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Reference Bullets and Cartridge Cases for Automated Ballistics Inspection Systems

T.V. Vorburger (tvtv@nist.gov), W. Chu, A. Zheng, T.B. Renegar, J. Yen, J.F. Song, J.A. Soons, R.M. Thompson
National Institute of Standards and Technology (NIST)
Gaithersburg, MD

M.G. Ols
Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF)
Ammendale, MD

AAFS 66th Annual Scientific Mtg.
Seattle, WA
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Contents

- Introduction to SRM Bullets and Cartridge Cases
- Topography and Microscopy Images of SRM Cartridge Cases
- Reproducibility
- Traceability and User Acquisition
- Availability

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Funding Provided by

- National Institute of Justice
  NIST Law Enforcement Standards Office
  NIST Standard Reference Materials Program

Note:
Certain commercial equipment may be identified in this presentation in order to specify an experimental procedure. This does not imply recommendation or endorsement by NIST, nor does it imply that the equipment are the best available for the purpose.

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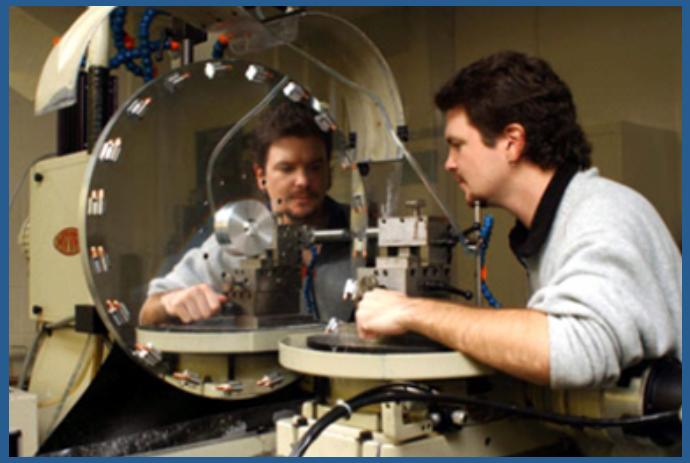
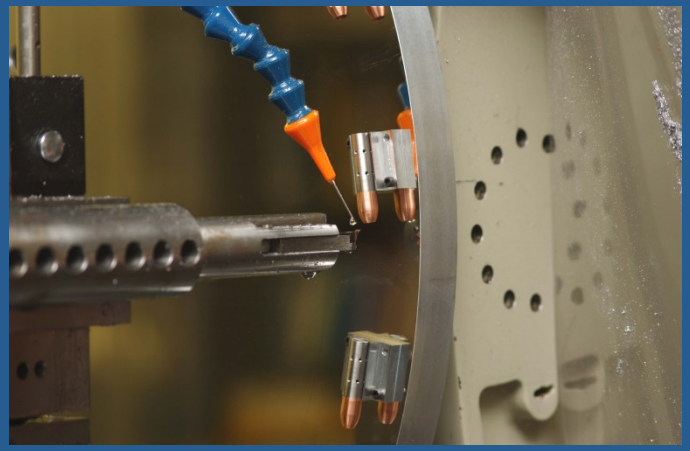
SRM 2460 Standard Bullet and SRM 2461 Standard Cartridge Case

- For demonstrating consistency in image acquisitions of bullets and cartridge cases from place to place
- Aimed at automated ballistic inspection systems, such as those in the National Integrated Ballistic Information Network (NIBIN)
- Requires high degree of similarity from one SRM unit to another

SRM 2460 Standard Bullets manufactured by numerically controlled diamond turning





40 SRM Bullets were produced and distributed.

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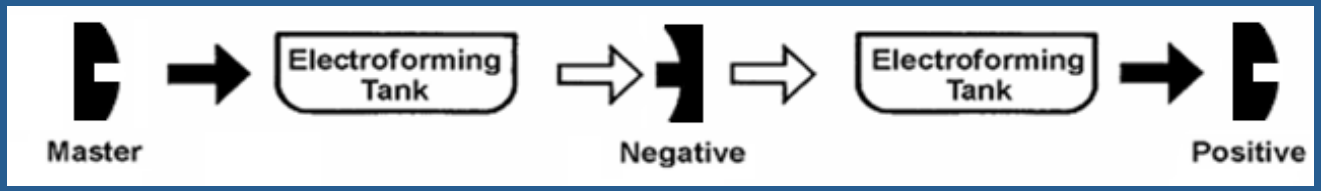
SRM 2461 Standard Cartridge Cases manufactured by commercial electroforming

- Negatives are made from a master cartridge case
- Positive replicas are then made from the negatives



SRM Cartridge Cases became available in July 2012.

