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Human Factors and Behavioral Sciences Division

Research • Transition • Innovation

DHS Rapid and Low-cost DNA Biometrics

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Homeland Security

DHS S&T Rapid DNA-Based Screening

Goal

- Rapid and low-cost DNA-based verification of family relationships (kinship) and watch list checks of those seeking asylum or immigration into the United States; children put up for overseas adoptions; and mass-casualty identifications

Approach

- DHS needs and requirements study
- R&D to automate and integrate DNA laboratory processing steps
- Use of DHS small business innovative research (SBIR) program
- Collaborative R&D program with DoD and DOJ
- Additional R&D to extend kinship analysis capabilities
- NIST standards development and evaluation of prototype products
- User and public acceptance assistance

Payoff

- DNA screening for kinship is reduced from weeks to under an hour, from $500 to $100 per sample, and conducted in-house vs. external labs

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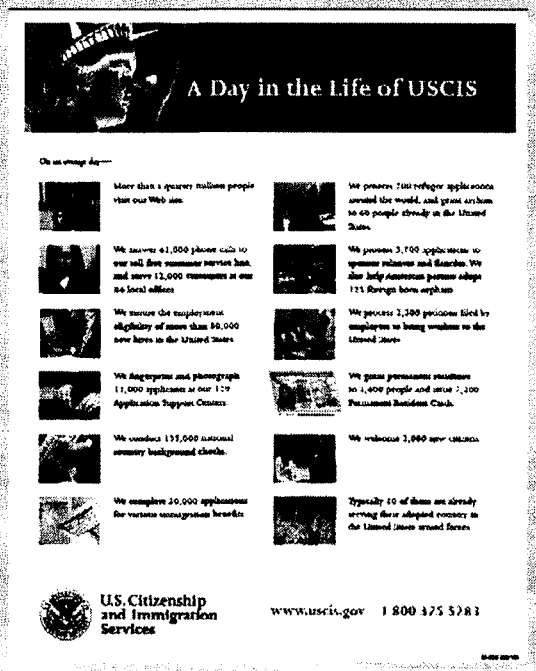
DHS S&T Rapid-DNA Based Screening

Why Does DHS Need Rapid-DNA?

Needs and Requirements Findings:



- On an <u>average DAY</u> in the life of USCIS:
  - 400 refugee applications processed worldwide
  - 40 persons in the US are granted asylum
  - 3700 applications to sponsor relatives and fiancées entry to the United States
  - 100 foreign born orphans are adopted by American parents
  - Fingerprints and photographs are taken of 11,000 applicants at the 133 Application Support Centers (ASC)
  - 135,000 national security background checks are conducted
  - 3,400 persons are granted citizenship (30 are serving in the US military)

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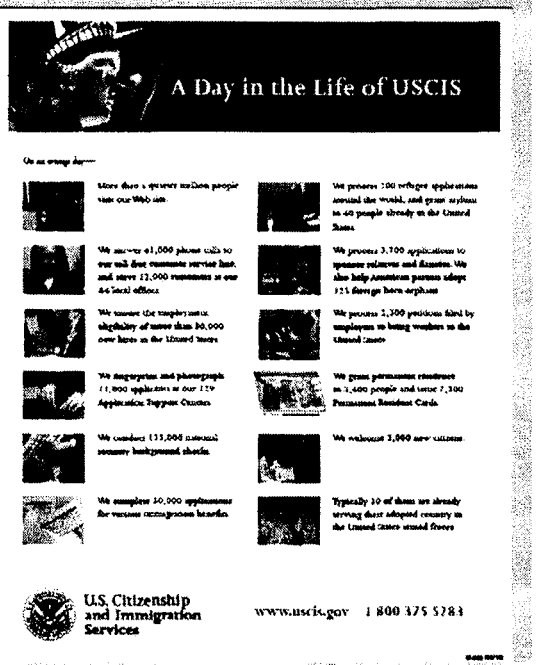
Why Does DHS Need Rapid-DNA?

