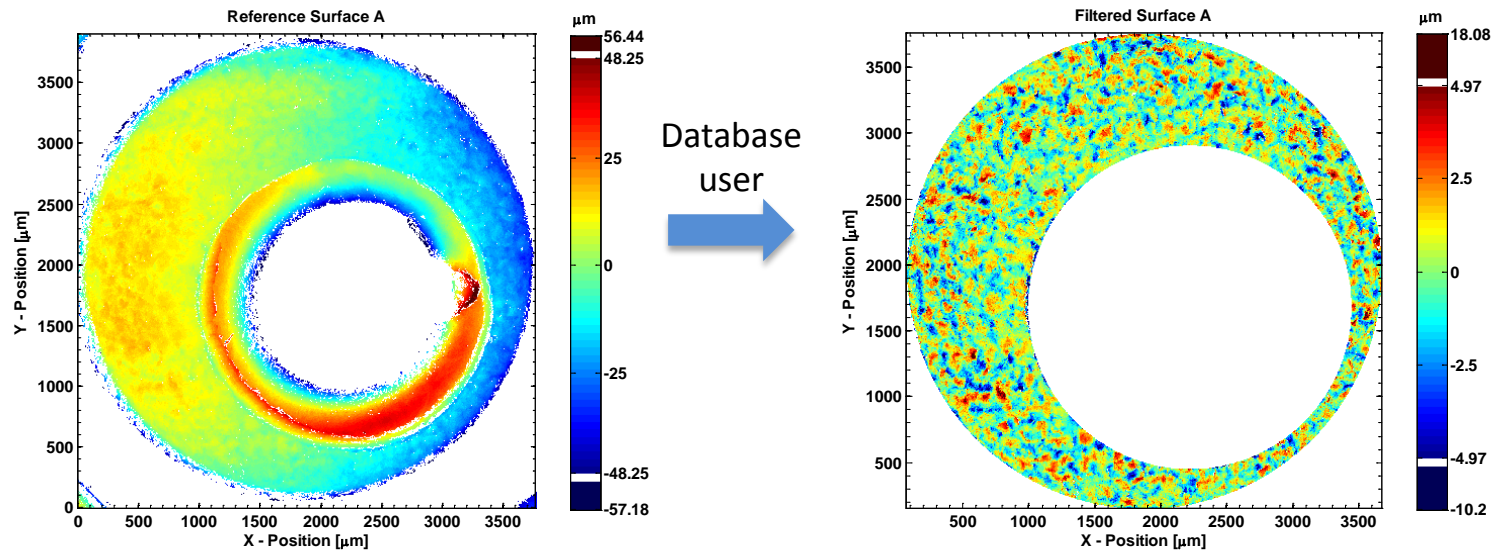
- Reflectance microscopy images in lossless TIFF format
- 3D topography data in X3P (XML 3D surface Profile):

Standard File Exchange Format

XML **3**D Surface **P**rofile (X3P) is defined in the draft

ISO 25178-72 standard (OpenGPS)

Each file contains 4 records:

1) Header, data types, and axes definition.

2) Meta data regarding the instrument and user.

3) Profile data (x, y, z)

4) Checksum of the xml-document

- Allows for extra XML meta data to be attached to the measurement file. This could include additional meta data on the firearm, ammunition, and measurement conditions.

- Open-source read/write functions and converters.

