Scientific Foundation of Firearms and Toolmark Identification

7 JUN 2013

Purpose: To provide members of the legal community the scientific underpinnings of forensic firearm and toolmark analysis, its compliance with applicable scientific criteria for admission under Daubert and Frye standards, and associated published research substantiating the discipline

Agenda

- Firearm and Toolmark Theory
- Class, Individual, and Subclass characteristics
- Testability of Scientific Principle
- Known Error Rate
- Peer Review/Publication
- Acceptance in Relevant Field
- Use of Standards and Controls

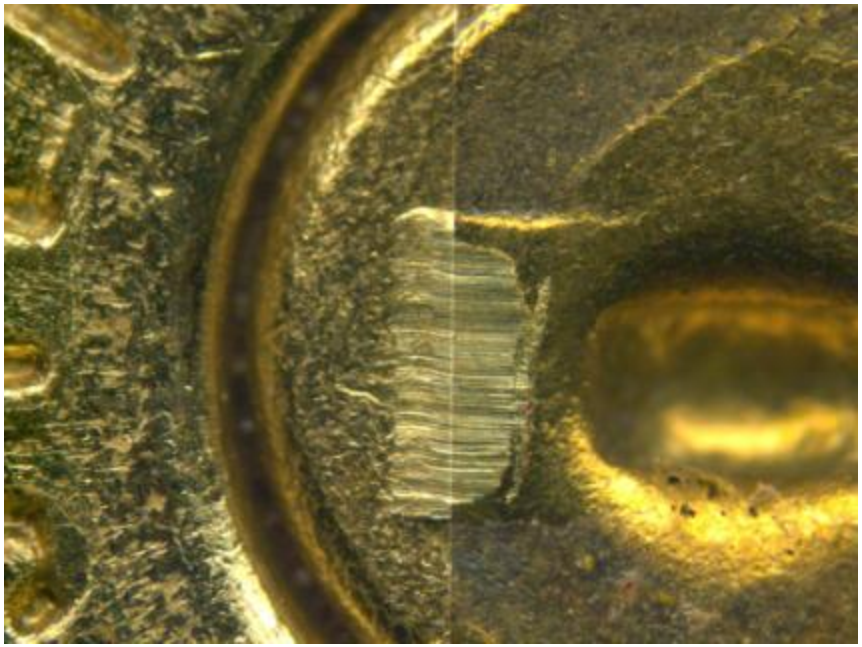
Firearm and Toolmark Theory

- Proposition #1 – Most manufacturing processes involve the transfer of rapidly changing or random marks onto work pieces such as gun barrels, breech faces, knife blades, and screwdriver tips. This is caused principally by the phenomena of tool wear and chip formation or by electrical/chemical erosion. Microscopic marks on tools will then continue to change from further wear, corrosion, and abuse.

Tools for creating rifling in firearm barrels; gang broach (top) and button (bottom).

Firearm and Toolmark Theory

- Proposition #2 – Toolmarks imparted to objects by different tools will rarely, if ever, display agreement sufficient to lead a qualified examiner to conclude the objects were marked by the same tool. Likewise, those objects with sufficient agreement can be said to have a common origin, or to have come from the same tool.



Theory of Identification

- The theory of identification as it pertains to the comparison of toolmarks enables opinions of common origin to be made when the unique surface contours of two toolmarks are in "sufficient agreement."
- This "sufficient agreement" is related to the significant duplication of random toolmarks as evidenced by the correspondence of a pattern or combination of patterns of surface contours.
- Significance is determined by the comparative examination of two or more sets of surface contour patterns comprised of individual peaks, ridges and furrows. Specifically, the relative height or depth, width, curvature and spatial relationship of the individual peaks, ridges and furrows within one set of surface contours are defined and compared to the corresponding features in the second set of surface contours.
- **Agreement is significant when it exceeds the best agreement demonstrated between toolmarks known to have been produced by different tools and is consistent with agreement demonstrated by toolmarks known to have been produced by the same tool.**
- **The statement that "sufficient agreement" exists between two toolmarks means that the agreement is of a quantity and quality that the likelihood another tool could have made the mark is so remote as to be considered a practical impossibility.**

Subjectivity

- Currently the interpretation of individualization/identification is subjective in nature, founded on scientific principles and based on the examiner's training and experience.
- Subjective does not mean unscientific and does not imply a need to be quantifiable. Many people recognize the shapes and patterns of facial features for identity every day and "trained/experienced" individuals can tell the difference between identical twins.
- All science involves some subjectivity whether it is reading an analog instrument or a doctor diagnosing an illness.
- The subjective criteria of identification of firearm and toolmark examiners is based on personally observing thousands of known matches and known non-matches. This is an **objective** conclusion (meaning based on observation; without bias or opinion) based on a **subjective** interpretation.

