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Electronics and Electrical Engineering Laboratory

Office of Law Enforcement Standards

Programs, Activities, and Accomplishments

The Electronics and Electrical Engineering Laboratory

Through its technical laboratory research programs, the Electronics and Electrical Engineering Laboratory (EEEL) supports the U.S. electronics industry, its suppliers, and its customers by providing measurement technology needed to maintain and improve their competitive position. EEEL also provides support to the Federal government as needed to improve efficiency in technical operations, and cooperates with academia in the development and use of measurement methods and scientific data.

EEEL consists of six programmatic divisions and two matrix-managed offices:

Electricity Division

Semiconductor Electronics Division

Radio-Frequency Technology Division

Electromagnetic Technology Division

Optoelectronics Division

Magnetic Technology Division

Office of Microelectronics Programs

Office of Law Enforcement Standards

This document describes the technical programs of the Office of Law Enforcement Standards (OLES). Similar documents describing the other Divisions and Offices are available. Contact NIST/EEEL, 100 Bureau Drive, MS 8100, Gaithersburg, MD 20899-8100, Telephone: (301) 975-2220, On the Web: www.eeel.nist.gov

Cover Caption: The Office of Law Enforcement Standards assists the criminal justice and public safety communities through the development of equipment performance standards, users' guides, standard reference materials, and scientific research. Our logo (lower right) reflects some of the projects that we conduct: DNA research, arson research, forensic sciences, and law enforcement weapons and equipment. Also shown on the cover are pictures that reflect the more recent emphasis on our projects that further Homeland Defense initatives; including development of concealed weapons detection and imaging technologies; related equipment performance standards, such as for metal detectors; users' guides for chemical and biological protective equipment; and other types of protective equipment used by first responders to critical incidents.

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U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

Technology Administration
Phillip J. Bond, Under Secretary of Commerce for Technology

National Institute of Standards and Technology
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Contents

Welcome

The **Office of Law Enforcement Standards (OLES)** helps law enforcement, corrections, and criminal justice agencies ensure that the equipment they purchase and the technologies they use are safe, dependable, and effective. **OLES**, with a staff of ten, is based in Gaithersburg, Maryland, and is one of the two Offices within the Electronics and Electrical Engineering Laboratory at NIST.

OLES was established as a matrix management organization in 1971 and was based on recommendations from the President's Commission on Crime. The Commission report, entitled "Crime in a Free Society," recommended that a Federal agency be appointed to assist criminal justice agencies by developing equipment standards and providing technical support and assistance. The report indicated that the then National Bureau of Standards was one such agency suitable for this task. As a result, the Department of Commerce (DOC) and the Department of Justice (DOJ) signed a Memorandum of Understanding and the Office was established. The National Institute of Justice (NIJ), which is the research arm of the Department of Justice, is the primary sponsor of **OLES** projects. Projects also have been supported by the National Highway Traffic Safety Administration (NHTSA), the Federal Bureau of Investigation (FBI), the Office of Management and Budget (OMB), and the Federal Aviation Administration (FAA).

OLES fulfills its mission by applying science and technology to the needs of the criminal justice community, including law enforcement, corrections, and forensic science as well as the fire service. The Office focuses on the development of performance standards, which are promulgated as voluntary national standards by the NIJ. **OLES** also conducts research on protective clothing, communication systems, emergency equipment, investigative aids, protective and enforcement equipment, security systems, traffic enforcement systems, vehicles, weapons and ammunition, and analytical techniques and standard reference materials (SRM) used by the forensic science community. The composition of the project portfolio varies depending on the priorities of the criminal justice community at any given time, and, as necessary, draws upon the resources of NIST's Measurement and Standards Laboratories and outside agencies.

OLES has published, mostly through NIJ, more than 230 standards, guides, and technical reports over its 30-year history. These publications have dealt with such topics as emergency vehicle warning devices, police clothing and equipment, components of intrusion alarm systems, physical security of door and window assemblies, metal and explosive vapor detectors, arson accelerant detectors, and narcotic test kits. **OLES** also developed standard reference materials for glass comparisons and DNA profiling and reference collections of automobile paints and synthetic fibers for use by forensic laboratories.

Mission

The mission of **OLES** is to serve as the principal agent for standards development for the criminal justice and public safety communities. **OLES** has been instrumental in the development of numerous standards and the issuance of various technical reports that have had significant impact on both of these communities. Through its programs, OLES helps criminal

justice and public safety agencies acquire, on a cost-effective basis, the high quality resources they need to do their jobs. To accomplish this task, **OLES**:

- Develops methods for testing equipment performance;
- Develops methods for examining evidentiary materials;
- Develops standards for equipment and operating procedures;
- Develops users' guides;
- Develops standard reference materials; and
- Performs other scientific and engineering research as required by the criminal justice and public safety communities.

OLES' programs are organized into six areas: Weapons and Protective Systems; Detection, Inspection, and Enforcement Technologies; Chemical Systems and Materials; Forensic Sciences; Public Safety Communication Standards; and Critical Incident Technologies. Within each program area there are a variety of projects that are described herein. The projects listed in this book are those that **OLES** has proposed for fiscal year 2002. The actual portfolio is being negotiated as this book is being prepared. For additional information about **OLES**, please visit our web site at http://www.eeel.nist.gov/oles.