Cross-Modality Matching

TopMatch-GS 3D

Confocal Scan

?? Scan

X3P
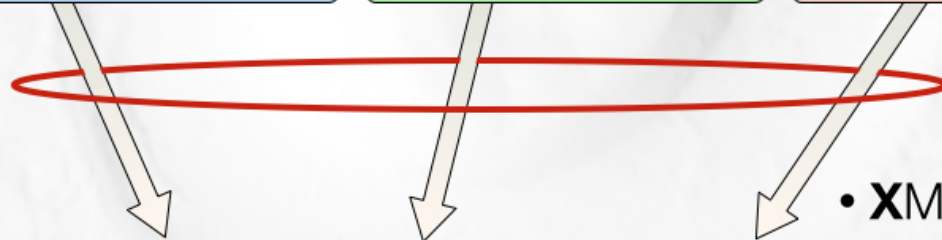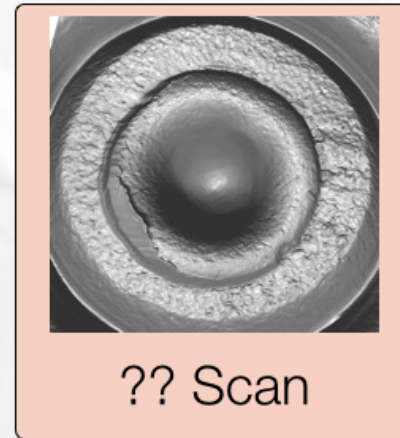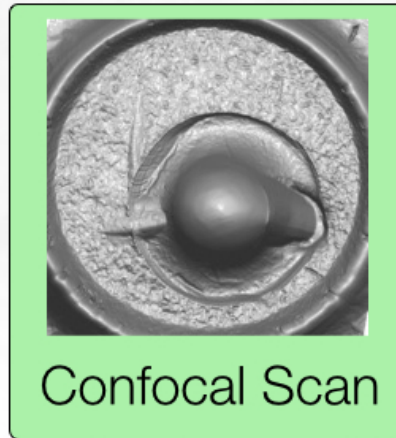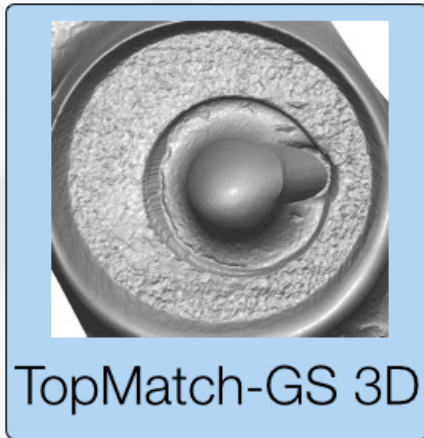
- **X**ML **3**D Surface **P**rofile
- Open format surface topography file structure
- Being adopted by several govt and industry groups

TopMatch Matching Software

Results from Cross-Modality Study

- Cadre research successfully imported NIST confocal data into their correlation software and was able to correctly identify all test fires.

- The same accuracy was achieved when comparing Cadre data vs NIST confocal data.

- This test demonstrates that X3P is a suitable format for interoperability between different instruments.

- Additional tests have been conducted between NIST and Cadre Research, FBI, John Jay College, and the Nederland Forensic Institute.
  - All exchanged data files have been successfully opened and verified.

Data transfer (meta data)

- Data is organized into toolmark studies
- Each study dataset has a spreadsheet with meta data.

Study:
- Name
- Creator
- Description
- Literature reference
- Has consecutive?
- Has persistence?
- Has different ammo?

Firearm:
- IdNumber
- Brand
- Model
- Caliber
- Firing pin class
- Breech face class
- Number of lands
- Twist direction

Bullet:
- IdNumber
- Brand
- Cartridge designation
- Lot number
- Nominal caliber
- Weight
- Surface Material
- Firing sequence
- Comments

Cartridge Case:
- IdNumber
- Brand
- Cartridge designation
- Lot number
- Nominal caliber
- Primer surface
- Firing sequence
- Comments

Bullet Measurement:
- File name
- Creator
- Measurement type
- Measurand
- Region of interest
- LEA or GEA number
- Instrument brand
- Instrument model
- Lateral resolution
- Vertical resolution
- Lighting type
- Objective magnification
- Objective NA
- Comments

Cartridge case Measurement:
- File name
- Creator
- Measurement type
- Measurand
- Has breech face?
- Has firing pin?
- Has ejector mark?
- Has aperture shear?
- Instrument brand
- Instrument model
- Lateral resolution
- Vertical resolution
- Lighting type
- Objective magnification
- Objective NA
- Comments