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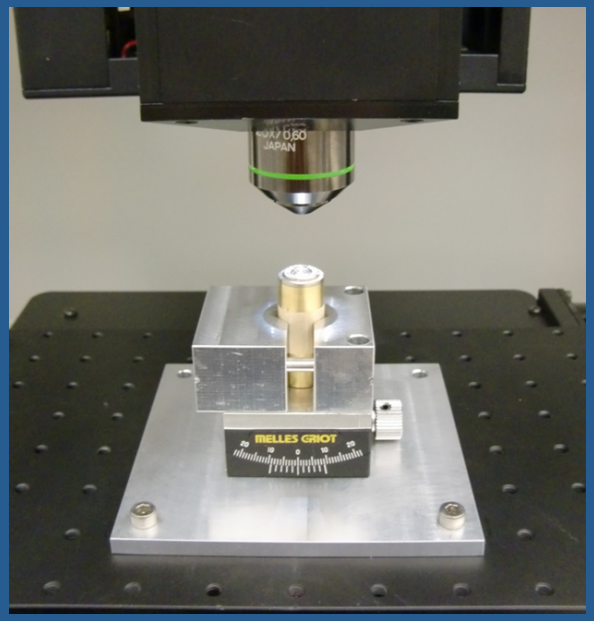
Image Acquisition

Confocal microscopy used to acquire 3D surface topography images of SRM Cartridge Cases



NIBIN stations at ATF's National Laboratory Center used to acquire optical microscope images of SRM Cartridge Cases.

Photo: www.forensictechnology.com

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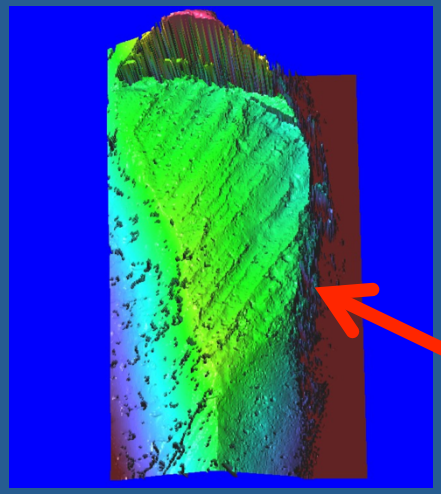
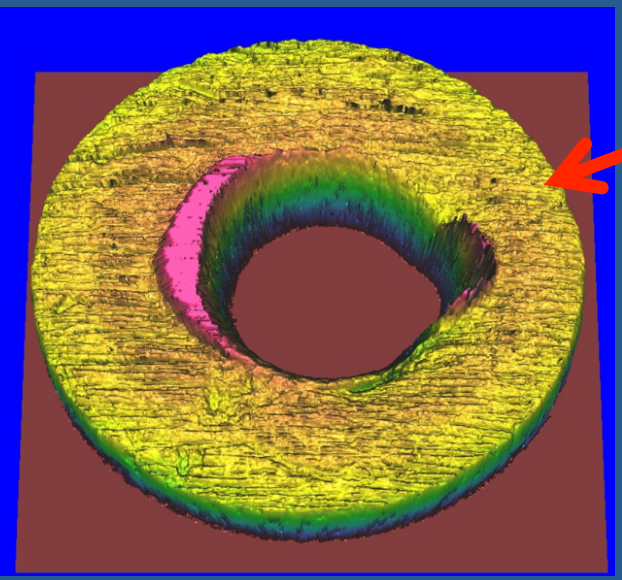
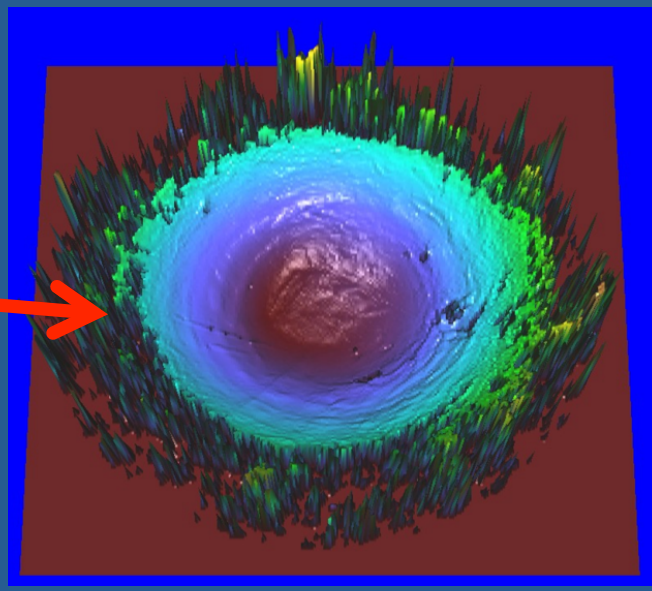
Topography Images for a SRM Cartridge Case



Ejector mark



Breech Face



Firing Pin

These images should be essentially **the same** for all units of the SRM.

