

Forensic Science and the NIST Laboratory Programs

Richard Cavanagh

Director, Office of Special Programs

June 11, 2013

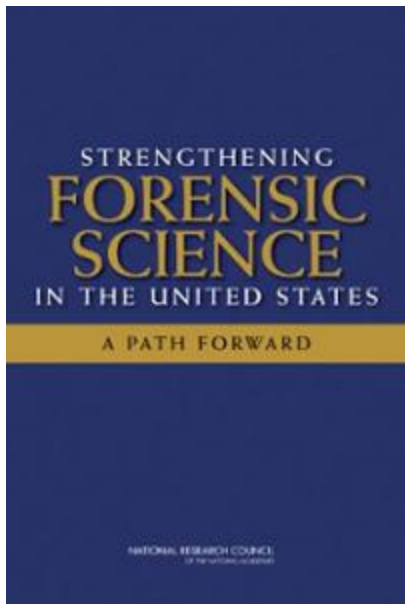
Impacts on the Labs

- **NIST Researchers and NIST Programs will be asked to develop a coherent research, measurement and standards program to:**
 - Test and validate select existing forensic science practices and standards
 - Quantify metrics and uncertainty measurements for disciplines including those currently using subjective, experiential test interpretation criteria
 - Identify gaps and develop new technologies to solve current and future forensic science challenges

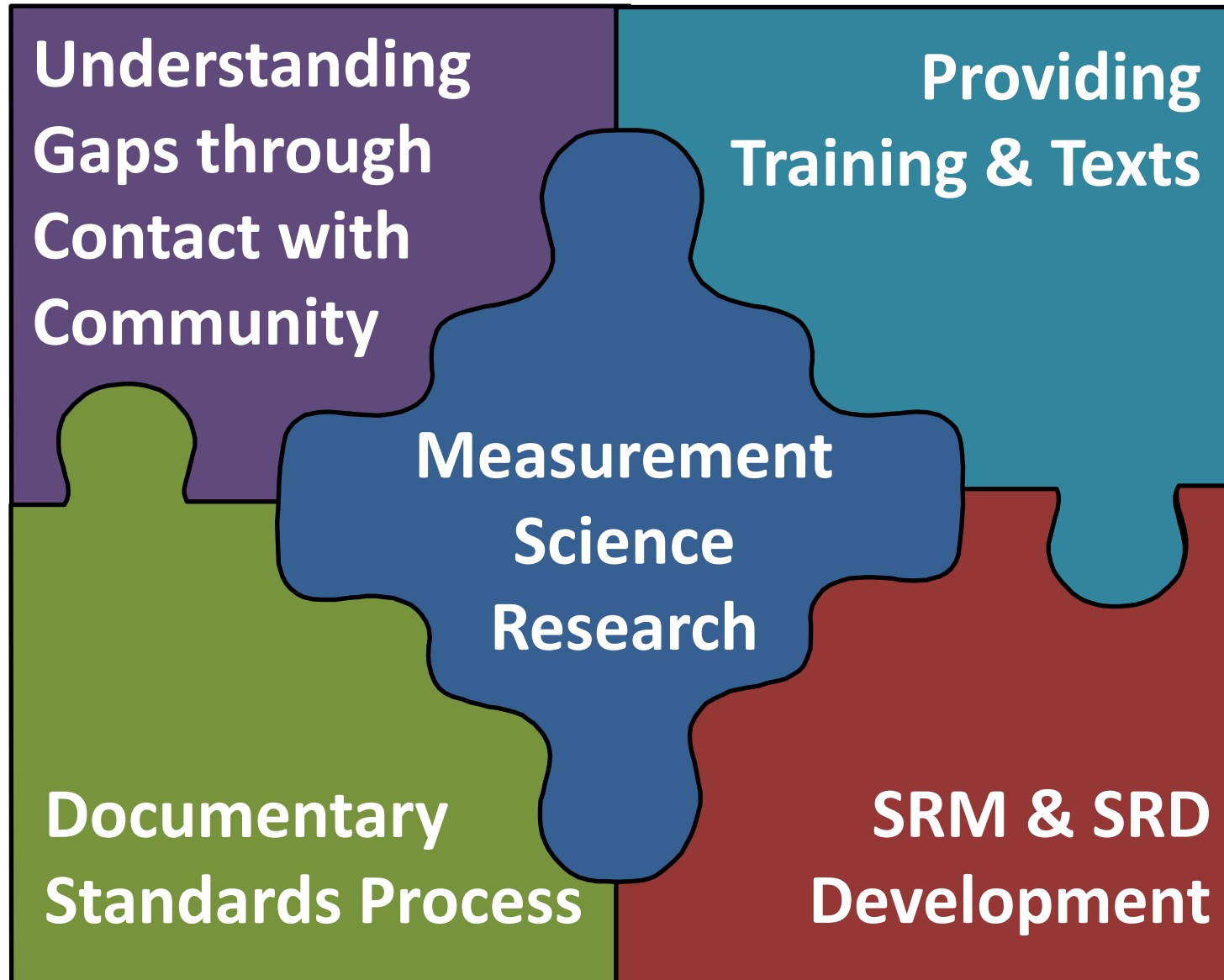
Guided by Engagement with Forensics Community