Match vs. Non-Match

- Almost all fired components with similar class characteristics have some matching striated lines
- Fired components known to be fired from the same gun will always have some matching striated lines as well as some that differ
- Firearm and toolmark identification is based on matching patterns of lines, not individual, scattered lines and these have been shown to be unique both statistically* and empirically†
- Identifications based on both quantity and quality of individual characteristics

* *Biasotti-1959, Bracket-1970, Blackwell & Framan-1980, Deinet-1981, and Uchiyama-1988 and 1992*

† *Tulleners, Giusto, & Hamiel-1998, Tulleners, Stoney & Hamiel-1998, Miller-1998, and Miller 2000*

Class Characteristics

Measurable features of a specimen which indicate a restricted group source. They result from design factors, and are therefore determined prior to manufacture.

Class characteristics Illustrated on cartridge cases (above) and fired bullet (left)

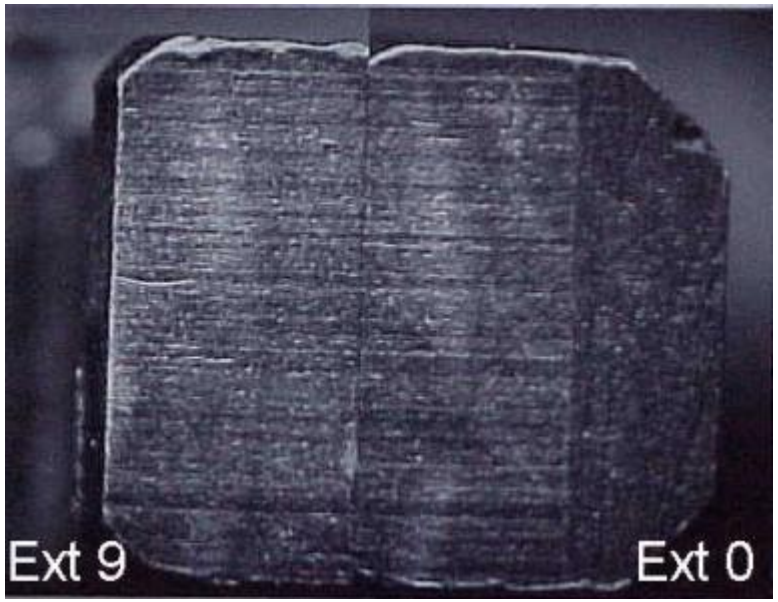
Source: Association of Firearm and Toolmark Examiner (AFTE) Glossary 5th Edition

Subclass Characteristics

- Discernible surface features of an object which are more restrictive than **CLASS CHARACTERISTICS in that they are:**

- Produced incidental to manufacture.
- Are significant in that they relate to a smaller group source (a subset of the class to which they belong).
- Can arise from a source which changes over time.
- Examples would include: bunter marks, extrusion marks on pipe, etc.

- (Caution should be exercised in distinguishing subclass characteristics from **INDIVIDUAL CHARACTERISTICS.)**

