Biometrics: Big Data, Analytics, & Biometric-Enabled Intelligence

— For Defense, Intelligence, Homeland Security and Law Enforcement —

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Rapid DNA Analysis: Military, Intelligence, Homeland Security, and Law Enforcement Applications
The Emerging Field of Rapid DNA Analysis

- Rapid DNA Analysis is the identification of a subset of a given human, animal, or pathogen genome
  - Performed by non-technical users outside the laboratory
  - Enabling end-users to obtain actionable data in real time

Company Background

- Incorporated in 2000, based on five years of research at MIT.
- Privately held, employee-owned, based in Waltham, MA.
- Supported by FBI, NIJ, NIAID, DHS, and DoD (SOCOM, DTRA, JIEDDO, ASDR&E).
- Corporate partnership with GE Healthcare for sales, marketing, and service to law enforcement markets.
Rapid DNA Analysis: A Transformative Technology

Allows non-technical users to generate DNA profiles at the point or near the point of collection and generate results quickly to provide real time actionable intelligence while the individual is still in custody.

DNA profiles generated in 84 minutes
Traditional DNA Forensic Laboratory Infrastructure

- Laboratory Infrastructure
- Capital Equipment
- Lab Supplies and Reagents
- Computers and software
- Laboratory Technicians
- Forensic Analysts

Sample Prep Lab

Amplification Lab

Separation & Detection Lab

U.S. Crime Lab $210 M, 351,000 sq ft

Forensic Analysis

Rapid DNA Analysis™ Solutions Company Proprietary
Rapid DNA Analysis: Significantly Expand the Uses for DNA Typing

Military and Military Intelligence:
- Military operations: enrollment, identification, and evidence processing
- Casualty confirmation
- Asset identity confirmation
- Enemy combatant identification/enrollment
- Battlefield friend of foe
- Security screening at forward deployed bases

Homeland Security
- Border and port Protection
- Immigration/refugee and asylee processing
- Family reunification
- Human trafficking intervention
- International adoption support
- Mass disaster victim identification
- High value target protection

Law Enforcement
- Forensic laboratories
- Police booking station
- Crime scene

A Common Goal: Generation DNA profiles in the field by non-technical operators to verify identity, family relationships, or involvement in a crime while the person is still present or detained.
Rapid DNA and Preventable Crime Studies

- Chicago (Eight Criminals)
  - 23 murders
  - 30 rapes
  - Attempted rapes
  - Aggravated kidnapping

- Denver (Five Criminals)
  - 3 murders
  - 18 sexual assaults
  - 1 attempted sexual assault
  - 7 kidnappings
  - 4 robberies
  - 3 felony assaults
  - 11 burglaries

- Maryland (Three Criminals)
  - 1 murder
  - 8 rapes
  - 1 attempted rape
  - 3 assaults
  - 3 batteries
  - 2 robberies
  - 1 burglary
  - 1 sex offense

70% of US crime is due to 6% of the criminal population. Rapid DNA Analysis can dramatically reduce recidivism.
STR Analysis: What Are Short Tandem Repeats (STRs)?

- Human DNA is 99% identical from person to person. However, some regions of the genome vary, and one type of variable region is the Short Tandem Repeat (STR).

- Short Tandem Repeats (STR) are non-coding repetitive sequences of DNA found interspersed throughout the human genome.

- Because STRs are variable—number of repeated units differs from person to person, they can be used to uniquely identify one individual from another.

- DNA is inherited from our mother and father, so there are two copies of each STR region (locus), and as such, an individual has two “alleles”.

- The number of repeated units determines your DNA profile.