DNA – The Gold Standard

- “Among the biggest problems that we uncovered in the report is the absence of the application of scientific methodology to determine whether or not the discipline was valid and reliable as was done with DNA,” says Harry T. Edwards, a U.S. federal judge and part of the NAS committee that produced that 2009 report. “DNA is really the only discipline among the forensic disciplines that consistently produces results that you can rely on with a fair level of confidence, when you’re seeking to determine whether or not a piece of evidence is connected with a particular source.”



DNA Forensics at NIST



Understanding
Gaps through
Contact with
Community

Crime Labs Visited by NIST DNA Group (Past 2 Years)



March 2011



March 2011



April 2011



April 2011



April 2011



May 2011



June 2011



Aug 2011



April 2012



FBI LABORATORY

May 2012



June 2012



Sept 2012

NIST DNA Group -Current Committee Contributions

Documentary
Standards Process



SWGAM

(Scientific Working Group on DNA Analysis Methods)

John Butler – Mixture Committee (chair)

Pete Vallone – Rapid DNA Committee (co-chair)

Mike Coble – Enhanced Detection Methods & Interpretation

NIST/NIJ Technical Working Group on Biological Evidence Preservation **Margaret Kline** -member

Virginia Department of Forensic Science – Scientific Advisory Committee **John Butler** - member

North Carolina State Bureau of Investigation Forensic Science Advisory Board **Mike Coble** -vice-chairman and member

DNA Mixture Interpretation

April 12, 2013 Webcast

- **8-hours of DNA mixture interpretation training**
- **11 presentations from five different presenters**
- **20 poll questions** asked via SurveyMonkey (>600 participated)
 - Addressed additional questions sent via email or Twitter
- **>1000 participants** (almost entire U.S. represented and >10 countries)
- **Available for viewing or download** for at least six months



Left to right:

Gladys Arrisueno (NIST, Twitter feed monitor & poll questions)

John Paul Jones (NIST, webcast organizer)

Mike Coble (NIST, presenter)

John Butler (NIST, presenter & organizer)

Charlotte Word (Consultant, presenter)

Robin Cotton (Boston University, presenter)

Bruce Heidebrecht (Maryland State Police Lab, presenter)

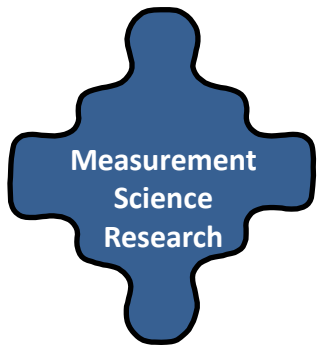
NIST Reference Materials (SRMs) for Forensic DNA Measurement Assurance

Required under FBI Quality Assurance Standard 9.5.5
for labs connected to the national DNA database or
receiving federal funding