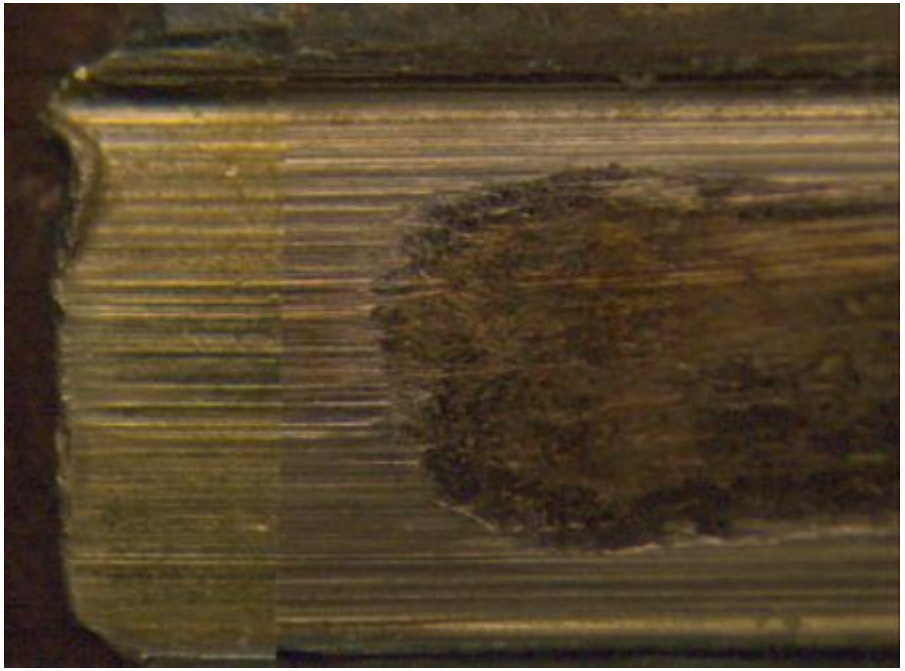


Sublclass marks present on consecutively manufactured extractors. Of note, this study concluded that the subclass marks were NOT transferred to the tool surfaces and did not hinder identification

Source: Association of Firearm and Toolmark Examiner (AFTE) Glossary 5th Edition

Individual Characteristics

Marks produced by the random imperfections or irregularities of tool surfaces. These random imperfections or irregularities are produced incidental to manufacture and/or caused by use, corrosion, or damage. They are unique to that tool and distinguish it from all other tools.



Identification based on individual characteristics from the land of a firearm barrel imparted onto the surface of a bullet

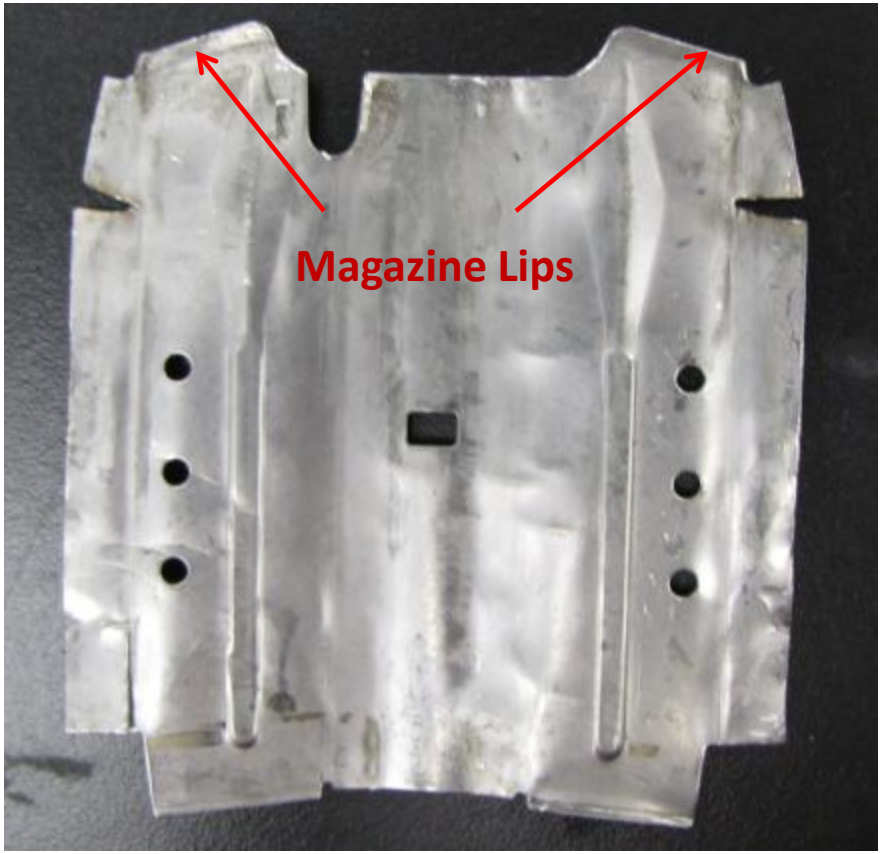
Source: Association of Firearm and Toolmark Examiner (AFTE) Glossary 5th Edition