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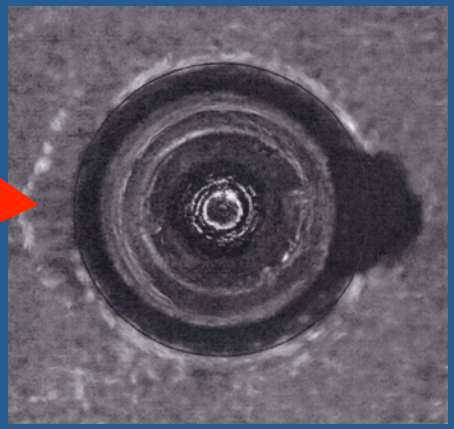
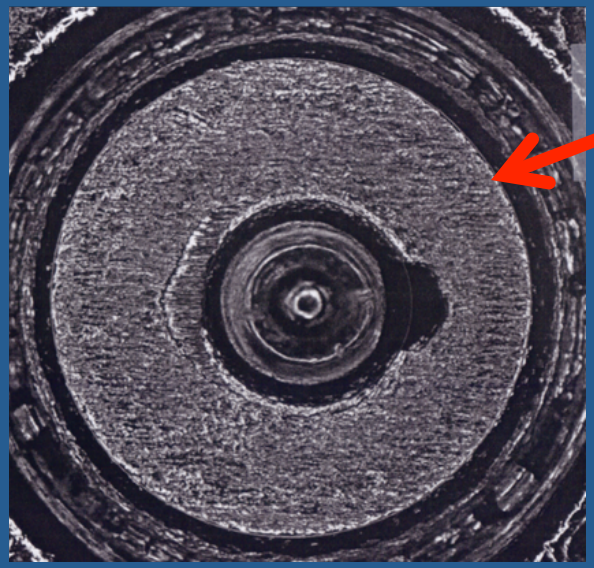
NIBIN *Golden Images* for the Standard Cartridge Case Using Optical Microscopy at ATF National Lab. Ctr.

Ejector mark



Firing Pin



Breech Face

These images should be essentially **the same** for all units of the SRM.

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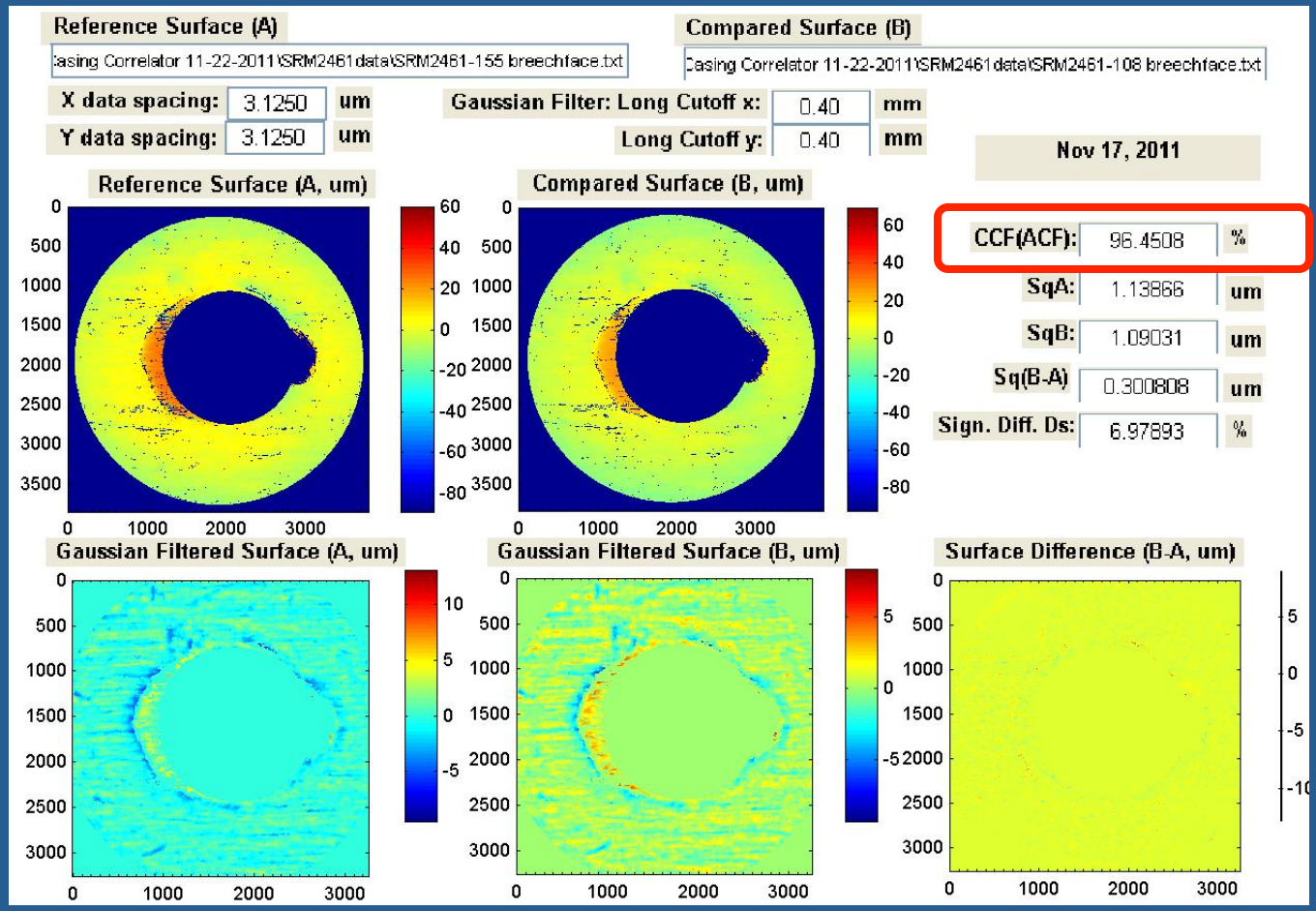
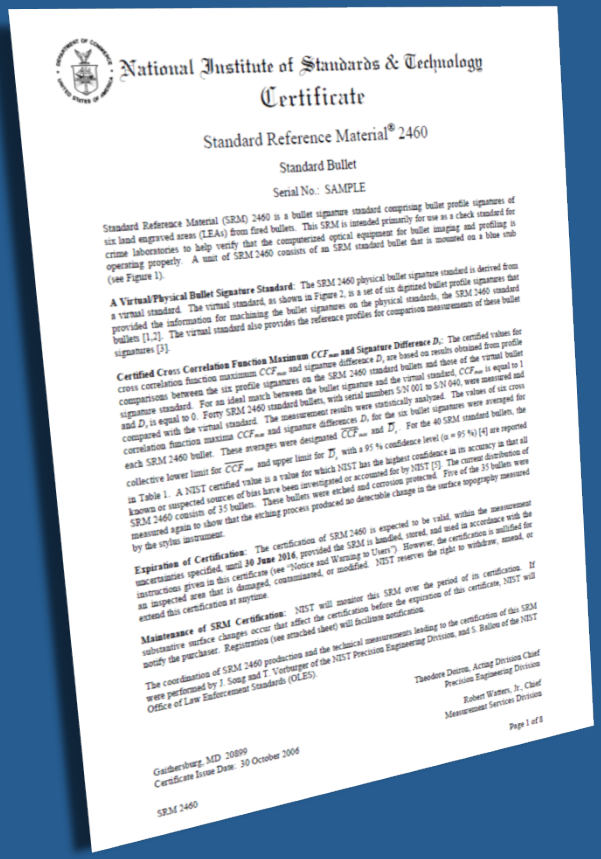
SRM 2461 Analysis – Breech Face