DNA quantity

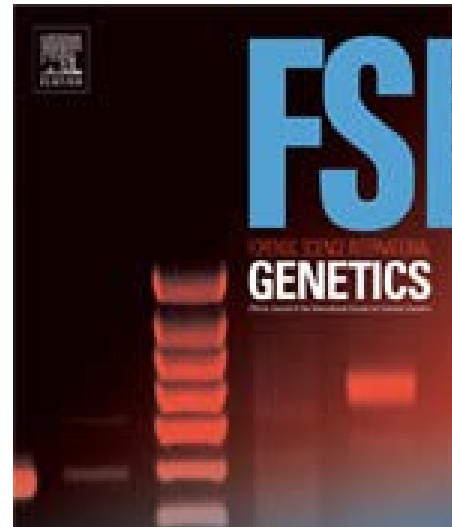
Autosomal and Y-chromosome
short tandem repeat (STR)



Publications on Forensic DNA

from the NIST Applied Genetics Group

- **144 publications since 2002**
 - 40 in the past 2 years
 - Includes journal articles, book chapters, and textbooks
- **References are all listed on STRBase web site**
 - Many are available directly from STRBase



Most NIST DNA Forensic articles are published in *Forensic Sci. Int. Genetics* – currently the highest impact journal in the field

EXPERTISE CURRENTLY in the NIST LABORATORIES

- Pattern Recognition
- **Fire Dynamics**
- **Trace Explosives**
- Trace Biologicals
- Statistical analysis
- **Image analysis**
- Computer forensics
- Toxicology
- Drug analysis
- **Firearms**
-

Ballistics at NIST

SRM2460 Standard Bullet and SRM2461 Standard Cartridge Case

The 2009 National Academies report on forensics called into question, among other issues, the objectivity of visual toolmark identification by firearms examiners. Similarly, the 2008 Academies report, *Ballistic Imaging*, stated: “Conclusions drawn in firearms identification should not be made to imply the presence of a firm statistical basis when none has been demonstrated.”

The Standard Bullet and Standard Cartridge Case are intended to provide U.S. ballistic crime labs with a traceable quality assurance standard for all of their measurements using the Integrated Ballistic Identification System (IBIS).

SRM2460 Standard Bullet – Produced by diamond turning using the digitized profiles of land engraved areas from bullets test fired by the ATF and FBI.

- A total of 40 bullets were manufactured.
- Only 2 remain in stock at the SRM office.

SRM2461 Standard Cartridge Case – Produced by electroforming using a master 9 mm cartridge case fired by the ATF.

- A total of 115 cartridge cases were manufactured.
- Went on sale as of May 2012.



SRM2460 Standard Bullet



SRM2461 Standard Cartridge Case



Future SRM2460a Replica Bullet



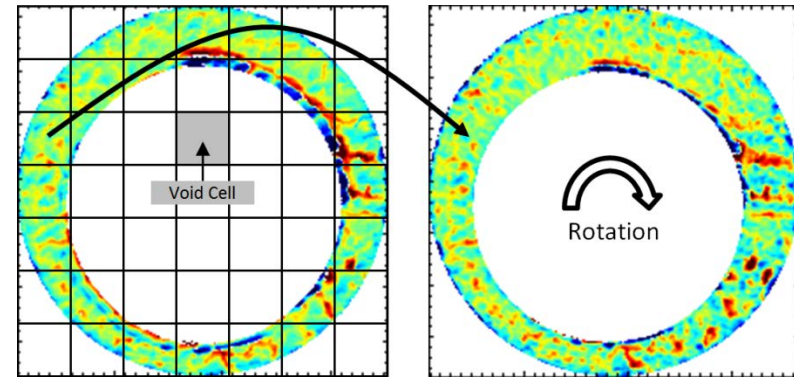
Prototype Error Rate Analysis for Bullet Casing

Firearm examiners often use only informative features on a ballistic surface to make an identification. The Congruent Matching Cell (CMC) method mimics the firearm examiner by only matching the informative regions on a ballistic surface.