Donor’s DNA profile at this given locus is 11,13
STR Matching for Crime Scene Investigation

Suspect A
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Maternal / 10 repeats
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Paternal / 10 repeats

Suspect B
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Maternal / 11 repeats
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Paternal / 13 repeats

Suspect C
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Maternal / 12 repeats
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Paternal / 10 repeats

Match
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Maternal / 12 repeats
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Paternal / 10 repeats

Evidence
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Maternal / 12 repeats
- CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT CTAT
  Paternal / 10 repeats

Rapid DNA Analysis™ Solutions
Company Proprietary
DNA Fingerprinting is Extraordinarily Accurate

### CODIS 13 Core STR Loci

![CODIS 13 Core STR Loci Diagram]

<table>
<thead>
<tr>
<th>Locus</th>
<th>Allele</th>
<th>Value</th>
<th>Allele</th>
<th>Value</th>
<th>1 in</th>
<th>Combined</th>
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<td>16</td>
<td>0.2533</td>
<td>17</td>
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<td></td>
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<td>1.13 x 10^13</td>
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<td>TPOX</td>
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<td>8.37 x 10^14</td>
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The probability of a random match for this STR profile in the U.S. population is less than 1 in 837 trillion.
Unlike other biometrics, DNA is inherited from our mother and father, and as such, can be used to verify family relationships. By comparing STR profiles, kinship probabilities can be determined. The more loci available for assessment, the higher the confidence will be.
Female DNA Profile

NetBio

Rapid DNA Analysis™ Solutions

Allele Report

D3S1358  TH01  D21S11  D18S51  PentaE

D5S818  D13S317  D7S820  D16S539  CSF1PO  PentaD

Am  vWA  D8S1179  TPOX  FGA

X  17  11  14  8  25  26

Fragment Length (bases)
In 2009 NetBio was awarded the ANDE contract, a competitive R&D program funded by a consortium of 5 Federal agencies to develop a Rapid DNA Analysis System based on:

- **Ease-of-use.** The Operator has no technical training.
  - No manual processing
  - No reagent loading—reagents should be incorporated into the single-use consumable
  - No instrument calibration or assembly
  - No data interpretation—automated allele calling and searching

- **Reagent Stability/Out-of-the-box functionality.** The System will be placed in a field forward environment.
  - No temperature, humidity, or particulate control
  - No refrigeration
  - No tools or technicians to install/align system
  - Generator power
Requirements: ANDE Rapid DNA Analysis System (II)

- **Ruggedization.** The system must be hardened for transport to and operation in deployed environments.

- **Rapid.** DNA analysis must provide results within a time period that allows decisions to be made BEFORE releasing a person of interest.

- **Data security and privacy.** All aspects of system operation and data generation must be secure and protect privacy of the DNA donor.
  - User and sample tracking
  - Encryption of all generated data and database
  - Tiered User accounts to limit data access to only an approved subset of Users.

- **Flexibility.** The system must provide a customizable foundation for field forward forensic DNA analysis.
  - Touch sample analysis
  - Kinship analysis
  - Multi-assay capability
ANDE: NetBio’s Rapid DNA Instrument

- Instrument Weight: 50 kg (two person lift)
- Instrument Size: 68 x 42 x 59 cm
- Ruggedized to MIL STD 810F for shock / vibration
- No calibration or realignment required after transport
BioChipSet™ Cassette: NetBio’s Rapid DNA Consumable

- BioChipSet Cassette is a fully integrates lab on a chip that performs all process steps required for DNA analysis.
- Processes up to five samples per 84 minute run.
- All reagents on board and stable for 6 months at room temperature; no refrigeration required.
Operating the ANDE System: Collect Samples
Enter Sample ID

Sample #1
Type in the ID for Sample 1
Press Done When Finished

Sample #1 ID

Done
Scan a Sample with the Integrated RFID Reader
Insert Sample and Press the Done Button

NetBio

1. Remove plastic seal from the first Swab Chamber.
2. Remove swab from tube.
3. Place swab in Swab Chamber. Push down on swab cap until it clicks. Press Done when finished.