Processing steps:

- Trimming
- Removal of outlier data
- Form & noise filtering
- Image registration
- Correlation calculation



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Certificate

Standard Reference Material® 2460

Standard Bullet

Serial No.: SAMPLE

Standard Reference Material (SRM) 2460 is a bullet signature standard comprising bullet profile signatures of six land engraved areas (LEAs) from fired bullets. This SRM is intended primarily for use as a check standard for crime laboratories to help verify that the computerized optical equipment for bullet imaging and profiling is operating properly. A unit of SRM 2460 consists of an SRM standard bullet that is mounted on a blue stub (see Figure 1).

A Virtual/Physical Bullet Signature Standard: The SRM 2460 physical bullet signature standard is derived from a virtual standard. The virtual standard, as shown in Figure 2, is a set of six digitized bullet profile signatures that provided the information for machining the bullet signatures on the physical standards, the SRM 2460 standard bullets [1,2]. The virtual standard also provides the reference profiles for comparison measurements of these bullet signatures [3].

Certified Cross Correlation Function Maximum CCF_{max} and Signature Difference D_s: The certified values for cross correlation function maximum CCF_{max} and signature difference D_s are based on results obtained from profile comparisons between the six profile signatures on the SRM 2460 standard bullets and those of the virtual bullet signature standard. For an ideal match between the bullet signature and the virtual standard, CCF_{max} is equal to 1 and D_s is equal to 0. Forty SRM 2460 standard bullets, with serial numbers S/N 001 to S/N 040, were measured and compared with the virtual standard. The measurement results were statistically analyzed. The values of six cross correlation function maxima CCF_{max} and signature differences D_s for the six bullet signatures were averaged for each SRM 2460 bullet. These averages were designated $\overline{CCF}_{max}$ and $\overline{D}_s$. For the 40 SRM standard bullets, the collective lower limit for $\overline{CCF}_{max}$ and upper limit for $\overline{D}_s$ with a 95 % confidence level (α = 95 %) [4] are reported in Table 1. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or accounted for by NIST [5]. The current distribution of SRM 2460 consists of 35 bullets. These bullets were etched and corrosion protected. Five of the 35 bullets were measured again to show that the etching process produced no detectable change in the surface topography measured by the stylus instrument.

Expiration of Certification: The certification of SRM 2460 is expected to be valid, within the measurement uncertainties specified, until **30 June 2016**, provided the SRM is handled, stored, and used in accordance with the instructions given in this certificate (see "Notice and Warning to Users"). However, the certification is nullified for an inspected area that is damaged, contaminated, or modified. NIST reserves the right to withdraw, amend, or extend this certification at anytime.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive surface changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The coordination of SRM 2460 production and the technical measurements leading to the certification of this SRM were performed by J. Song and T. Vorburger of the NIST Precision Engineering Division, and S. Ballou of the NIST Office of Law Enforcement Standards (OLES).