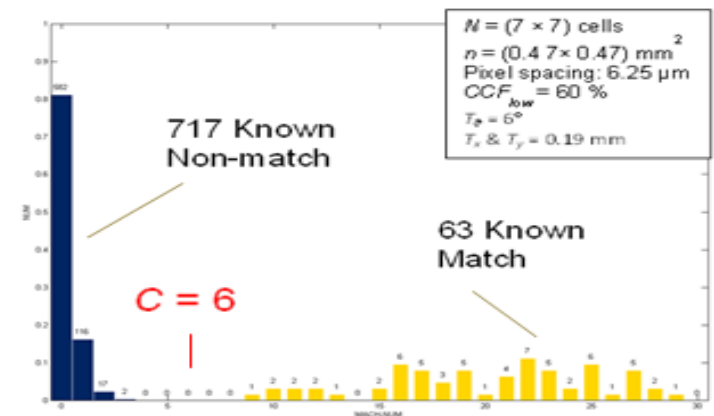
The CMC method separates the ballistic surface into discrete cells that must exceed four similarity thresholds. Each pair of correlated surfaces require at least 6 CMCs to qualify as a match.

The CMC method has now been applied in a realistic blind validation study and was able to correctly identify all cartridge cases.

NIST's Surface and Nanostructure Metrology Group is also developing an error rate analysis for ballistic identifications. Similar to DNA, we are developing an error rate to supplement a firearm examiner's testimony in court.



Example image on the left is divided into correlation cells. Each cell is scanned over the reference image (right) at each rotated position.



Example error rate analysis using the known matching and known non-matching distributions.

Chemical Forensics at NIST

International Validation of ASTM Standard Method on Limit of Detection in Trace Explosive Detectors

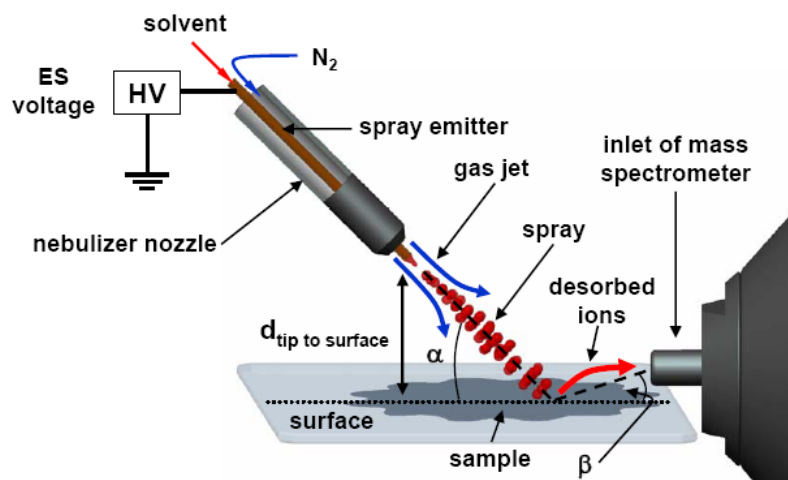
- Trace detection systems are internationally deployed to thwart the use of explosives in weapons of terror. One of the most important measures of performance is the limit of detection (LOD), which defines the lowest amount of explosive that can be reliably detected. There is a distinct LOD for each compound, but LODs are typically poorly known because they have been difficult to determine consistently. NIST expertise was sought on this fundamental measurement issue in order to develop a robust means to determine LOD values for the domestic and international agencies that deploy trace detection systems.



The "LOD kit" distributed by NIST to participants of the international exercise.



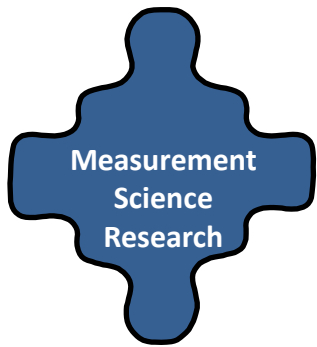
Drug Case Backlogs are a Serious Problem:



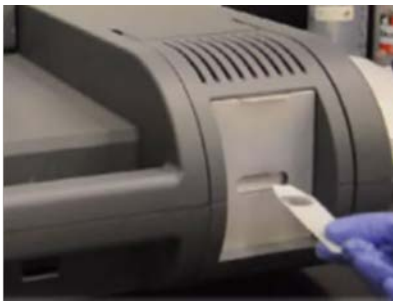
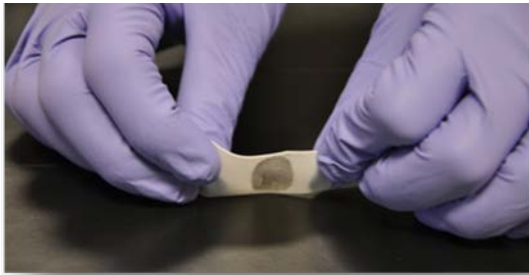
Experimental configurations DESI-MS

¹Takats Z, Wiseman JM, Cooks RG, Mass Spectrom.(2005) 40,1261 – 1275.

- Controlled substance identification is performed by the vast majority of crime labs and accounts for roughly half (51 % in 2005) of backlogged requests.
- One solution to the backlog problem is the development of fast methods with high discriminating power.
- A number of ambient ionization (AI) mass spectrometry (MS) techniques have been developed recently that are designed for rapid MS analysis of solid samples without any sample preparation.
- Studies on the application of these techniques to the analysis of drug exhibits have demonstrated the feasibility and speed of the approach, however, a thorough validation and development of standard protocols remains to be done.



Combined Chemical and Biometric Fingerprint Analysis



Adhesive coated swab with lifted print (top) and analysis in an ETD (bottom).

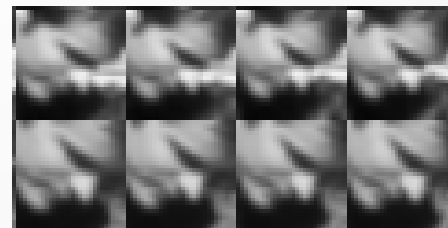
Fingerprints are used routinely for biometric matching purposes, but they may also contain trace chemical evidence if the individual has handled contraband material. Samples are not typically collected for explosive trace detectors (ETD)s in a manner that preserves the biometric information, or allows for standard latent fingerprint development techniques. Addition of the an adhesive has been shown to improve sampling swabs so they perform similarly to adhesive lifting tape . The explosive laden fingerprints can be collected with these adhesive swabs and successfully screened in an ETD without affecting the biometric information in the fingerprint.

Face and Person Recognition at NIST

Why is identifying people in video hard?

- Why is it hard?
 - Varying pose
 - Unconstrained environment (changes in illumination)
 - Image blur and bad focus
 - Compression artifacts
- Identify technology gaps
 - Tools for users
 - Long term technology goals
- In concert with
 - Industry and Academia
 - Government partners—FBI, DHS, DoD, and the IC
 - Facial Identification Scientific Working Group (FISWG)