Weapons and Protective Systems

OLES' Weapons and Protective Systems program is responsible for some of the organization's most successful efforts. It provides ongoing technical support and research for the National Institute of Justice (NIJ) standard for ballistic-resistant body armor (bullet-resistant vests), which OLES first developed for NIJ in 1972. The body armor program is part of NIJ's successful Law Enforcement and Corrections Standards and Testing Program, through which companies may have their products voluntarily certified as compliant with the standard. Ballistic-resistant body armor has been credited with saving more than 2500 lives, and the program's evaluations of new materials and ballistic threats and its revisions of the standard help ensure the continued effectiveness of this technology.

The Weapons and Protective Systems program also develops and supports other equipment performance standards vital to the safety of law enforcement and corrections personnel, including stab-resistant body armor; ballistic helmets; riot helmets and face shields; bomb suits; metallic handcuffs; and firearms. It is evaluating new "smart gun" technologies and developing a test protocol for gunlocks, as well as working toward the country's first standard for armored cars to protect our nation's leaders, diplomats and visiting dignitaries.

This year, under the Weapons and Protective Systems program area, OLES will provide: 1) technical support for standards that are active under the NIJ Compliance Testing Program; 2) conduct or oversee research that will lead to the revision of *existing* equipment performance standards to address the current state of technology or to improve test methodologies; and 3) conduct or oversee research that will lead to the publication of *new* equipment performance standards, test protocols, or technology assessments because the law enforcement and corrections communities have indicated the need for these. Projects in each of these three categories will be described in this section.

Support of NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor"

Goals

The objective of this project is to address any issues with NIJ Standard-0101.04 that arise during NIJ's ballistic-resistant body armor Compliance Testing Program, which utilizes this performance standard and is administered by the National Law Enforcement and Corrections Technology Center (NLECTC). OLES maintains a support role in this testing program by monitoring testing, conducting studies where needed, and providing technical consultation services.

Customer Needs

The criminal justice community requires a standard for purchasing ballistic-resistant body armor ("bullet-proof vests" and related products). Procurement officials may refer to this standard in their procurement documents and require that vests being considered for purchase meet its requirements. The standard enables the U.S. criminal justice agencies to acquire, on a cost-effective basis, high quality ballistic-resistant body armor used by some 17,000 U.S. police departments and their 680,000 law enforcement officers.

NIJ Standard-0101.04 was issued in September 2000, and two commercial test laboratories have been certified to conduct testing to the standard. Numerous issues have arisen during the Compliance Testing Program that required technical studies and assessments to resolve.

Technical Strategy

OLES staff will monitor testing to identify any potential problem areas, and work to resolve those. This might include conducting independent testing at the OLES laboratory, consulting with others in the field, or issuing clarifying instructions to address the deficiency.

Of particular interest are the following:

- Evaluate the failure rate of body armor as a result of the somewhat more stringent backface signature (BFS) requirement, which now requires two measurements rather than one.
- Study the Ballistic Limit data obtained using the Modified Langlie Method.

Technical Contacts:

Kirk Rice

Thomas Russell

Staff-Years:

4.6 professionals

1.0 technician

1.0 contractor

Funding Sources:

Other Government Agencies (100%)

Project Champions:

- Armor & Protective Systems Working Group of government agencies
- Bosik Consultants Limited, Manotick, Ontario
- Defence Research Establishment Valcartier, Val Bélair, Quebec
- E-Labs, Inc., Colonial Beach, VA
- Home Office, Police Scientific Development Branch (PSDB), United Kingdom
- National Law Enforcement and Corrections Technology Center, Rockville, MD
- NIST Electronics and Electrical Engineering Laboratory (EEEL)
- Office of Special Technology, Technical Support Working Group (TSWG) of government agencies, Arlington, VA
- Royal Canadian Mounted Police, Ottawa, Ontario
- The Tekne Group, Inc., Hot Springs, AR
- Touchstone Research Laboratory, Ltd., Triadelphia, WV
- University of Virginia, Charlottesville, VA
- U.S. Army Aberdeen Test Center (ATC), Aberdeen, MD
- U.S. Army Soldier and Biological Chemical Command, Natick Soldier Center, Natick, MA
- U.S. Secret Service, Washington, DC
- Wayne State University Detroit, MI

■ Evaluate alternative methods for collecting and assessing ballistic limit data, such as the Kneubuehl method.

■ Evaluate the failure rate of new body armor designs tested against the new threat rounds.

FY2002 DELIVERABLES: Reports describing any relevant findings and conclusions of studies will be issued. Furthermore, any recommendations for clarifying the standard, or otherwise improving it, will be made.

Support of NIJ Standard-0115.00, "Stab Resistance of Personal Body Armor"

Goals

The objective of this project is to provide continuing support to the stab resistant body armor Compliance Testing Program, which utilizes NIJ Standard-0115.00, is sponsored by NIJ, and is administered by NLECTC. OLES maintains a support role in the formal Compliance Testing Program by monitoring testing, conducting studies where needed, and providing technical consultation services.