Identity

- There is no way to be ABSOLUTELY certain of any identification without comparison to marks from every particular tool in existence, ever made, or ever will be made. This is impossible.
- All firearm and toolmark examinations can conclude is that a conclusion is one of “practical certainty” or has made an identification “to a reasonable degree of scientific certainty”

Steps in Magazine Production

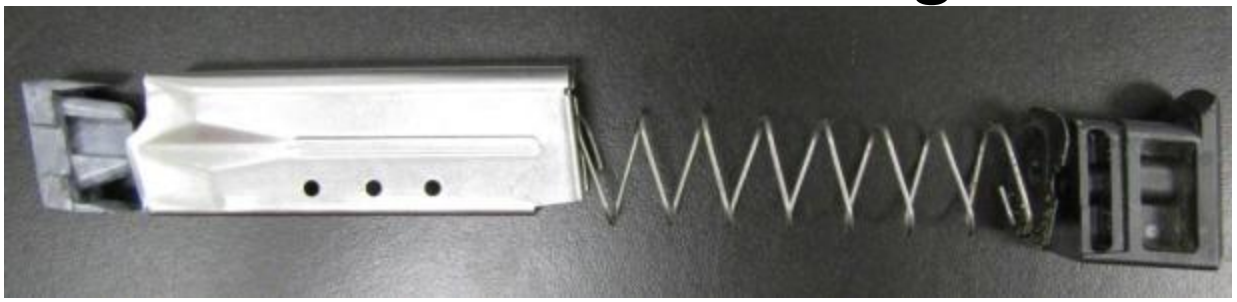
Magazines begin as a flat sheet of metal which is stamped from a large, hydraulic press that exerts several tons of pressure.



Steps in Magazine Production (Cont)

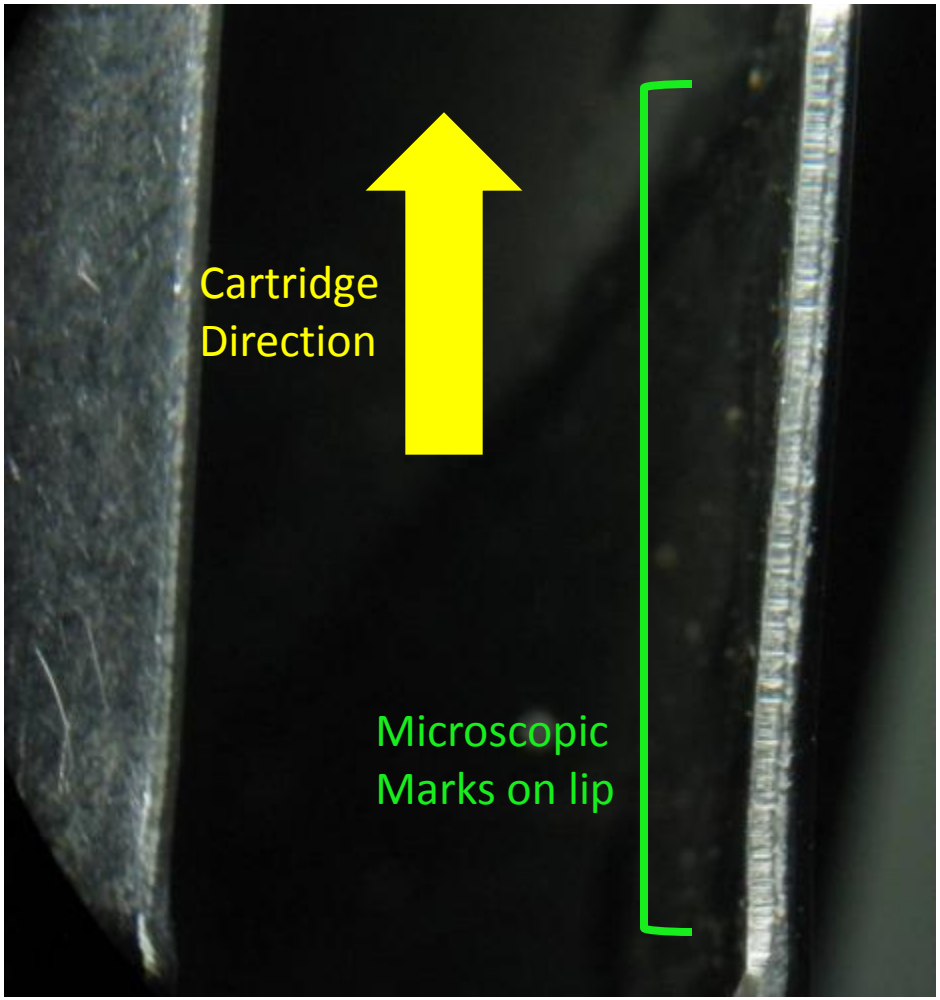
The flat sheet of metal is folded into a rectangle and then welded across the back.