Theodore Doiron, Acting Division Chief
Precision Engineering Division

Robert Watters, Jr., Chief
Measurement Services Division

Gaithersburg, MD 20899
Certificate Issue Date: 30 October 2006

SRM 2460

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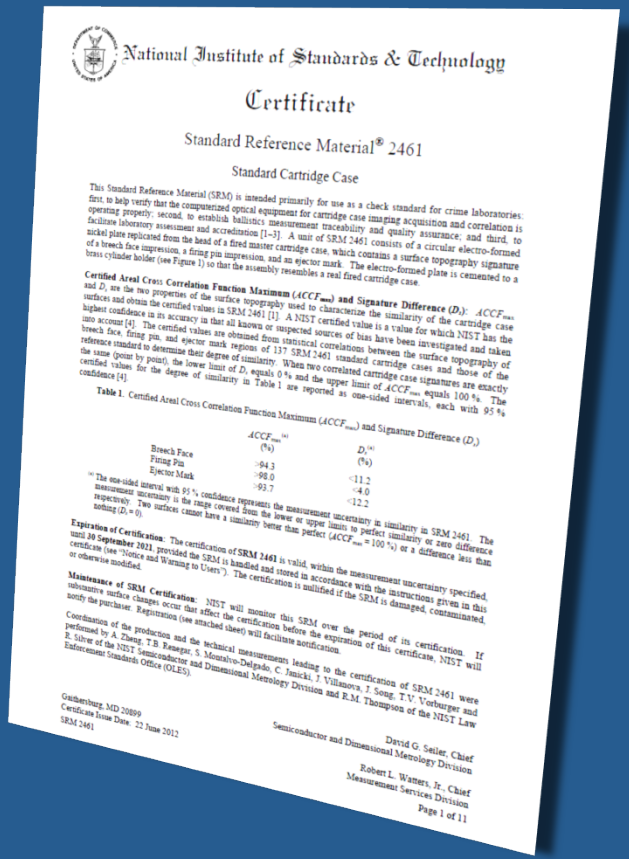

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Certificate

Standard Reference Material® 2461

Standard Cartridge Case

This Standard Reference Material (SRM) is intended primarily for use as a check standard for crime laboratories: first, to help verify that the computerized optical equipment for cartridge case imaging acquisition and correlation is operating properly; second, to establish ballistics measurement traceability and quality assurance; and third, to facilitate laboratory assessment and accreditation [1–3]. A unit of SRM 2461 consists of a circular electro-formed nickel plate replicated from the head of a fired master cartridge case, which contains a surface topography signature of a breech face impression, a firing pin impression, and an ejector mark. The electro-formed plate is cemented to a brass cylinder holder (see Figure 1) so that the assembly resembles a real fired cartridge case.

Certified Areal Cross Correlation Function Maximum ($ACCF_{max}$) and Signature Difference (D_s): $ACCF_{max}$ and D_s are the two properties of the surface topography used to characterize the similarity of the cartridge case surfaces and obtain the certified values in SRM 2461 [3]. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated and taken into account [4]. The certified values are obtained from statistical correlations between the surface topography of breech face, firing pin, and ejector mark regions of 137 SRM 2461 standard cartridge cases and those of the reference standard to determine their degree of similarity. When two correlated cartridge cases and those of the the same (point by point), the lower limit of D_s equals 0 % and the upper limit of $ACCF_{max}$ equals 100 %. The certified values for the degree of similarity in Table 1 are reported as one-sided intervals, each with 95 % confidence [4].

Table 1. Certified Areal Cross Correlation Function Maximum ($ACCF_{max}$) and Signature Difference (D_s)

	$ACCF_{max}$ [a] (%)	D_s [a] (%)
Breech Face	>94.3	<11.2
Firing Pin	>98.0	<4.0
Ejector Mark	>93.7	<12.2

[a] The one-sided interval with 95 % confidence represents the measurement uncertainty in similarity in SRM 2461. The measurement uncertainty is the range covered from the lower or upper limits to perfect similarity or zero difference respectively. Two surfaces cannot have a similarity better than perfect ($ACCF_{max}$ = 100 %) or a difference less than nothing (D_s = 0).

Expiration of Certification: The certification of **SRM 2461** is valid, within the measurement uncertainty specified, until **30 September 2021**, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Notice and Warning to Users"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive surface changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

Coordination of the production and the technical measurements leading to the certification of SRM 2461 were performed by A. Zheng, T.B. Renegar, S. Montalvo-Delgado, C. Janicki, J. Villanova, J. Song, T.V. Vorburger and R. Silver of the NIST Semiconductor and Dimensional Metrology Division and R.M. Thompson of the NIST Law Enforcement Standards Office (OLES).

David G. Seiler, Chief
Semiconductor and Dimensional Metrology Division

Robert L. Watters, Jr., Chief
Measurement Services Division

Gaithersburg, MD 20899
Certificate Issue Date: 22 June 2012
SRM 2461

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NIST Statisticians participated in the analysis of the uncertainty estimates and control values, and preparation of the Certificate.