Crowdsourcing Data

To achieve a truly diverse and representative database, NIST cannot do this alone. It requires the help of the firearms forensic community
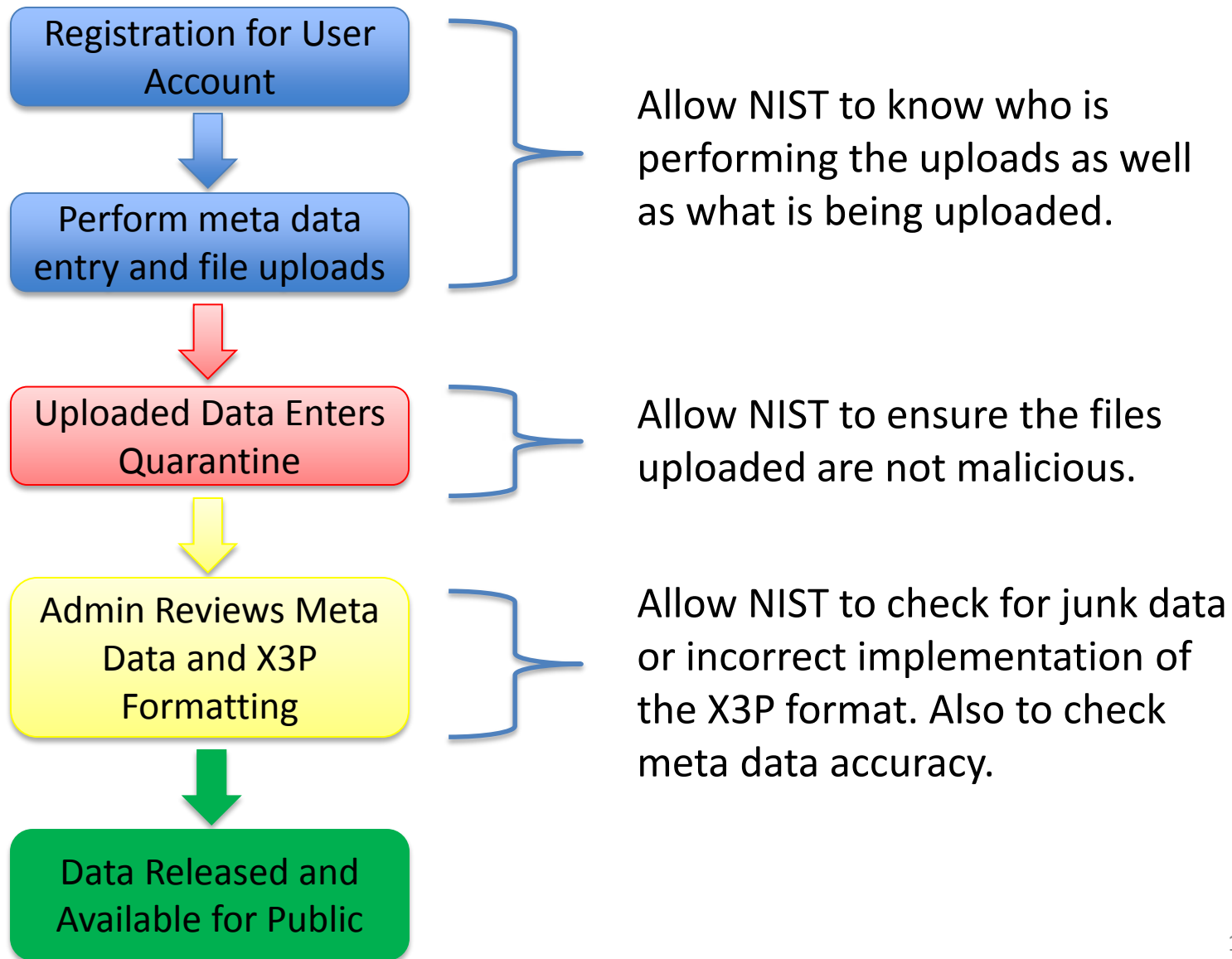
Outreach

Presentations:

- Association of Firearms and Toolmark Examiners (AFTE) conference (Seattle 2014, Dallas 2015).

- American Academy of Forensic Sciences (AAFS) conference (Seattle 2014, Orlando, 2015).

- Forensics@NIST 2014 Conference.

- Research Triangle International (RTI) 3D Optical Metrology Working Group 2015.

- Eastern Regional AFTE Conference (2015 Quantico, VA)

- Various Lab Tours

Collaborators

Upload Process and Quality Checks

Registration for User Account

Perform meta data entry and file uploads

Allow NIST to know who is performing the uploads as well as what is being uploaded.

Uploaded Data Enters Quarantine

Allow NIST to ensure the files uploaded are not malicious.

Admin Reviews Meta Data and X3P Formatting

Allow NIST to check for junk data or incorrect implementation of the X3P format. Also to check meta data accuracy.

Data Released and Available for Public

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Performance Metrics

- Number of test fires entered into the database.
    - There are currently over 1600 test fires with thousands coming from the FBI.

- Number of unique visitors to the website.
    - Web statistics will be tracked by Google Analytics

- Number of downloads for each study/file.
    - In phase 3 of the database, reports can be generated showing data usage statistics.

- Publications from research using the NBTRD.
    - Three universities have already accessed the Ballistics Toolmark Database for their research. One have already published and presented their research using data from NBTRD.
    - NIST plans on datamining the database for error rate research.

Future of the NBTRD

- Phase 3 of the development will focus on:
  - Ensuring data accessibility and integrity
  - Administrative reporting functions
  - Streamlining data uploads
  - More discriminative search results

Management of the NBTRD will be the responsibility of the Forensic Topography Analysis Project.

- Main administrators: Xiaoyu Alan Zheng and Johannes Soons.

OISM will maintain the IT infrastructure and database integrity.

http://www.nist.gov/forensics/ballisticsdb

Thanks for your attention!

Questions?

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