SOUTH AFRICAN POLICE SERVICE: FORENSIC SCIENCE LABORATORY

PERSPECTIVES ON TESTS AND MEASUREMENTS FOR LEGAL PURPOSES

Col. AAS Marais
Technical Management: Chemistry
BALLISTICS

CORE FUNCTIONS:

• Firearm & Tool Mark Examination & Identification
• Identification of Firearms & Ammunition
• Restoration of Defaced / Removed Numbers on Metals [Etching]
• Internal, External & Terminal Ballistics [Angels, distances, etc]
• Research in the field of Firearm & Ammunition Technology
• Reconstruction of Vehicle Accident Scenes
• Examination of Wheels & Tyres
• Assist in Vehicle Theft-related Examinations [mechanical tests]
• Examination of Filaments / Fibre
• Reconstruction & Examination of Illegal Entries & Exits
• Queries concerning Fields of Mechanical & Metallurgical Engineering in general
CORE FUNCTIONS:

The examination of biological exhibit material to determine the identity and relationship thereof

- Evidence Recovery: Body Fluids & Hair
- Preliminary Testing of Body Fluids
- Blood Spatter Pattern Analysis
- DNA Analysis & Comparison of DNA Profiles
- Microscopic Comparison of Hair
- 2D & 3D Facial Reconstruction
- Mummified Fingerprinting [Decomposed Bodies]
- Establishment of a DNA Statistical Data Base & Criminal Intelligence Data Base [Link individuals to crime scenes]
CHEMISTRY

CORE FUNCTIONS:

• Identification & Classification of Drugs controlled into Drugs & Drug Trafficking Act

• Identification & Classification of Medicines scheduled into Medicines & Related Substances Act

• Attendance of Drug and/or Medicine Related Crime Scenes

• Identification of Substances involved in illicit [clandestine] synthesis & formulation of drugs and/or medicines

• Generation of Drug Intelligence Reports

• Fire Origin & Cause Determination

• Arson Chemistry [Determination of Fuel Element]

• Poison Analysis

• Toxicology related Crime Scenes

• Alcohol Analysis
SCIENTIFIC ANALYSIS

CORE FUNCTIONS:
The forensic investigation of cases concerning matters in electronic & electrical engineering, a variety of chemical analyses as well as science & physics

• Audio Enhancements on Magnetic Tapes
• Voice Comparisons & Audio Authentication
• Electrical & Electronic Investigations
• Assisting in Arson Related Investigations
• Polygraph Investigations & Truth Verification
• Specialized Forensic Photography
• Image Processing & Analysis
• Analysis of Rubber, Plastics, Polymers & Tape, Explosives, Explosive Devices & Explosive & Propellant Residues, Fibers, Ropes, Liquids, Paint, Glue, etc
• Precious Metal Analyses
• Analyses of Jewelry & Gemstones
• Analyses of Gun Shot Residue
CORE FUNCTIONS (Continued):

• Analysis of Soils & Related Materials
• Analysis of Cables & Wires
• Comparison of Impressions & Prints
• Analysis & Classification of Ivory
• Examination of Glass
• Analysis of Material pertaining to Environmental Pollution & Toxic Waste
• Elemental Analysis
• Profiling of all Materials
CORE FUNCTIONS:

The forensic examination of documents and document-related exhibits

- Individualization of Handwriting, Signatures, Typescript, Printed Matter & Stamped Impressions
- Identification of Forgeries, Erasures & Additions
- Examinations: Writing Instruments, Ink, Paper & other media used in committing Criminal Offences
- Identification or Elimination of Source & Output of Mechanical / Electronic Imaging Devices [Printers, Copy Machines, etc]
- Establishment of Date, Source, History, Sequence of Preparation, Alterations or additions to Documents & Relationships of Documents
- Decipherment & Restoration or both of Erasures, Deleted or Damaged Parts of Documents
- Deciphering of Obscured Writing & Indentations
PROCESSING OF FORENSIC EVIDENCE RECEIVAL INCREASES / DECREASES

111,068 [97%]
110,522 [97%]
98,906
90,170 [91%]
90,222
93,162 [117%]
94,014
80,247
80,465
78,772
78,890
74,200 [94%]
77,114
78,900
77,114
74,200
79,664
83,957
73,566 [108%]

ENTRIES RECEIVED
FINALIZED

11/12 Q1 11/12 Q2 11/12 Q3 11/12 Q4 12/13 Q1 12/13 Q2 12/13 Q3 12/13 Q4 13/14 Q1 13/14 Q2 13/14 Q3 13/14 Q4

60,451 65,214 60,210 60,451
83,996 80,448 80,448
98,906 90,170 90,170
107,287 107,122 107,122
111,068 110,522 110,522

[125%] [97%] [96%] [92%] [91%] [102%] [117%] [97%] [97%] [109%] [108%] [94%]
DEFINITION

- Forensic science can be defined as the practical application of science to matters of the law
  - *Forensic*: Pertaining to law or judiciary process
FORENSIC DISCIPLINES

- Scientific fields that have found application in forensics
  - Largely based on instrumental analysis and measurement standards
    - Biology (DNA analysis)
    - Chemistry
    - Physics

- Forensic fields that have some scientific underpinning
  - Largely based on expert interpretation of observed patterns
    - Questioned documents
    - Toolmarks
    - Fingerprints

- Data used quantitatively or qualitatively
  - Binary responses
SCIENTIFIC VALIDITY

• (1) whether a theory or technique can be (and has been) tested;
• (2) whether the theory or technique has been subjected to peer review and publication;
• (3) the known or potential rate of error of a particular scientific technique;
• (4) the existence and maintenance of standards controlling the technique’s operation;
• (5) a scientific technique’s degree of acceptance within a relevant scientific community

Strengthening Forensic Science in the United States: A Path Forward
http://www.nap.edu/catalog/12589.html
QUESTIONABLE SCIENCE?