Customer Needs

This is the first true U.S. standard addressing the stab resistance of body armor, and it provides a consistent method by which stab resistant body armor performance can be assessed. The stab threat from sharp and edged weapons represents the primary threat to corrections officers and a secondary threat to police officers in the United States. Many state and local agencies are taking advantage of the matching federal funds offered through the Bulletproof Vest Partnership Act program, which requires stab resistant armor covered under the Program to be compliant with this standard.

This new standard was issued in September 2000, and two commercial test laboratories have been certified to conduct testing to the standard. Some issues have arisen during the Compliance Testing Program that required technical studies and assessments to resolve.

Technical Strategy

OLES staff will monitor testing to identify any potential problem areas, and work to resolve those. This might include conducting independent testing at the OLES laboratory, consulting with others in the field, or issuing clarifying instructions to address the deficiency.

Stab test apparatus used to support development of NIJ body armor standard for stab resistance.

FY2002 DELIVERABLES: Any relevant findings will be documented and, if necessary, clarifications will be made to the standard.

Support of NIJ Standard-0112.03, "Autoloading Pistols for Police Officers"

Goals

The objective of this project is to maintain a support role in NIJ's formal pistol Compliance Testing Program, which is administered by NLECTC. This entails monitoring testing, conducting studies where needed, and providing technical consultation services.

Customer Needs

This performance standard is specified by some law enforcement purchasing authorities to ensure that firearms under consideration as duty firearms meet certain basic safety, quality, and reliability requirements. This latest revision of the standard was issued in July 1999, and two commercial test laboratories have been certified to conduct testing to the standard. Issues sometimes arise during the Compliance Testing Program when the commercial labs test a firearm manufacturer's products. OLES staff provide a fair, unbiased resolution of the matter.

Technical Strategy

OLES staff will monitor testing to identify any potential problem areas, and work to resolve those. This might include conducting independent testing at the OLES laboratory, consulting with others in the field, or issuing clarifying instructions to address the deficiency.

FY2002 DELIVERABLES: Any relevant findings will be documented and, if necessary, clarifications will be made to the standard.

Revision of NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor"

Goals

The objective of this project is to obtain information from numerous studies that will lead to improved requirements or tests in a future revision of NIJ Standard-0101.04, "Ballistic Resistance of Personal Body Armor."

Customer Needs

The criminal justice and public safety communities would benefit from better body armor, and this can be realized by improving the body armor performance standard. NIJ's experience with NIJ Standard-0101.03 suggested that the ballistic resistant body armor standard needs to be maintained and updated more frequently than in the past, so that it can be kept current with ever-improving ballistic resistant materials, changing ballistic threats, and the introduction of special types of body armor.

Technical Strategy

The ballistic resistant body armor standard would benefit from more research or the application of newer technologies in a variety of areas, each of which is being addressed in a subproject under this overall project: 1) The methods used to define reasonable threats and then how to best represent those threats in the standard will be examined; 2) The ballistic impact with body armor will be studied to determine if there are better ways to assess the deformation of the armor; 3) Research related to the effects of ballistic blunt trauma to the body and the possible influence this might have on the minimum performance of body armor will be monitored; 4) The influence of environmental life cycle on the ballistic performance of armor will be studied; 5) The effect of multiple, nearly isochronic impacts with body armor will be studied; 6) The procedures for testing female body armor will be studied, and any special considerations that would influence the design of female body armor will be examined; and 7) Methods to test trauma packs will be developed.

Significant findings from these subproject studies will be considered for possible adoption into the next revision of the body armor standard. More information on each of these subprojects is included below.

FY2002 DELIVERABLES: Reports describing relevant findings and conclusions of studies will be issued throughout the year.

A. Threat Selection and Applications

The selection of appropriate threat levels is important to ensure that the minimum performance level expected of body armor is reasonable. Under this subproject, other methods for estimating the threat potential of different cartridges will be explored. One method in particular will base the threat potential on generalized energy levels rather than firearm-specific threats. As a logical extension of this process, modifications or refinements to the relative impact factor (RIF) concept will be examined. As part of this effort, a database compiling bullet energies and other properties and known performance trends, such as penetration into standardized target materials, will be established. The data will be analyzed to determine if some empirical method serves well in a predictive manner.

Other areas to be studied deal with the use of commercial off the shelf (COTS) ammunition versus NIJ-designed and manufactured ammunition. Ammunition manufacturers will be contacted to discuss the possibility of creating "standardized" test bullets for future use.

The number of NIJ armor classes needed to address today's threats will be carefully considered, with the possibility of introducing one or two other threat levels between existing levels and eliminating other levels, such as Type I.

B. Body Armor Impact Phenomena

This subproject is focused on determining if there are better ways to assess the energy dissipating characteristics of body armor. The current method for assessing backface deformation with a clay block is satisfactory under controlled conditions, but it could be improved upon. Other measurement techniques for assessing the impact to the body armor are being explored by other researchers. Internal studies into replacement media for the clay are planned, as well as considering the possibility for developing an electronic

or optoelectronic method for measuring the forces and energies applied to the body armor.