Both SRMs and their Certificates include User Guides as appendices

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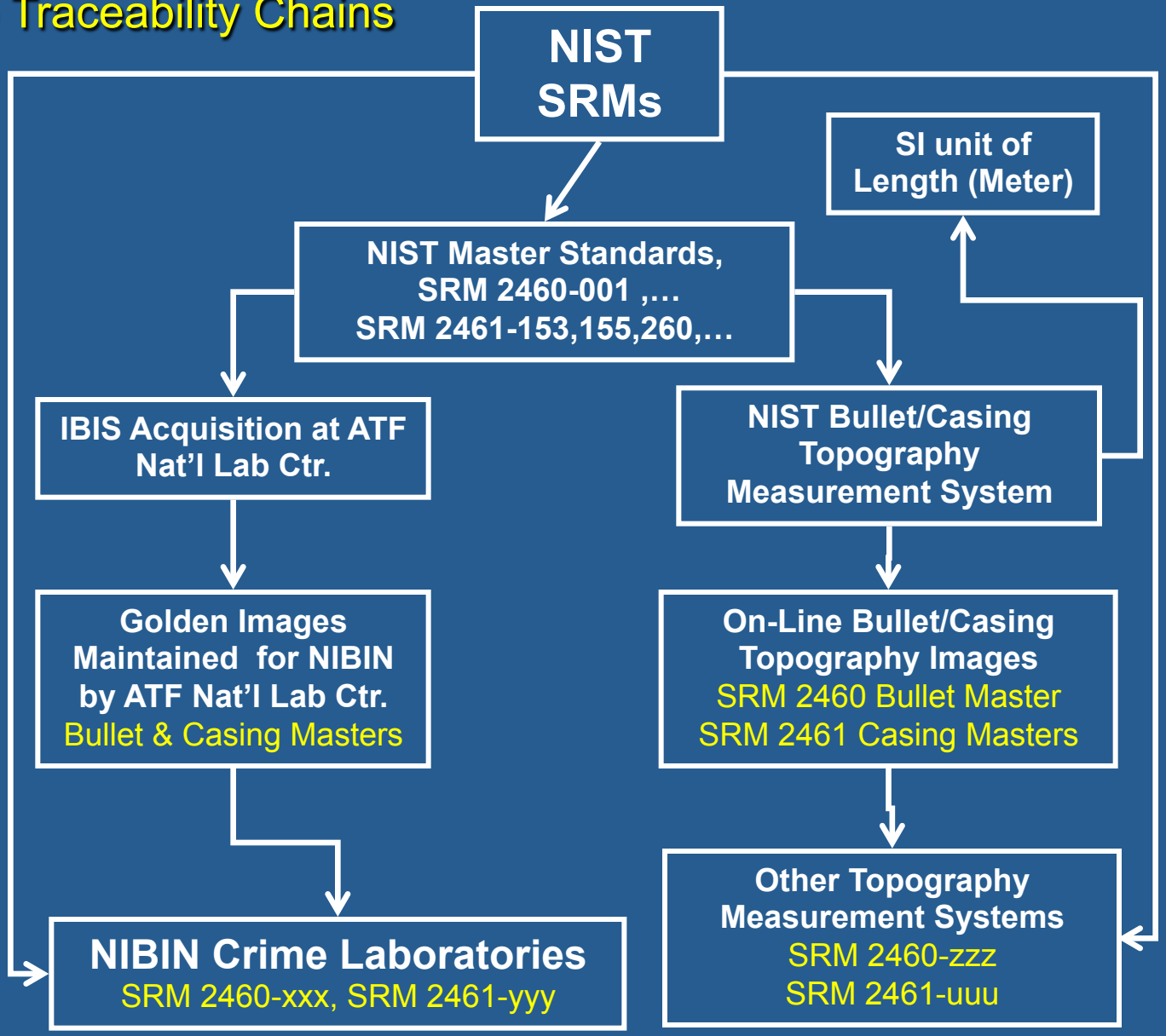
Two Traceability Chains



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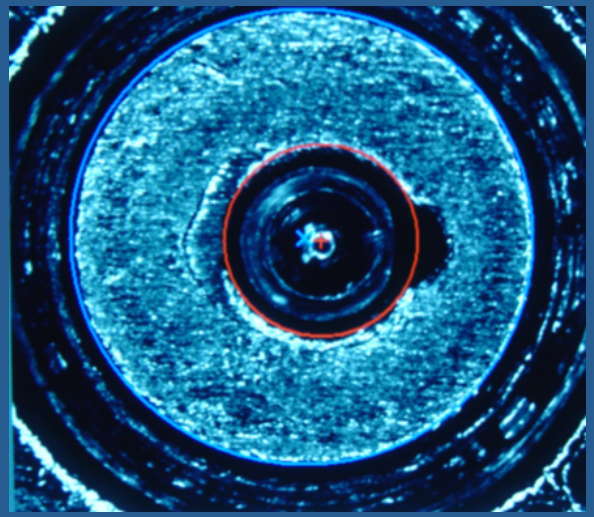
SRM 2461 Documentation Includes a User Guide mainly for NIBIN Users