Sample #1
A1
Load the Sample into the BioChipSet
Insert the BioChipSet Cassette
DNA Processing Complete

Processing Complete

Sample 1: (1)
Sample 2: (2)
Sample 3: (3)
Sample 4: (4)
Sample 5: (5)

Done
Data Analysis and DNA Profile Generation

- Expert System software performs automated data processing & allele designation.
- Four data output files are automatically generated, including a file for database searching.
- No data review or analysis by a forensic analyst is required.
<table>
<thead>
<tr>
<th>Key Attribute</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Easy to Use**               | • Fully-integrated with all process steps performed on a single instrument and consumable  
• Fully automated with no manual processing of samples or reagent loading, operator only loads samples and inserts chip  
• System set up in 15 minutes  
• Integrated sample tracking to eliminate sample mix up |
| **Fast**                      | • Results are generated in 84 minutes or less  
• No data analysis required  
• Database easily exportable for database search and/or kinship analysis |
| **Cost Effective**            | • Eliminates need for specialized laboratory setting  
• Can be operated with minimal training – does not require skilled technician  
• Eliminates need to ship samples to laboratory |
| **Field Ready**               | • Consumable is stable at room temperature, no refrigeration  
• Ruggedized to MIL STD 810F for shock / vibration  
• Does not require recalibration after transport  
• Designed for two person lift – 49kg, 26.6” x 16.5” x 23.1” |
• ANDE System commercialization complete, CE marked, not ITAR regulated

• U.S. Testing Partners: DFSC, FBI, and NIST have been performing laboratory testing for the past 18 months

• U.S. Military/Intelligence Exercise: deployed in maritime operations

• U.S. DOD: laboratory testing on going, has been deployed operationally for field testing

• Deployed in international Military field exercise Q3 2013

• DHS: Immigration pilot scheduled for Q1 2014

• ANDE System developmental validation scheduled for Q1 2014
Expanding Rapid DNA Analysis Capabilities

• Processing of Touch Samples

• Expanded STR Analysis
NetBio has developed a modified BioChipSet for processing samples collected from objects handled by an unknown persons of interest (touch samples).

Rationale:

- ANDE was designed to process buccal swabs that typically contain 1000 - 2000 ng DNA
- The goal of the buccal swab purification process is to discard ~99.9% of the input DNA.
- Touch samples typically contain <0.5 ng – 100 ng DNA
- The goal of the Touch Sample purification process is to capture 100% of the input DNA.

The Touch Sample BioChipSet is currently undergoing commercial manufacturing and it will function in the same ANDE instrument.
Full STR Profiles from Touch Sample BioChipSet (III)

Swab from Rim of Water Glass
Rapid DNA with Expanded STR Multiplex Assay:

Enhanced International Database Searches and Kinship

International Data Compatibility:

• STR multiplex assay contains all existing and proposed standard loci for database searches in U.S., Europe, and Asia will support cross-border searching of all existing and proposed databases.

• Increasing the number of loci in multiplex sets will not only permit compatibility across borders, but will also diminish the chances of obtaining false hits in databases.

Generation of Additional Information per Assay

• Based on DHS funding, NetBio has developed a 27plex PCR assay using all internationally accepted STR loci.

• The expanded STR set will improve the application of DNA for verification of familial relationships, expanding beyond parent/child.

• The system can be expanded to process Y-STRs, Mitochondrial DNA, and other markers, allowing for generation of significantly more information from a sample in a single assay.
The 6 color, 27-plex Kinship Assay

D3S1358  D19S433  D2S1338  SE33

TH01  AM  D18S51  D1S1656  D10S1248  D2S441  Penta C

D16S539  vWA  D21S11  D12S391  Penta D

D5S818  D13S317  D7S820  TPOX  CSF  Penta E

D22S1045  DYS391  FGA  D8S1179  D6S1043

Rapid DNA Analysis™ Solutions  Company Proprietary
Conclusions

• Rapid DNA technology is broadly applicable to military, homeland security, intelligence, and law enforcement applications.

• The movement of DNA analysis from the laboratory to the field offers the potential to improve societal safety and security, and application of the technology is in its infancy.

• In partnership with GE, NetBio has launched our first Rapid DNA product—DNAscan—into the law enforcement market. Based on FBI guidance and policies, forensic labs are the initial goal.

• The ANDE platform is flexible, allowing for multiple spirals based on stakeholder requirements—no single configuration is appropriate for all ConOps.

• NetBio’s initial pipeline expansion are products for the rapid analysis of touch samples and an expanded STR set.

• NetBio gratefully acknowledges funding and guidance from DoD (ASDR&E, DFSC, JIEDDO, SOCOM), FBI, and DHS.
NetBio
Rapid DNA Analysis™ Solutions

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