C. Behind-Armor Effects Research

An unsuccessful attempt was made last year to initiate a contract through the Technical Support Working Group (TSWG) channels to study behind-armor effects. Instead, OLES plans to monitor other efforts related to this. Measurement techniques for assessing ballistic impact to the body are being explored by other researchers. Efforts, such as those being funded by the U.S. Army (at Natick, the University of Virginia, and elsewhere), the Naval Research Laboratory (NRL), the North Atlantic Treaty Organization (NATO) Behind Armor Blunt Trauma group, Canada's Defence Research Establishment Valcartier (DREV) (at Biokinetics), and Johns Hopkins University (JHU), and less-lethal studies conducted by Battelle and Wayne State University (WSU), are relevant to this area of research. The validity of the 44 mm backface signature is being examined by these and other researchers. In some of these efforts, attempts will be made to correlate backface signatures to blunt trauma.

D. Environmental Effects on Body Armor Ballistic Resistance

Past studies on the ballistic performance of body armor have been limited to either new armor or armor that was aged only. TSWG has recently contracted with The Tekne Group, Inc. to study how the ballistic resistance of body armor is influenced by aging, as well as other environmental effects. OLES will serve as the government technical monitor on this contract, and conduct other in-house studies to supplement the TSWG effort.

E. Multi-Hit Test

Some in the law enforcement community have indicated that the performance of body armor subjected to automatic weapons fire is of concern to them. To assess the effect of multiple, nearly isochronic ballistic impacts, Bosik Consultants Limited in Canada has developed a multi-hit gun test fixture. OLES will provide technical support of a contract with Bosik, which will lead to the delivery of a 3-barrel test rig and a multi-hit test method to OLES.

F. Female Body Armor

The current version of the body armor standard specifies special treatment for female body armor. This subproject is aimed at a more detailed study of female body armor to determine if there are better ways to assess the performance of female body armor. TSWG has recently contracted with WSU to address this area. OLES will serve as the government technical monitor on this contract entitled “Female Body Armor Studies.” In addition, OLES will conduct in-house studies to supplement the TSWG effort. Based on the results of the TSWG contract and related studies, any special requirements, test equipment, and test methodologies specific to female armor will be developed.

G. Test Protocol for Body Armor Trauma Packs

Presently, supplemental trauma packs included with armor, which are intended to lessen the severity of behind-armor trauma over a localized area, are not tested with the armor during compliance testing. Past efforts to study this through TSWG contracts have not been successful, so OLES plans to conduct in-house testing. The purpose of this effort is to determine a suitable method for testing and evaluating soft body armor that includes trauma packs. Samples of various trauma packs will be obtained and tested several ways to determine if some modified test method can accommodate trauma packs. If this proves successful, the test method will be validated through more testing.

Revision of NIJ Standard-0115.00, "Stab Resistance of Personal Body Armor"

Goals

The objective of this project is to continue studies that will provide information to support a future revision of NIJ Standard-0115.00, "Stab Resistance of Personal Body Armor."

Customer Needs

The first year of the stab resistant body armor Compliance Testing Program has been a successful one, with about 80 armor models tested for compliance with the standard. During the latter stages of the standards development process, and during this first year of the testing program, several areas were identified for further study:

The portion of the standard dealing with the spike test needs more attention. A very close variant of the test methodology developed by Police Scientific Development Branch (PSDB) in their 1999 stab standard was adopted in this NIJ standard. Not addressed by PSDB is the threat due to a spike-style weapon. OLES adopted a spike based

on a design similar to the California Ice Pick threat, while retaining the standard test methods already specified in the NIJ standard.

The slash threat was not directly addressed in NIJ Standard-0115.00, although it is not believed to be as severe as the stab threats. Future improvements to this standard will incorporate a slash test methodology.

The tip sharpness of the knife blades and spike that are defined in the NIJ standard must meet certain requirements. Not addressed in the standard are any requirements for knife blade edge sharpness. Future improvements to this standard will probably incorporate an edge sharpness requirement and test methodology and equipment.

The backing material specified in the NIJ standard consists of multiple layers of commercially available rubber and sponge foam sheets. These materials typically have fairly large variations in their physical properties due to routine production variations. Future improvements to this standard will probably incorporate better definition of these materials or specify new and improved materials.

The public safety community, commercial test laboratories, and armor manufacturers will benefit from a revised standard that addresses these points, as it will lead to greater test consistency, greater flexibility in product design (since "slash only" protection will become an option), and improved armor designs.

Technical Strategy

OLES established a formal collaboration with PSDB by executing an annex to the existing bilateral agreement with the UK through TSWG channels. This permits the program to proceed at an accelerated pace. The areas requiring attention, which are described in the section above, will be addressed through a collaborative effort with PSDB. Work at PSDB is already underway to advance the research on spike threats, the edge sharpness test, and backing materials. OLES staff will conduct in-house studies on spike threats, backing materials, and edge sharpness testing, and validate PSDB's slash test methodology through testing.

FY2002 DELIVERABLES: Potential improvements to the test methods in the standard will be validated in FY2002, with progress being reported quarterly. A future revision of the standard is expected in FY2003.

Revision of NIJ Standard-0108.01, "Ballistic Resistant Protective Materials"

Goals

The objective of this project is to revise the NIJ standard that establishes minimum performance requirements and methods of test for ballistic resistant protective materials.