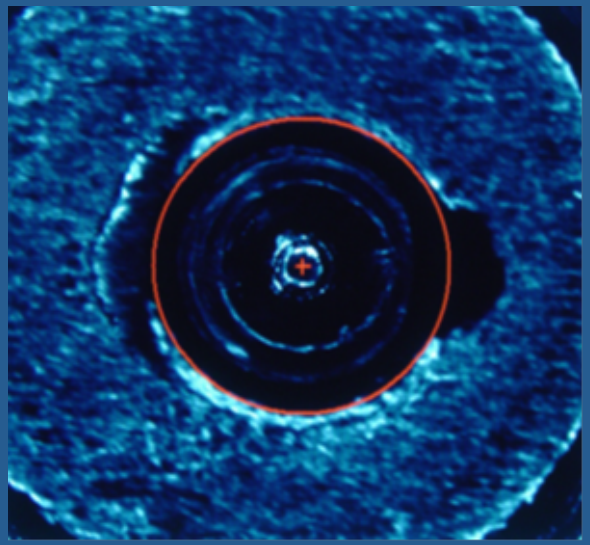
APPENDIX

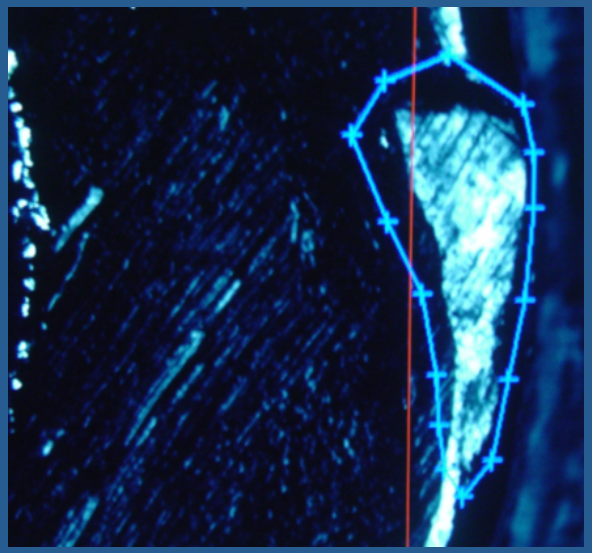
USER GUIDE FOR NIST SRM 2461 STANDARD CARTRIDGE CASES

A Draft Data Acquisition Procedure for the Integrated Ballistics Identification System (IBIS)

1. The NIST SRM standard cartridge case is intended for quality testing of automated ballistics signature acquisitions. It is recommended that an acquisition of the standard cartridge cases be entered into IBIS once a month to verify the proper operation of the system. However, you should refer to your own laboratory's policy and procedure guidelines (PPG's) for the frequency of acquisition. The cartridge case should also be entered into the system during each software and hardware upgrade as well as after any scheduled or unscheduled maintenance. All entries and results should be documented.







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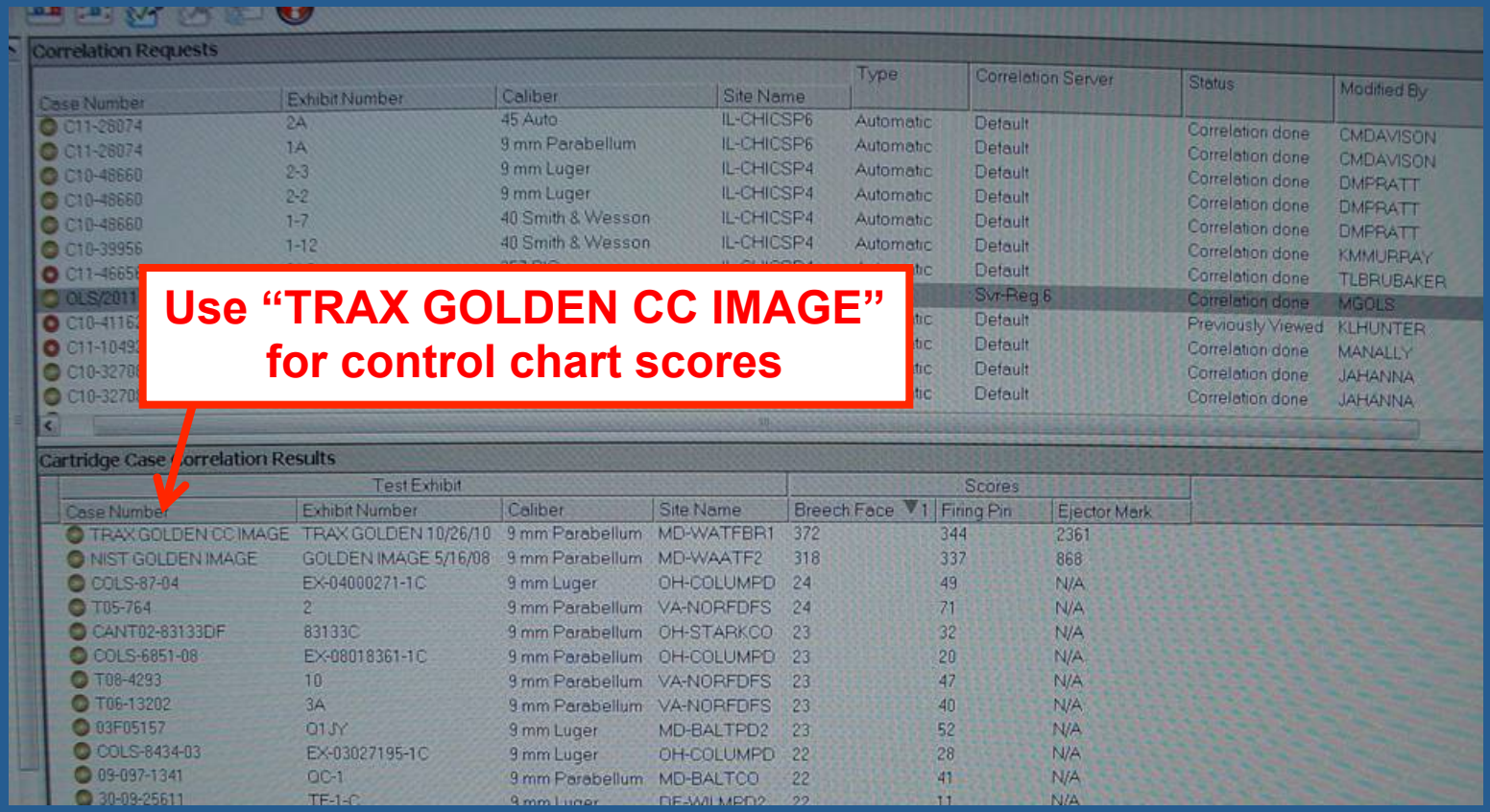
Example of Correlation Results for BrassTrax Acquisitions of SRM 2461