- 223 post-conviction DNA exonerations in the United States since 1989 (as of November 2008)

- Uniqueness of fingerprints
  - Questionable probability of $1/10^{97}$ individuals
  - Difference between ‘perfect’ rolled prints and ‘imperfect’ latent prints of greater importance

- Expert testimony under cross examination the traditional means of validity evaluation
VALUE OF EVIDENCE

- Probative value defines the evidence sufficiently useful as proof in a legal proceeding
- Class characteristic evidence
  - DNA from a specific ethnicity
  - Firearm make and model
- Individual characteristic evidence
  - DNA profile of individual
  - Cartridge/Projectile from a specific firearm
- Ultimate goal of forensic science is to answer the need of the client i.e. linking a potential offender to a crime or crime scene (individual characteristics)
IDENTIFICATION (MATCHING)

- Uniqueness determines the assignment of individual characteristics
  - Forensic discipline level of detail dependant
- Unambiguous identification of item A is the comparative match obtained for item A regarding its properties/features and the concurrent mismatch of its properties/features with those of all other items under specified conditions
  - Confirmation bias risks
  - Minimum number of properties/features needed as related to theoretical incidence in population
  - Statistical models e.g. Bayes Theorem
  - Diagnostic value of analytical process
CHEMICAL IDENTIFICATION: MS

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Cocaine

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\text{Cocaine}
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STANDARDISATION

- Accreditation to a standard such as ISO 17025:2005 highly beneficial
  - Processes applicable to all forensic disciplines
  - Measurement traceability
  - Fitness for purpose of tests and measurements equally evaluated by statistical models across all disciplines

- Forensic science hindrances
  - Variable nature of sample substrates and types
  - Focus on examiners and not on processes
  - Limited testing materials for developmental validation
  - Expectations within the legal system (CSI effect)
The intent of any analytical procedure is to provide accurate and reliable data to answer a specific need. Method validation supports this intent by:

- The specification of analytical method performance criteria
- Objective assessment of suitability for intended purpose

![Fitness for Purpose Diagram]

- Client Need
- Result fit for purpose
- Method Validation
- Analytical Methodology
- Scientific Underpinning

QMS

SAU

QDU

Ballistics

Biology

Chemistry
### Defining a Test Process

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Analysis Purpose</strong></td>
<td>• DNA profile based on STR</td>
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<tr>
<td><strong>Sample Matrix / Sample type</strong></td>
<td>• Semen</td>
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<td>• Non-Semen</td>
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<tr>
<td><strong>Sampling</strong></td>
<td>• Statistical</td>
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<tr>
<td></td>
<td>• Non-Statistical</td>
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<tr>
<td><strong>Preliminary analysis/findings</strong></td>
<td>• Luminol</td>
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<td>• Brentamine</td>
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<tr>
<td><strong>Sample Preparation</strong></td>
<td>• DNA extraction</td>
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<tr>
<td><strong>Analytical technique</strong></td>
<td>• PCR / Q-PCR / CE</td>
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<tr>
<td><strong>Test Result</strong></td>
<td>• DNA profile</td>
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## FSL Validation Approach

<table>
<thead>
<tr>
<th>Relevant Validation Figure of Merit</th>
<th>Test Method Process</th>
<th>Method Category</th>
<th>Validation Model</th>
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<tbody>
<tr>
<td>Selectivity (Identity)</td>
<td>Sample Matrix</td>
<td>Standard</td>
<td>Qualitative</td>
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<tr>
<td>Accuracy (Recovery)</td>
<td>Sample type</td>
<td>Non-Standard</td>
<td>Quantitative</td>
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<tr>
<td>Linearity</td>
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<td>(3 Phases)</td>
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<tr>
<td>Selectivity</td>
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<td>Precision</td>
<td>Preliminary</td>
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<td>analysis/findings</td>
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<td>Precision</td>
<td>Analytical technique</td>
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<td>Limit of Detection</td>
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<td>Limit of Quantification</td>
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<td>Linearity</td>
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<td>Accuracy</td>
<td>Validation Report</td>
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<td>Precision</td>
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**QUALITATIVE VALIDATION MODEL**

**Phase 1: Instrument Parameters/Examination Conditions**
- Standard Method: Verify Critical Parameters
- Non-Standard: Validate all parameters

**Phase 2: Comparison Data**
- Comparison of results obtained by test method under established parameters/conditions to a reference source
- External Proficiency, “Gold Standard” method, Inter-laboratory comparison.

**Phase 3: Validation Report**
- Data Analysis
- Statistical tests of significance
LEGISLATION AND ROLEPLAYERS

- Increased interaction between the relevant NMI and forensic science bodies required
- Reviews to legislation
  - The Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, Act 19 of 2006
  - The Measurement Units and Measurement Standards Act, Act 18 of 2006
  - Trade Metrology Act, Act 77 of 1973 (Legal Metrology Bill)