Customer Needs

Law enforcement agencies rely on NIJ Standard-0108.01 to ensure the quality and reliability of ballistic resistant materials used for personal protection purposes. These materials are of many types, and can be found in shields, ballistic resistant plates, and vehicle armor. The current standard does not reflect any of the improvements that were recently introduced into the ballistic resistant body armor standard.

Technical Strategy

The current revision of the standard, NIJ Standard-0108.01 was released in September 1985. It added ballistic threat level IIIA and established threat level classifications that were consistent with other NIJ standards for ballistic protection. The general strategy of the current effort is to develop a new draft revision of NIJ Standard-0108.01 by incorporating many of the improvements from the body armor standard; specifically: 1) introduction of a ballistic limit test methodology; 2) updating of the ballistic threats; and 3) specification of formal test procedures that require a uniform reporting style.

A determination will be made whether to include testing of transparent materials in the revised standard or to develop a separate performance standard for those materials. All test methods will be validated through experimental testing, and the draft standard will be submitted to user and technical committees for review and comment.

FY2002 DELIVERABLES: A revised draft of the standard is expected in mid-FY2002, with plans to finalize it by the end of FY2002.

Revision of NIJ Standard-0104.02, "Riot Helmets and Face Shields"

Goals

The objective of this project is to review NIJ Standard-0104.02, develop solutions for some deficiencies in it, and issue an improved revision.

Customer Needs

NIJ Standard-0104.02, "Riot Helmets and Face Shields," was last reviewed in October 1984. Since that time the safety equipment testing industry as well as the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) have switched to "headforms" endorsed by the International Organization for Standardization (ISO) for all protective headgear testing. OLES has received over the past few years many complaints from the safety equipment testing laboratories about the lack of availability of the "headform" specified in the NIJ Standard and that this NIJ Standard is not conforming to the adoption of International Standards wherever feasible. Additionally, there are concerns about how to test the "tails" (i.e., protection components for the neck) on helmets, and how to assess the flame resistance of the entire assembly (helmet, face shield, and tail). The current standard has no provisions for evaluating these components.

Because of these standards-related issues, riot helmets and face shields are not tested as rigorously as they should be. By addressing these deficiencies with the standard, law enforcement and corrections personnel would be able to specify that their equipment must comply with the performance standard, thereby leading to better equipment that meets more stringent technical requirements.

Technical Strategy

OLES will review the standard to determine if: a) other existing national standards can be utilized; b) upgrading the identified threat levels covered in the current standard is necessary; c) changing to an ISO "headform" will change the protection levels covered under the old standard; and d) a test methodology can be developed for the tails.

OLES staff will consult with other standards bodies to discuss their rationale for and experiences with the ISO headform. Staff will also research existing flammability resistance test methods and impact resistance methods for potential inclusion in this standard.

If changes are necessary, revised test procedures will be developed and validated. The changes will be issued in a revised standard.

FY2002 DELIVERABLES: Recommendations will be made for testing riot helmets and face shields. If changes to the standard are warranted, a draft of the new revision will be developed by the third quarter of FY2002.

Revision of NIJ Standard-0106.01, "Ballistic Helmets"

Goals

The objective of this project is to revise NIJ Standard-0106.01, "Ballistic Helmets," the equipment standard that establishes minimum performance requirements and methods of test for ballistic helmets.

Customer Needs

Law enforcement agencies rely on the NIJ ballistic helmet standard to ensure the quality and reliability of their bullet resistant helmets. The current version of the helmet, NIJ Standard-0106.01, was issued in December 1981. Since that time, there have been several developments that collectively indicate the need for a revised standard: 1) the current revision only addresses threats up to level II, while helmet technologies have made them more capable than that; 2) the threat definitions in the current revision are different than those in the recently updated ballistic-resistant body armor standard; 3) instrumentation for assessing helmet performance has improved dramatically; 4) head trauma research has led to a better understanding of injury mechanisms and injury risk criteria; and 5) as helmets grow lighter, through the utilization of new and improved materials, the shock loading to the head from ballistic impacts may increase. By improving the standard with the latest research in each of these areas, law enforcement personnel will benefit from better equipment.

Technical Strategy

In FY1999, an Interagency Agreement between OLES and the Natick Soldier Center created a means to support additional research through a 5-phase, 28-month R&D contract to the University of Virginia, which is jointly funded by the Army and OLES, with a majority of the funding coming from the Army. The primary goals of the contract are to assess the limiting performance of helmets for the prevention of head injury and to define risk-of-injury criteria under ballistic impacts. A secondary goal is to identify an experimental test using anthropometric test devices (ATDs). Correlation of forces recorded on an ATD with the risk of injury studies will promote the development of improved, lighter weight, energy absorbing, protective helmet systems for both the military and the law enforcement community. This correlation can subsequently be used to predict the risk of human injury through the use of ATDs alone.

The remainder of this project will involve the following:

- Evaluate findings from the University of Virginia effort for potential inclusion in this revision of the standard.
- Reestablish helmet test capability at OLES.
- Draft the next revision of the standard, NIJ Standard-0106.02, "Ballistic Resistance of Helmets," including 1) adoption of the NIJ Standard-0101.04 ballistic threat levels; 2) ballistic limit testing; 3) revision of the impact measurement system for performance testing; 4) re-evaluation of baseline performance requirements; 5) improvements in the area of test quality assurance by specifying the use of formal test procedures; and 6) normalized compliance test report forms.