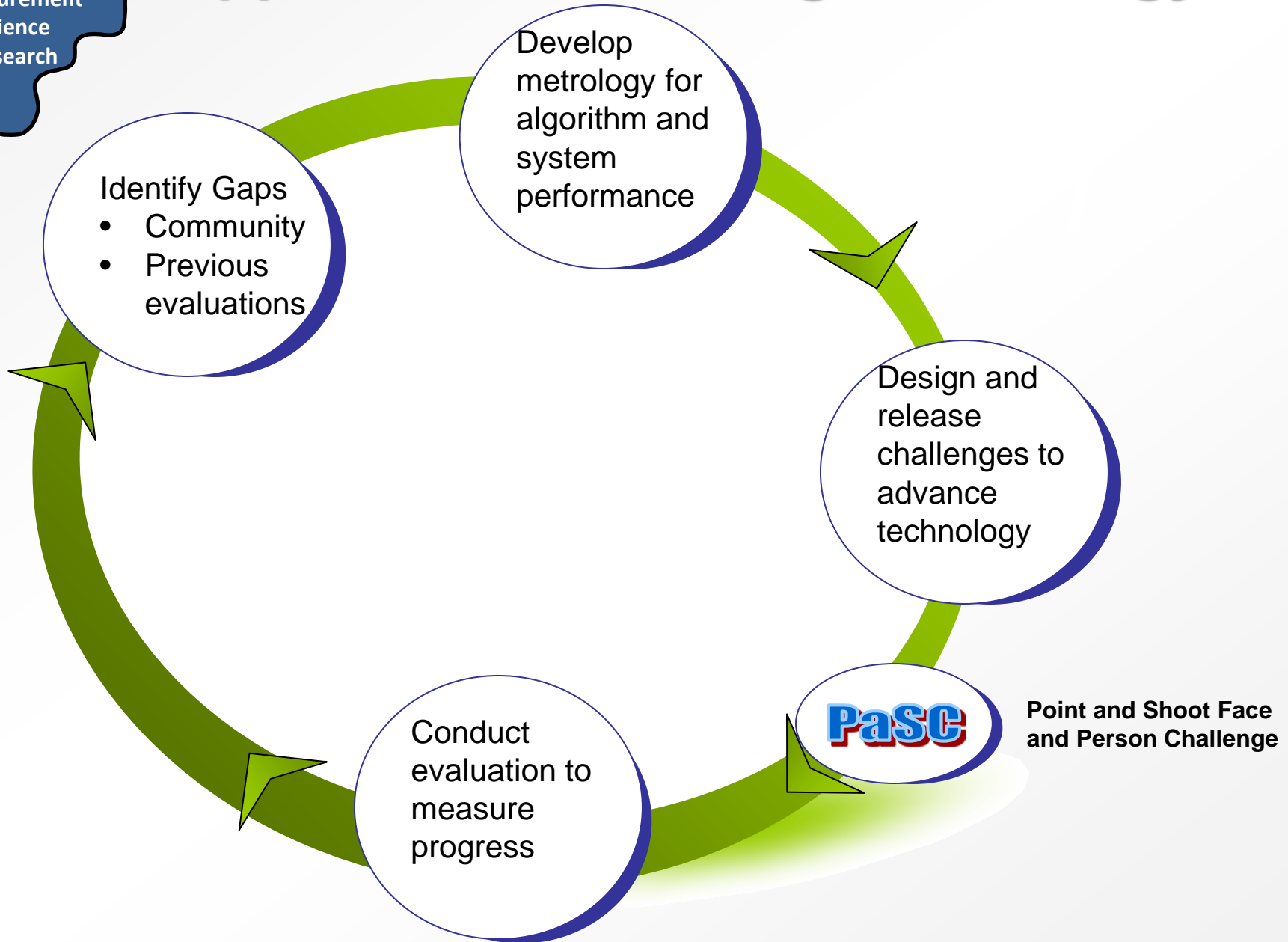
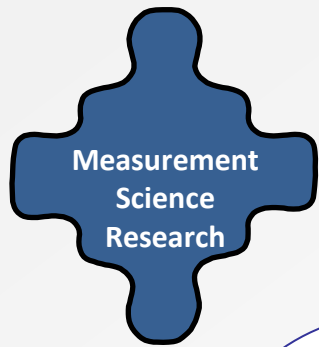
Video



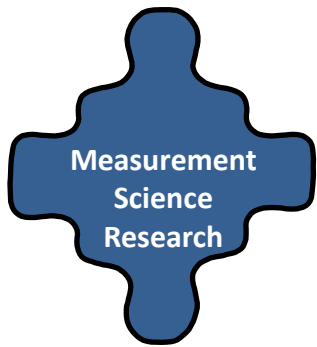
Extracted Faces



Approach to Maturing Technology



Arson Forensics at NIST

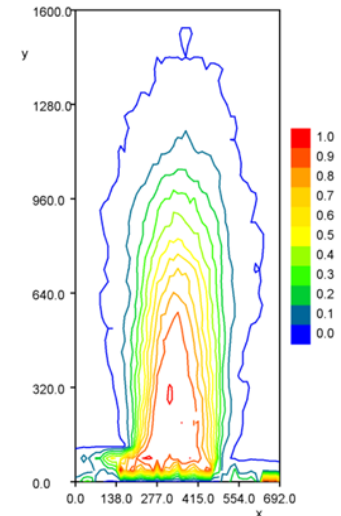


Arson Investigation

“Many of the rules of thumb that are typically assumed to indicate that an accelerant was used (e.g., ‘alligatoring’ of wood, specific char patterns) have been shown not to be true.”