Needs and Requirements Findings:

- DHS Needs to Verify Family Relationships
  - Kinship for Asylum and Refugee cases
  - Kinship for Adoptions
  - Kinship for Child Smuggling/Border Trafficking
- DHS to Identify Known Criminals
  - Immigration
    - DNA Criminal Check is not redundant to fingerprint check
  - CBP Border Violators & ICE Detainees
    - DOJ mandate to collect DNA from all detained persons
- DHS also Needs DNA for Mass Casualty and Missing Persons Identification



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Rapid DNA-Based Screening

DHS SBIR Rapid DNA-based Biometrics Awards

Goal

- Demonstrate an automated desktop prototype device that verifies identity or kinship within an hour from DNA samples

SBIR Program

Approach

- Phase I: Three, 6 month, $100K studies
  - DHS needs and requirements assessment
  - Performance metrics established
  - Risk assessment & technical architecture developed
- Phase II: Two, 2 year, $750K prototype development efforts
  - Develop, test, and deliver prototype DNA-based biometric device
  - Substantiate cost, speed, and performance against the Phase I metrics
- Phase III: Fully commercial device for DHS and other applications
  - Mass-casualty situations, reunification of family members following mass evacuations, identification of missing persons, rapid processing of crime-scene and suspect DNA and various scientific and educational uses

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SBIR Rapid-DNA Projects

"Digital Microfluidics"

Phase I Goals: 6 month, $100K

- Develop detailed use cases
- Identify key technical risks and required research activities
- Develop a system architecture and preliminary design

Figure 2: Composite photograph illustrating fundamental digital microfluidic operations on one of ALL's chips using a dyed liquid. (A) Dispensing a unit-sized droplet from a reservoir; (B) Transporting the first droplet away and dispensing a second droplet from the same reservoir; (C) Merging the two droplets together; (D) Transporting the combined droplet to mix it; (E) Preparing to split the combined droplet; (F) Splitting the combined droplet; (G) Merging the droplets back into the reservoir.

Phase II Goals: 2 year, $750K

- Develop a prototype system using a disposable microfluidic cartridge containing all of the required reagents and materials
- Employs a low-cost disposable microchip enabling precise manipulation of liquid droplets using an array of electrodes formed on an inexpensive printed-circuit-board (PCB)

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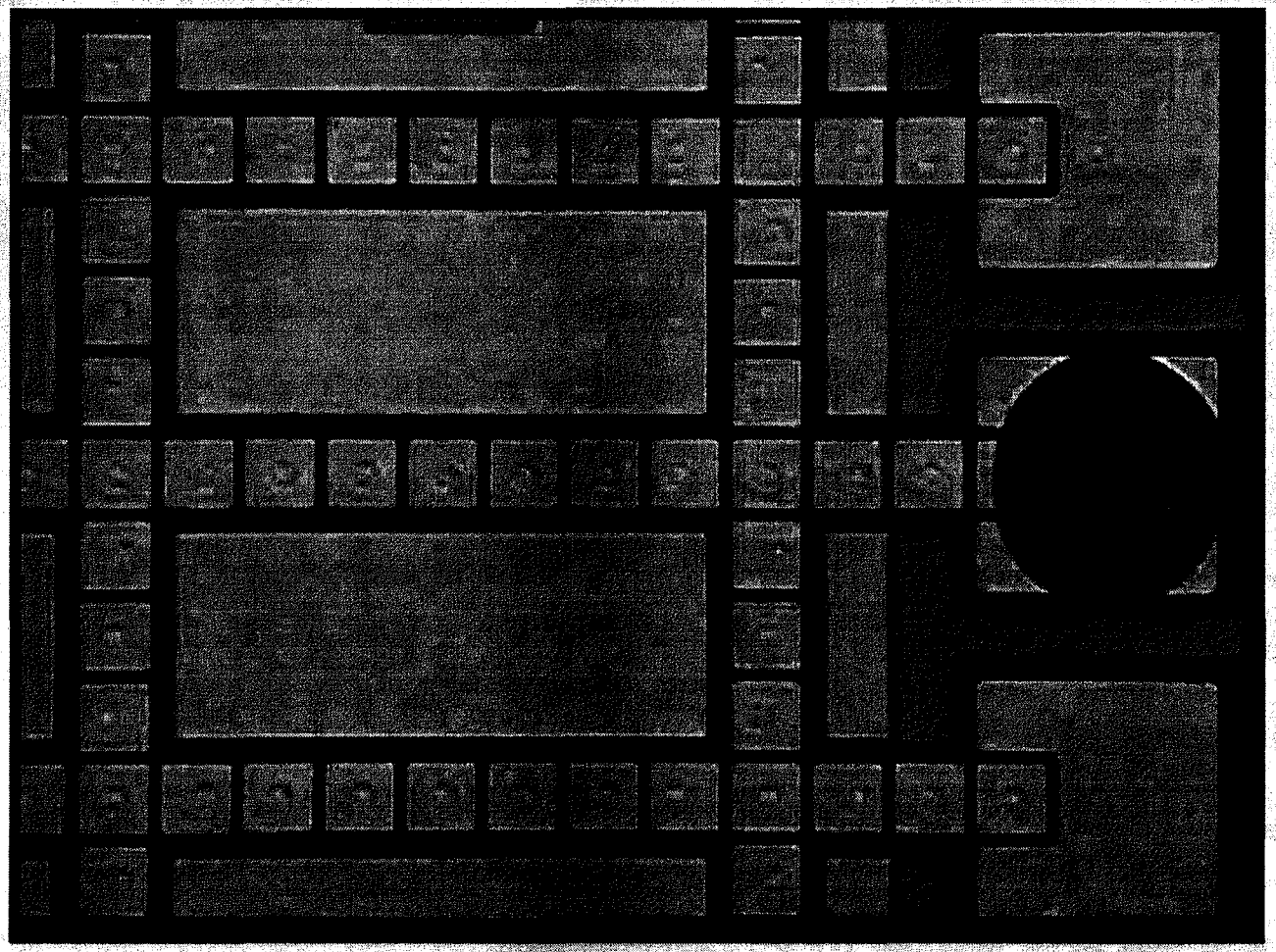
SBIR Rapid-DNA Projects