FY2002 DELIVERABLES: Progress reports will be issued quarterly. After the University of Virginia contract is completed, a draft of the revised standard will be developed by the third quarter of FY2002.

Revision of NIJ Standard-0307.01, "Metallic Handcuffs"

Goals

The objective of this project is to revise NIJ Standard-0307.01, the performance standard for metallic handcuffs.

Customer Needs

The classic mass-produced steel handcuff, little changed over the last 90 years, is used in arrests and for prisoner transport. The limitations of traditional handcuffs become evident, particularly during the transport of prisoners, where prisoners have been known to pick the double lock with a bit of wire, defeat the pawl directly with a piece of thin material, or break the "cheek plates" apart at the ratchet pivot. With the anticipated improvements, a revision to this standard would provide a better way to test and evaluate handcuffs, force desired improvements in metallic handcuffs design, and result in better equipment being available to public safety officers.

Technical Strategy

OLES has been conducting an investigation into handcuff design parameters and performance test options. A force-torque apparatus for evaluating loads applied to typical handcuffs was developed. A theoretical analysis describing the handcuff components as curved beams was developed and used to examine the way in which the stiffness of those "beams" depends on shape and material composition.

A contract with Touchstone Research Laboratory addressed design details and shortcomings including: longitudinal testing of handcuffs having no tongues on the cheek plates; factors affecting the picking of handcuff locks; and handcuff size issues. The remainder of this project will involve the following:

- Evaluate the Touchstone report for relevant information that could be used to improve the standard.
- Develop improved test methods, finalize the design of any special equipment needed to test handcuffs, and validate the testing methodology.
- Develop a draft revised standard.

FY2002 DELIVERABLES: A draft of the revised standard and specifications of specialized test equipment.

Revision of NIJ Standard-0113.00, "12-Gauge Shotguns for Police Use"

Goals

The objective of this project is to revise the performance standard for shotguns used by law enforcement and corrections officers.

Customer Needs

This standard can be used to ensure that shotguns meet basic dimensional, functional, safety, and firing requirements. The current base version of the standard, NIJ Standard-0113.00, was released in March 1989. Today, shotguns are used in a greater variety of applications than ever before, as launchers for certain types of special devices (such as flares and barrier penetrators), to deliver less-than-lethal munitions on target, and in their traditional role to fire shotshells and slugs. It is critical for the shotgun performance standard to remain responsive to the types of shotguns that are commonly used by public safety officers, and to consider the different applications identified so that public safety officers can benefit from equipment that will work as intended for their unique applications.

Technical Strategy

The base version of this standard has been reviewed. New test fixtures have been built so that the shotguns can be consistently held in a safe position for controlled firing tests. Studies are underway to determine the most popular types of shotguns used by law enforcement and corrections personnel. The remainder of this project will involve the following:

- Research specific performance requirements for shotguns used in the applications identified above. Develop a revised draft of the standard.
- Validate the revised draft standard through experimental testing.
- Submit the validated draft standard for comment and review.

FY2002 DELIVERABLES: Progress reports will be issued quarterly, and a revised draft of the standard is planned for late FY2002.

OLES Research Facility Improvements

Goals

The objective of this project is to relocate and improve OLES' Research Test Facility (RTF). The test facility is used to support work on nearly all of the Weapons and Protective Systems projects, as well as a few in other program areas. Some of the ballistics-related projects that will be conducted at this facility are: standards development efforts for ballistic resistant materials, ballistic resistant body armor, ballistic helmets, shotguns, pistols, and "Smart" guns, and support of gunshot residue forensic projects. Some of the non-ballistics projects that will be conducted there involve the development of standards for stab resistant body armor, riot helmets, handcuffs, and gunlocks.

Customer Needs

Currently the laboratory is located in an underground concrete bunker on a property annex adjacent to the NIST campus. Late in FY2002, NIST expects to turn this annex over to the city of Gaithersburg, so relocation of the facility is necessary. This dedicated laboratory provides OLES the flexibility it requires to respond rapidly on a cost-effective basis to meet customers' needs.

Technical Strategy

Improvements in the areas of data acquisition and other equipment are made on an ad hoc basis to support specific projects. Plans are to move the physical facility to an existing building on campus, in the basement of the Industrial Building. This requires construction of the laboratory space, which will be done through a contract. The schedule for this part of the effort follows:

- Release the Request for Proposal – Fall 2001
- Evaluate proposals – Winter 2001
- Begin construction – Spring 2002
- Move into facility – Fall 2002

FY2002 DELIVERABLES: An equipped and functional RTF.

Development of an NIJ Standard for Bomb Suits

Goals

The objective of this project is to establish minimum performance requirements and methods of test for bomb suits used by law enforcement explosive ordnance disposal (EOD) personnel.

Customer Needs

Currently, there is no standard for bomb suits used by law enforcement EOD personnel. Purchasing agents typically rely on advice from others in the field and manufacturers' literature. The EOD community has identified this deficiency as a top priority. A bomb suit standard will provide a convenient means whereby agencies can confidently purchase bomb suits that meet basic safety and functional requirements.