National Research Council, *Strengthening Forensic Science in the United States: A Path Forward*, The National Academies Press, Washington, DC, 2009.

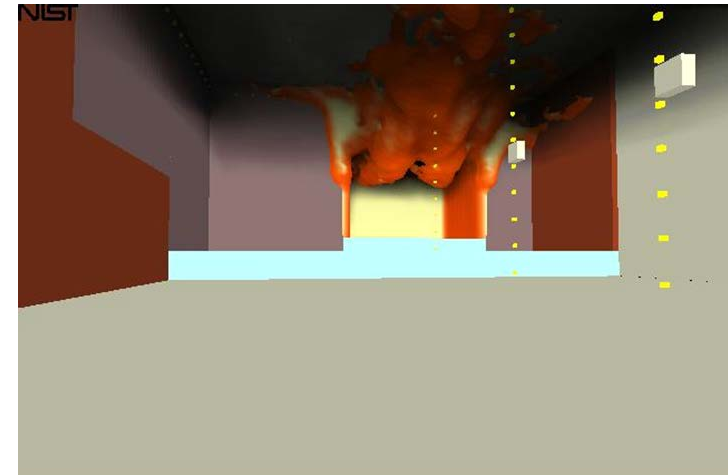
- Measurement science (metrology, instrumentation, simulation) for:
 - Ignition
 - Flame spread
 - Heat release rate
 - Smoke yield
- Research on fire patterns
 - Material behavior
 - Impact of ventilation
 - Experiments in lab and actual structures



Measurement
Science
Research

NIST Fire Dynamics Simulator (FDS)

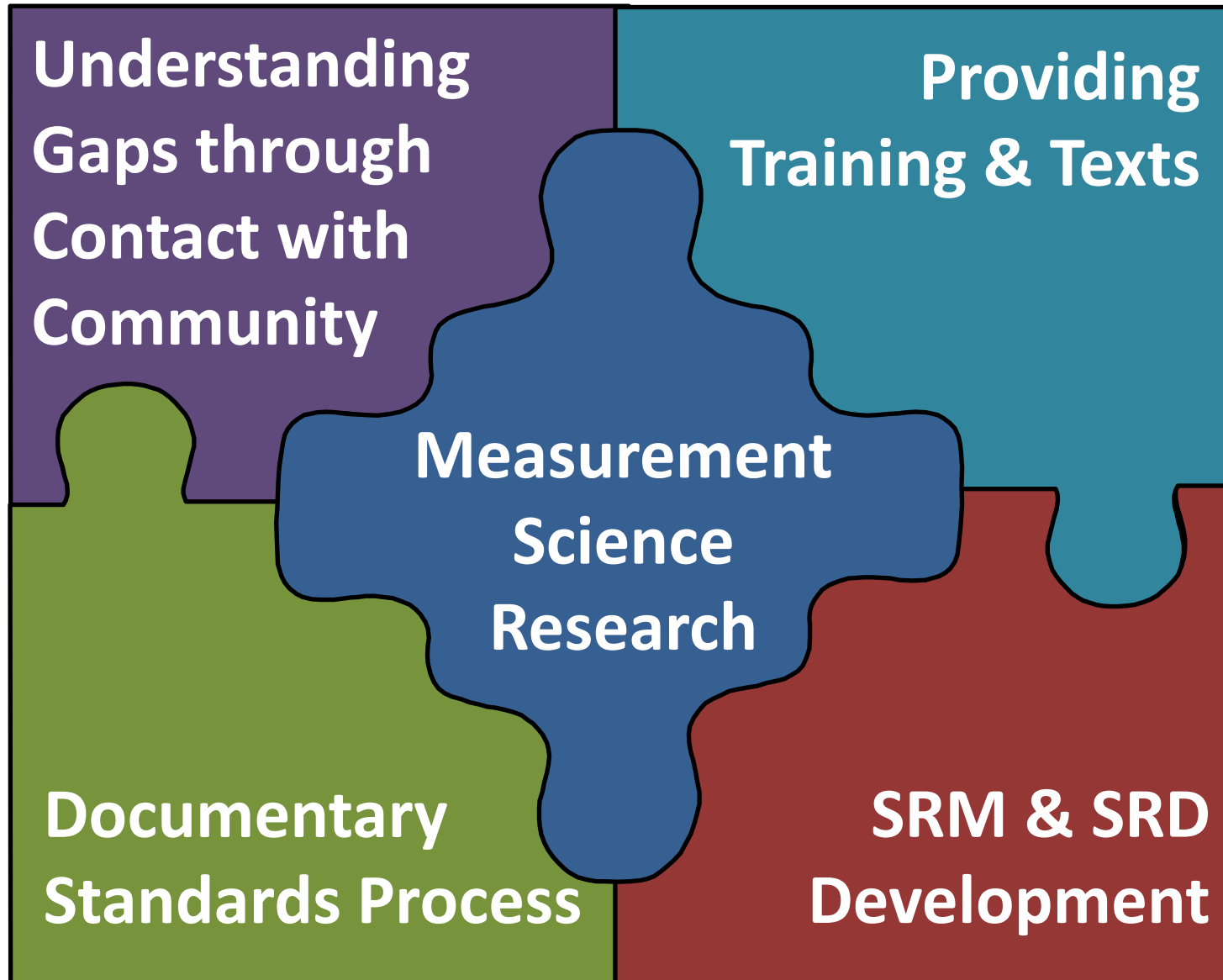
- Physics-based CFD fire model
- Simulation and fire scenario reconstruction:
 - WTC 1, 2, and 7 Fires
 - Station Night Club Fire
 - Cook County Admin Bldg (high rise fire)
 - Firefighter Line of Duty Deaths and Injuries
 - Washington D.C. - Townhouse
 - Keokuk, IA - Duplex
 - Houston, TX - Restaurant Fire
 - New York, NY – Hardware Store
 - Charleston, SC – Furniture Store
 - Houston, TX - Wind Driven Residential
 - New York, NY – Brownstone