"Digital Microfluidics"



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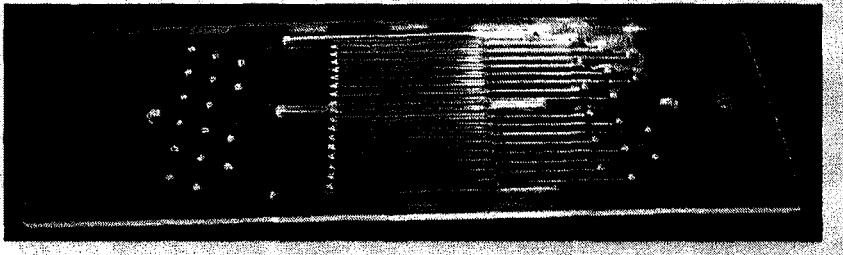
SBIR Rapid-DNA Projects

"BioChip "

Phase I Goals: 6 mo. $100K

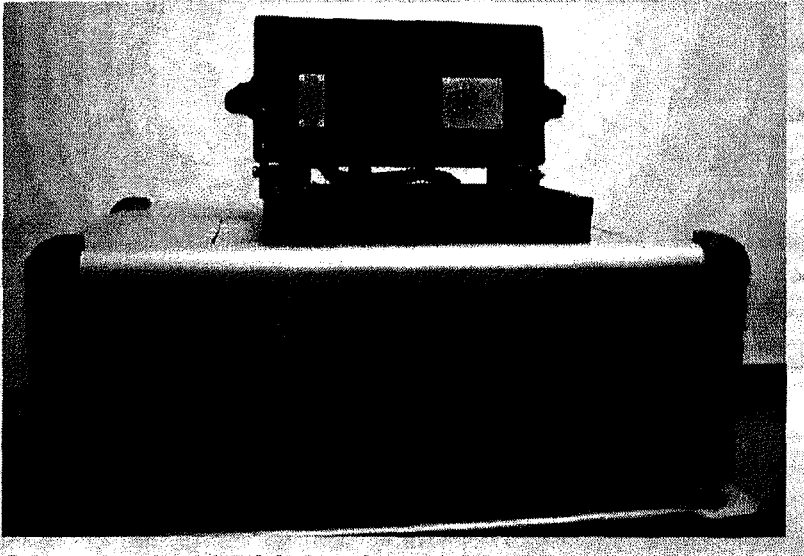
- DHS needs and requirements survey
- Establish performance metrics
- Study candidate technologies & risks
- Define a viable architecture



16-sample single use disposable PCR biochip

Phase II, 2 years, $750K

- R&D to expand kinship analysis beyond parent/child relationships to siblings and grandparents/ grandchildren



Genebench FX Series 100 separation and detection instrument.