The follower, spring and floor plate are attached to the assembled magazine.

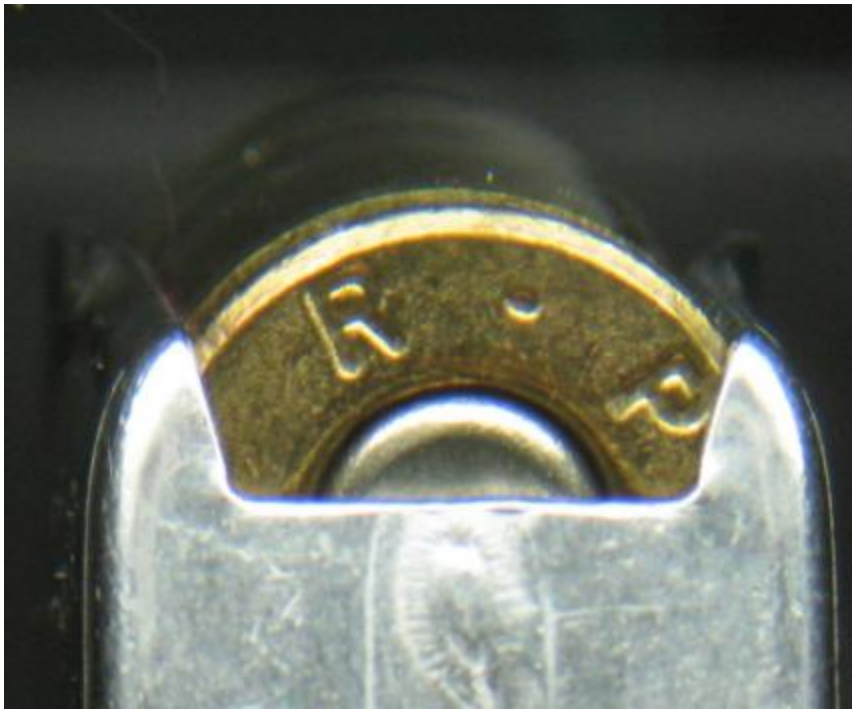


Microscopic Marks on Magazines

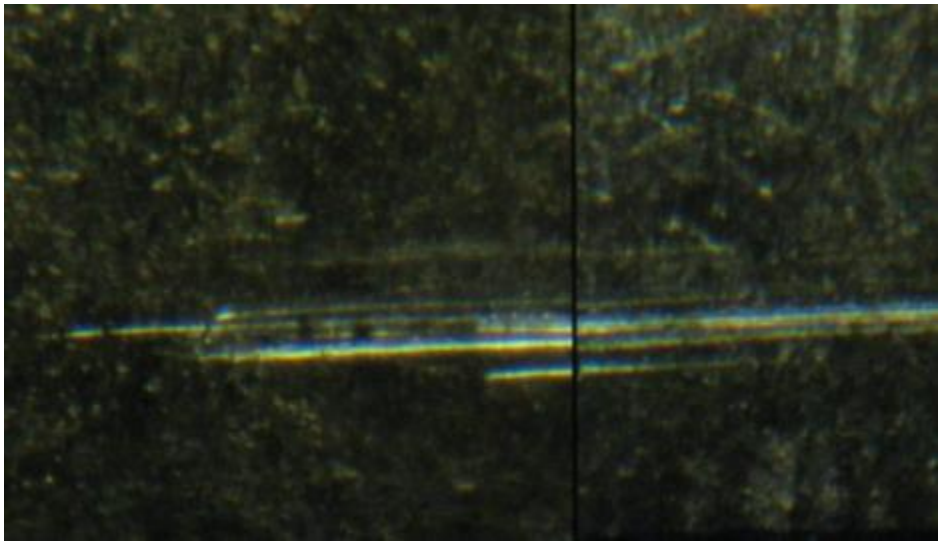
The downward force of the press leave microscopic marks on the edges of the magazine lips. The cartridges then move perpendicularly to these marks which leave a series of irregular marks on the bodies of the cases.