Time: 60.0



Station Night Club Fire simulation and experiment



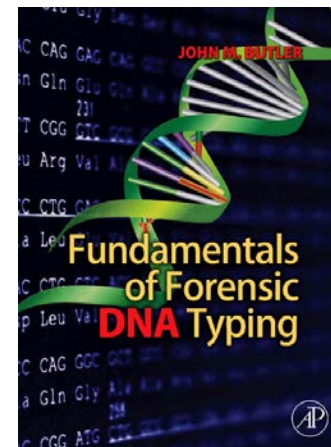
Forensic Science and the NIST Laboratory Programs



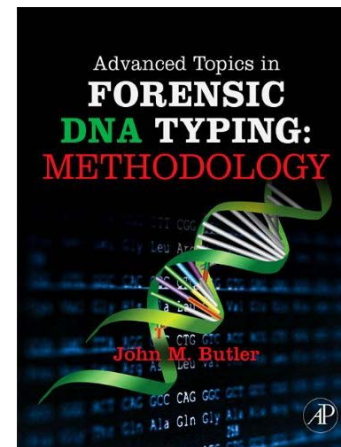
John Butler

3rd Edition (3 volumes)

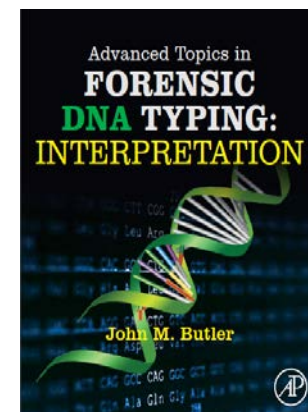
- Identify NIST champions in at least 10 forensics disciplines who will develop white papers on critical gaps in Forensics Science
- Internal NIST program on Forensic Research developed
- Tentative workshop for Feb. 2014 AAFS Forensics Conference (brief practitioners on NIST research and solicit feedback).
- Winter - Review articles of Forensic Science Gaps published



Sept 2009



Aug 2011



Fall 2014



FORENSICS @ NIST