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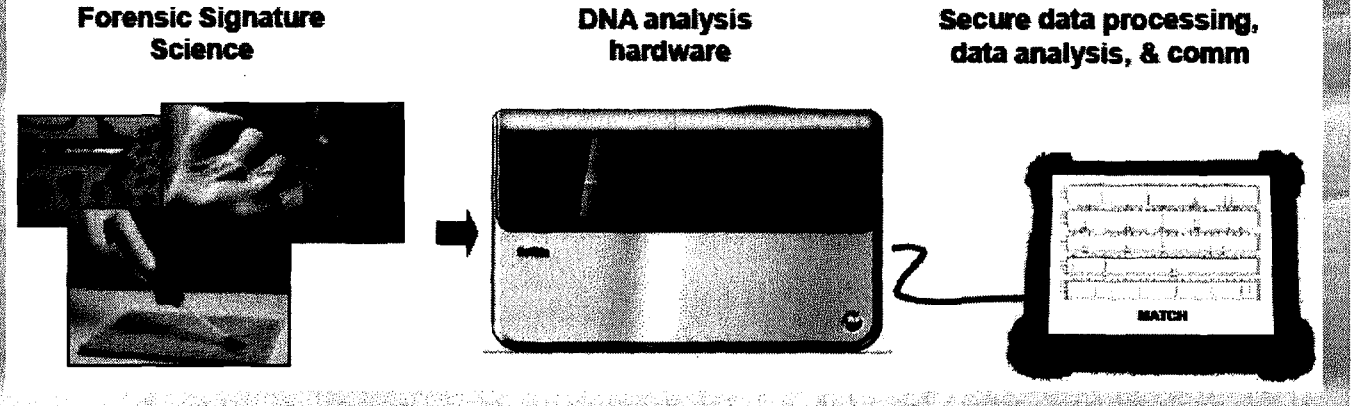
Rapid-DNA Based Screening

"Accelerated Nuclear DNA Equipment"

Jointly funded DoD, DOJ, DHS Project

- Conduct 18 month R&D effort to develop prototype system
- Initial desktop-size, automated system with low-volume unit cost of $275K available 6 months after prototype
- Current manual processing steps automated and integrated into a desktop-size device
- Delivery of Prototype in 18 months



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Rapid-DNA Based Screening

Joint Rapid-DNA Analysis Project

Operational Requirements

1. Non-technical user with 1 hr of training
2. Profile generation from buccal swab no manual user manipulations required
3. Set up by two person lift in ≤ 15 min & ruggedized to transportation vibrations
4. Specify reliability of system, MTTF
5. Routine maintenance intervals ≥ 1 month
6. No routine alignment or recalibration
7. Operate using 120V, drawing < 15 amps
8. Overall dimensions ≤ 6 cu.ft., not to exceed 30 in., weight < 50 kg
9. System cost ≤ $275K, cost/sample ≤ $100
10. Consumables must be disposable, pre-loaded with reagents and sealed
11. Prototypes at TRL 6 at end of 18 mo

Sample Analysis

1. Sample-in to profile out in T=<1 h, G= 45 m
2. Simultaneous processing of T=8 samples, G = 16 samples
3. Reagent stability of t=3 mo. At 20-30^{0}C, G=6 mo. At -10-50^{0}C
4. DNA extraction & purification comparable to bench top methods
5. PCR amplification of ≥ 16 loci (CODIS) in ≤ 30 min, G= Additional reagent sets
6. Separation & detection for ≥ 16 loci, single bp resolution with amplicons up to 500 bp
7. Accept and process fresh/dried buccal swabs & DNA samples prepared manually