Microscopic Marks on Magazines



Cartridge loaded into the finished magazine



Photomicrograph of a magazine lip mark between two cartridges loaded into the same magazine

Testability of Scientific Principle

- Consecutive Manufacture Studies
  - Worst case scenarios with potential for most agreement and most subclass carryover
    - Matty-1984 Smith & Wesson firing pins
    - Matty-1984 Raven .25 Auto breech faces
    - Watson-1978 Knives
    - Tuira-1982 Knives
    - Brundage-1994 Ruger Pistol Barrels
- Other "Black Box" Validation Studies
  - Bunch & Murphy-2003 0% error rate
  - De France-2003 0% error rate
  - Thompson & Wyant-2005 .78% error rate
  - Smith-2005 0% error rate
  - Orench-2005 0% error rate

Known Error Rate

- Error Rate can be calculated by use of annual proficiency tests
  - Designed to test competence of lab system, not validity of technique
  - Used primarily as a quality assurance device
  - Not all participants are trained examiners
  - Not anonymous
  - May be subject to less review
- Based on data from Collaborative Testing Services Proficiency tests:
  - 1.4% of those taking the firearms tests made a false identification or elimination
  - 4% of those taking the toolmark tests made a false identification or elimination

Source: Peterson and Markham-1995

Peer Review/Publication

- Association of Firearm and Toolmark Examiners (AFTE) Journal
  - Primary professional, peer reviewed journal for firearm and toolmark community
  - Extensive pre-publication and post-publication review process
  - Published since 1969
- Articles also published in *Forensic Science International* and *Journal of Forensic Science*

Articles Related to Magazine Marks

- Bouley, B. "Determination of Firing Sequence by Cartridge Case Markings." AFTE Journal, vol. 27 (3), Summer 1995, pp. 237-241.
- Clark, J. "An Interesting Magazine Mark." AFTE Journal, vol. 35 (1) Winter, pp. 71.
- Clow, C. "Bullets and Cartridge Cases Identified to a Single Unknown Firearm Using Magazine Marks." AFTE Journal, vol. 40 (3) Summer 2008, pp. 309-311.
- Moran, B. "The Application of Numerical Criteria for Identification in Casework Involving Magazine Marks and Land Impressions." AFTE Journal, vol. 32 (4) Fall 2000, pp. 326-331.
- Moran, B. "The Application of Numerical Criteria for Identification in Casework Involving Magazine Marks and Land Impressions." AFTE Journal, vol. 33 (1) Winter 2001, pp. 41-46.
- Siso R. and Kasachesko, P. "Magazine Marks on the Base of Cartridge Cases." AFTE Journal, vol. 41 (2) Spring 2000, pp. 176-183.
- Thompson E. and Wyant, R. "Magazine Lip Marks on Consecutively Made Magazines." AFTE Journal, vol. 38 (1) Winter 2006, pp. 48-50.

Acceptance in Field

- Scientific Working Group on Firearm and Toolmark Examination (SWGGUN)
- AFTE growing body dedicated to research on the scientific underpinnings of firearm and toolmark examination
- Recognized forensic discipline in the US since the 1930s with Firearms examiners at TX DPS since 1935
- Forensic firearm and toolmark analysis admitted in courts since *Commonwealth of Massachusetts v. Best* in 1902

Use of Standards and Controls

- Adherence to Standard Operating Procedures
  - Verification
  - Laboratory Accreditation
  - Internal/External Audits
  - 100% Technical Reviews
  - 100% Administrative Reviews
- Proficiency Testing
- Continuing Education

Firearms and the Scientific Method

Identify Problem	Do Background Research	Construct Hypothesis	Test With an Experiment	Draw Conclusion	Report Results
• Was this cartridge loaded in the same magazine as this fired cartridge case?	• Do class characteristics match?	• Class characteristics agree; cartridge / cartridge case may have been loaded in the same magazine • Class characteristics do not agree, cartridge / cartridge cases not loaded into same magazine	• Microscopically compare submitted evidence items to each other	• Microscopic marks agree that exceeds best known non-match; evidence was loaded into the same magazine	• Issue Report • Testify in court