Technical Strategy

The U.S. Army has developed preliminary performance requirements for bomb suits. This information is being examined, and field test methods are being evaluated to determine how to structure this performance standard. Additional work will involve the following:

- Consult with explosives experts in law enforcement and the military to identify essential features of bomb suits and rating categories.
- Evaluate existing commercial, military, and international standards to determine if any are suitable for use by law enforcement.
- Adopt or modify existing standards or develop a new standard to suit the needs of law enforcement.
- Validate the standard through experimental testing.
- Submit the validated draft standard for comment and review.

FY2002 DELIVERABLES: Progress reports will be issued quarterly. The technical team will be formed in early FY2002 to determine threat rating categories and to develop a working draft standard by late FY2002. Work is expected to continue through FY2003.

Development of an Armored Car Standard

Goals

The objective of this project is to develop an NIJ standard for the minimum performance requirements and methods of test for armored cars.

Customer Needs

There currently is no U.S. standard describing the protection levels of armored cars used for personal protection. As a result, there have been instances where vendors have advertised their armored cars as being able to defeat certain types of threats. Field tests have shown some of these claims to be untrue. To rectify this situation, a uniform standard is needed that clearly defines the types of threats being tested and the test methods. A standard would provide a consistent means by which to assess the performance of armored cars, allowing the purchasing agent to purchase an armored vehicle with confidence that it will meet desired performance levels.

Technical Strategy

OLES has been working with the U.S. Secret Service, Department of State, and Department of Defense to settle on an acceptable approach. TSWG plans to solicit contractors to address specialized areas required for this standard: ballistics testing, blast testing, optical qualities testing, automotive performance testing, and quality assurance testing.

Through the TSWG effort, OLES will play an integral role in monitoring progress on each phase of the program, coordinating the activities of the five efforts described earlier, and will ultimately be responsible for tying them together into a single coherent performance standard. This will involve coordinating the standard review process so that the armoring industry can comment on the draft standard; addressing comments from the advisory group and revising the draft standard; participating in experimental trials to validate the test methods; and developing the final draft standard.

FY2002 DELIVERABLES: Participation in the TSWG effort, with delivery schedules to be determined during the contracting process.

Test Protocol Development for Gunlocks

Goals

The objective of this project is to participate in the development of a standard test protocol for evaluating gunlocks.

Customer Needs

Gun safety is a common theme in the news media. One of the reasons public attention is focused on gun safety is because of the occasional incidents involving children. Congress requested the U.S. Department of Justice (USDOJ) to investigate ways of increasing handgun safety. Specifically, the request was to make guns "childproof" and to ensure that only authorized users could fire law enforcement officers' guns. This project is one of the steps taken to address the first part of the Congressional request - namely, making guns "childproof." Other projects, such as the development of "Smart Gun" technologies also address this same concern and the second part of the Congressional request.

Many states have enacted Child Access Prevention laws, or "safe storage" laws. These laws require firearms to be stored in such a manner that they are inaccessible to children, because they are locked in a secure container or because a separate locking device is applied to the firearm. With such emphasis on firearm safety measures, it is inevitable that certain issues will be raised; such as defining how good a locking mechanism must be, and describing how to assess the locking mechanism to determine if it is acceptable for its intended application. The U.S. Congress is planning to implement a gunlock program, whereby $75M per annum would be set aside to purchase and distribute gunlocks. No performance standards exist by which to assess the performance of gunlocks, potentially leading to problems should some of these locks distributed through the government program prove to be ineffective. Development of a standard test protocol will ultimately promote public safety by establishing a consistent method for assessing the performance of gunlocks.

Technical Strategy

OLES plays an active role on ASTM Subcommittee F15.53 “Non-Integral Firearm Locking Devices” to develop a “gunlock” standard. To date, a preliminary draft standard has been produced. OLES also has developed and procured test equipment necessary to conduct gunlock

testing. The level of effort on this project will depend on the specific requirements and schedule of the federal gunlock program described earlier, and those details are not yet known.

OLES will continue participation on ASTM F15.53, and continue meeting with manufacturers to identify their concerns and develop ideas for standardized test methods. Additionally, OLES will validate gunlock testing methods and participate in interlaboratory trials. An assessment will be made to determine if the ASTM standard will meet the needs of the federal gunlock program, or if something more must be done to support that program.

FY2002 DELIVERABLES: The implementation details of the federal program are currently being determined. OLES will continue participation in the ASTM standards development effort, which is expected to produce an industry-approved standard in 1-2 years.

Evaluation Of "Smart Guns"

Goals

The objective of this project is to evaluate smart gun technologies; and if a mature technology is incorporated into a fireman, to develop a standard test protocol for evaluating the firearm.

Customer Needs

As evidenced by recent news stories, there is great concern with regard to the safety of handguns for two main reasons: law enforcement officers are killed by criminals using the officers' own guns; and children are accidentally killed with guns they find at home or elsewhere.

Because of these problems, Congress requested that the U.S. Department of Justice (USDOJ) investigate ways to increase handgun safety. Specifically, the request was to make guns "childproof" and to ensure that only authorized users could fire law enforcement officers' guns. A study conducted by Sandia National Laboratories in the mid-1990's defined the operational requirements for firearms utilizing smart gun technologies. For several years, NIJ has awarded grants to develop smart gun technologies and smart guns. To make wise decisions regarding funding and technology development, specialized advice is needed to evaluate the technologies to determine if they are feasible.