Data Analysis

1. Raw & processed electropherogram data must be provided & stored
2. Create & export profiles compatible with CODIS & one other format defined by LL
3. Automated export of data in format compatible with COTS expert systems
4. Generate data file for sample tracking with unique identifier information
5. Bar code reader & GPS receiver that relay position & time to onboard computer
6. Software: Windows XP, network connection capability, automated STR allele calling & profile generation, Comms, System control
7. Wireless, wired, & USB network connections
8. External interfaces for display, keyboard, mouse

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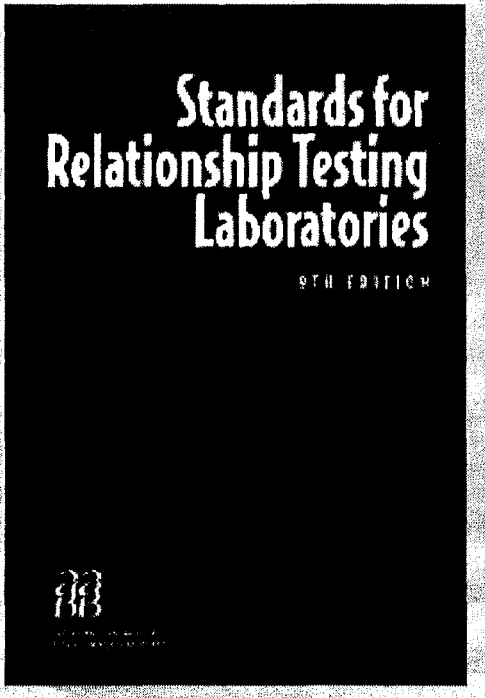
Rapid-DNA Standards

American Association of Blood Banks (AABB)

- Standards for Relationship Testing Laboratories, 9th edition
- Requirements that must be implemented by laboratories accredited by AABB for relationship testing
- Includes data collected with the sample, how long samples should be retained for, how many test samples should be run to validate device performance, records that should be maintained, requirements for test reports, etc.



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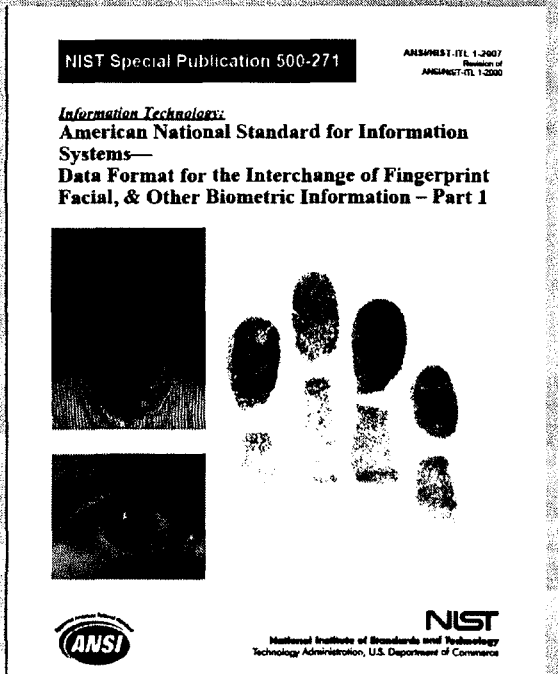
Rapid-DNA Data Sharing Standards

ANSI/NIST-Information Technology Laboratory (ITL)

- First published in 1986
  - exchange of fingerprint information
- Updated in 2007 and 2008
  - Iris exchange
  - Conformance to other standards - XML
  - Updated facial and fingerprint specifications
- 2011 update underway
  - Adds a DNA and Kinship record in addition to other significant changes



http://www.nist.gov/itl/iad/ig/ansi_standard.cfm

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Privacy and Civil Rights/Liberties

FBI Has Been Vigilant:

- CODIS loci are chosen to not reveal physical traits, race, ethnicity, disease susceptibility or other sensitive information
- Judiciary oversight committees advised 180 days before any change to core genetic markers
- No instance of misuse in ≈ 20 year history of program
- Congress, ACLU, Cato Institute and others remain sensitive

Privacy Act of 1974

DHS Will Be Vigilant!