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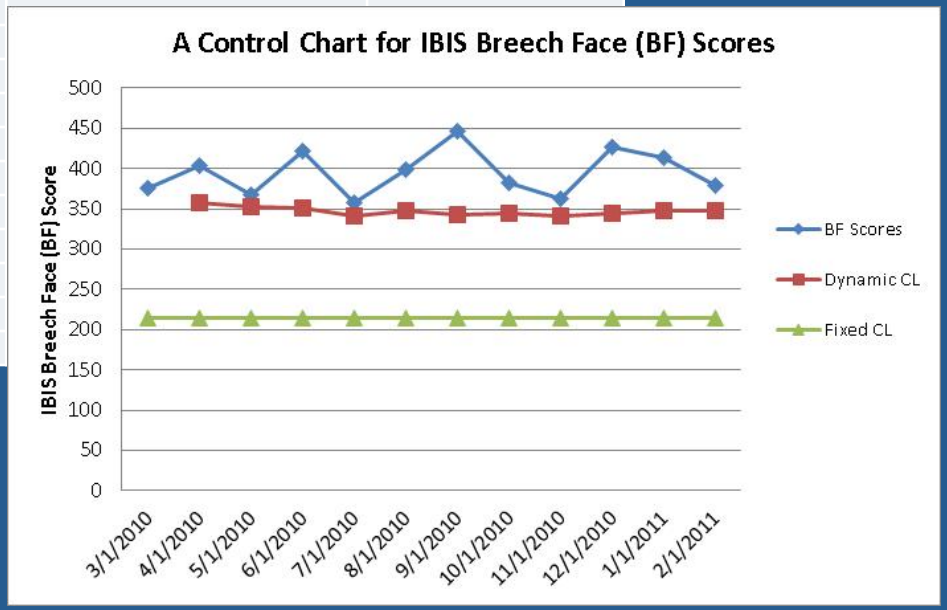
Excel Sheet available from NIST with Control Chart for Tests of SRM Cartridge Cases

Table 2. A Control Chart for Breech Face (BF) Scores of SRM Cartridge Case (Sheet 3 "BF")

Date	BF Score	Dynamic CL	Fixed CL	File Name	Notes
3/23/2010	376		214	SRM2461-018-23MAR10A	
4/23/2010	403	358	214	to be added	
5/23/2010	368	352	214		
6/23/2010	422	351	214		
7/23/2010	357	341	214		
8/23/2010	398	347	214		
9/23/2010	447	344	214		
10/23/2010	382	345	214		
11/23/2010	363	342	214		
12/23/2010	427	344	214		
1/23/2011	414	348	214		
2/23/2011	379	348	214		
			214		
			214		



Proposed Fixed Control Limits for Acquisitions of SRM 2461 (and 2460) Established by the National Ballistics Imaging Comparison Project Involving about 30 NIBIN Participants and their Systems

	Mean	Std. Dev.	95 % Control Limit
Breech Face	329	53	243
Firing Pin	344	44	273
Ejector Mark	1476	562	552

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Availability of SRM 2461

- Available from the NIST Standard Reference Materials Program (www.nist.gov/srm) since July 2012
- 37 units distributed
- 100 units available
- The certification of **SRM** 2461 is valid until **30 September 2021**, with proper handling.

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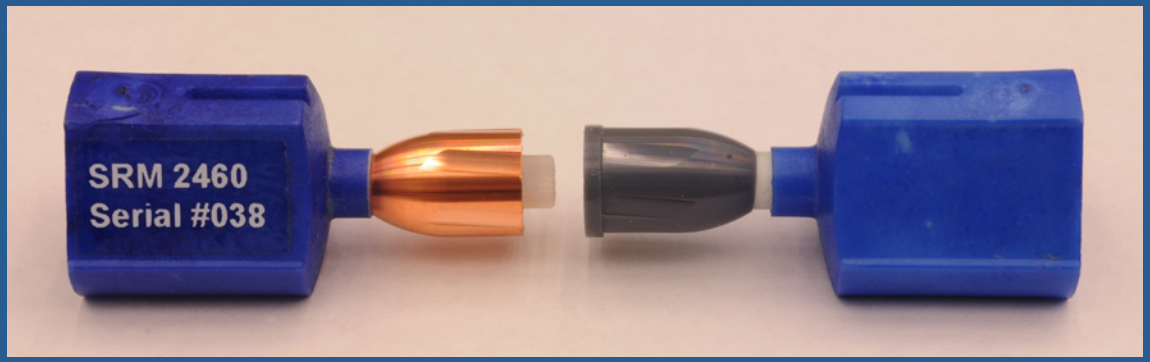
SRM 2460 Bullets not presently available

- Currently developing a polymer replication method for restocking



- See: Today, 10:40 a.m. - 11:00 a.m., Paper A170
  An Improved Vacuum Casting Method for the Replication of Reference Bullets
  Thomas B. Renegar et al.