FBI Combined DNA Index System (CODIS) Statistics (05/10)

Category	*Total Number of Profiles*
Offender Profiles	7,868,707
Arrestees	461,265
Forensic Profiles	319,601
Missing Person	760
Relatives of Missing Person	6,739
Unidentified Human Remains	3,854

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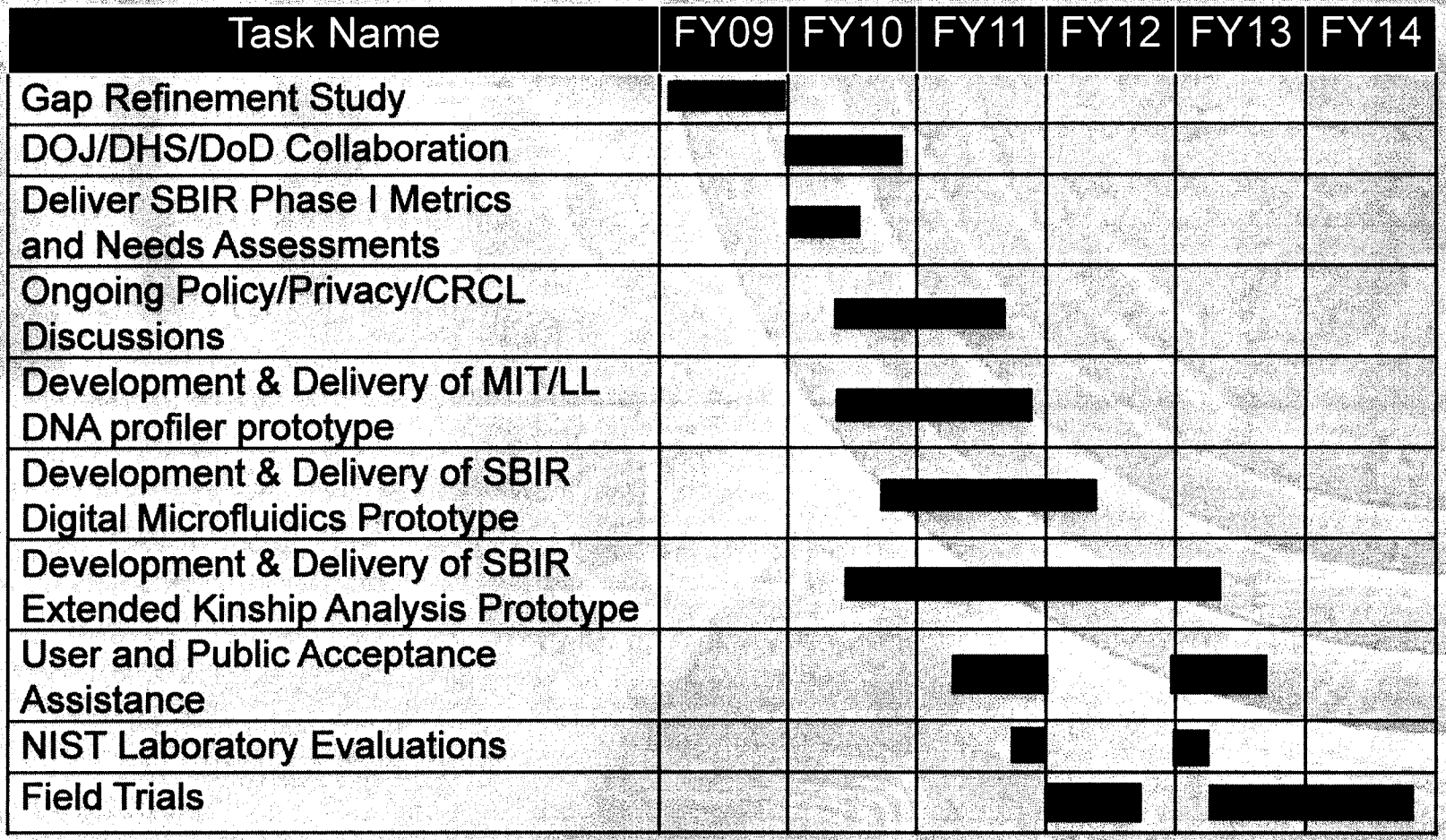
Schedule:



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