Technical Strategy

As smart gun technologies are developed, OLES will continue to provide technical guidance to evaluate the technologies and their integration into smart gun designs.

As designs mature, OLES will assist in developing a plan to conduct limited field testing of prototype smart guns at participating law enforcement agencies.

FY2002 DELIVERABLES: As needed.

Accomplishments

- Implementation of a formal Compliance Testing Program for ballistic resistant body armor. This program utilizes NIJ Standard–0101.04, "Ballistic Resistance of Personal Body Armor," which was published in September 2000. Two commercial laboratories were certified to conduct testing under the Compliance Testing Program.

- Publication of NIJ Standard–0101.04, "Ballistic Resistance of Personal Body Armor," Revision A, June 2001. This latest revision clarifies several issues that arose during the body armor Compliance Testing Program run by NIJ.

- Implementation of a formal Compliance Testing Program for stab resistant body armor. This program utilizes NIJ Standard–0115.00, "Stab Resistance of Personal Body Armor," which was published in September 2000. Two commercial laboratories were certified to conduct testing under the Compliance Testing Program.

- OLES' Research Facility was utilized to obtain residue from gunshots in support of NIST's Chemical Sciences and Technology Laboratory (CSTL) forensics projects.

Recent Publications

NIJ Standard–0101.04, "Ballistic Resistance of Personal Body Armor," Revision A, June 2001.

NIJ Standard–0115.00, "Stab Resistance of Personal Body Armor," September 2000.

NIJ Standard–0112.03, "Autoloading Pistols for Police Officers," Revision A, July 1999.

Detection, Inspection, and Enforcement Technologies

As America's homeland security efforts intensify, the work of OLES' Detection, Inspection and Enforcement Technologies program becomes increasingly important. Several projects focus on improving the capability to detect and image concealed weapons. One is developing a revolutionary millimeter-wave imaging system compact enough to be used almost anywhere and able to image metallic weapons under clothing in real time. Others projects support improvements in the accuracy and safety of current metal detectors. These include two studies -- one of the electrical properties of metals used in handheld weapons; the other of materials that emulate the electromagnetic properties of the human body -- and development of a handgun replica to improve metal detector testing and evaluation.

The Detection, Inspection and Enforcement Technologies program is also updating NIJ's standard for X-ray systems used to assist in disarming bombs, and is developing evaluation standards for advanced human recognition systems and an improved liquid-filled camera that will enhance law enforcement and security surveillance efforts.

Millimeter-Wave Concealed Weapon Imaging System Development Project

Goals

The objective of this project is to develop a long distance (up to 8 m) terahertz-wave actively illuminating concealed weapon imaging system.

Customer Needs

This imaging system will provide a method for examining/screening/scanning people for weapons and other threat items from a safe distance. The distance typically considered safe by the law enforcement community is 8 m.

The Law Enforcement and Corrections Technology Advisory Council (LECTAC) has listed concealed weapon detection and imaging as their top law enforcement and corrections (LEC) priority. Present metal weapon detectors are inadequate because of their limited range (less than 15 cm for a hand-held device and less than 0.5 m for a walk-through device) and form (hand-held device is a wand and the walk-through is a portal). Presently, there is no system that can be used as a portable long-distance concealed weapon viewer. Furthermore, the ambiguity of simple detection presents liability issues for subsequent search.

Technical Strategy

During FY2002, demonstrate imaging. Specific tasks are as follows:

- Interface back-end electronics to front-end electronics and acquire images.
- Provide assessment of imaging system considering spatial resolution, frame rate, clarity, and gray scale intensity and projections for improvements in these parameters, if applicable.

FY2002 DELIVERABLES: Prototype imaging system using two-dimensional monolithic imaging arrays

Two-Dimensional Monolithic Microbolometer Imaging Arrays for Concealed Weapons Detection

Goals

The objective of this project is to develop room-temperature, antenna-coupled, niobium microbolometer arrays, with requisite optics and front-end electronics, for concealed weapons imaging applications in the millimeter-wave range.

Customer Needs

LECTAC has listed concealed weapons detection and imaging as their top LEC priority. Presently there are no monolithic array technologies that are being developed in the millimeter-wave range; this range is the most appropriate for concealed weapons imaging because of the relatively short wavelength and the ability to penetrate clothing material. Monolithic detector arrays, using silicon integrated circuit processing technology, have the promise of being very inexpensive compared to present hybrid approaches (detector, mixer, local oscillator, etc. for each pixel). Furthermore, the present hybrid arrays must be scanned to provide sufficient areal coverage and resolution, and this scanning reduces system ruggedness and increases system cost. The low cost microbolometer arrays would simplify the design and lower the cost of milli-

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11.0 professionals

Funding Sources:

100% Other Government Agencies

Project Champions:

- Federal Bureau of Investigation (FBI), Engineering Research Facility, Quantico, VA
- Home Office, Police Scientific Development Branch (PSDB), United Kingdom
- Law Enforcement Video Association
- NIST Electronics and Electrical Engineering Laboratory (EEEL)
- NIST Information Technology Laboratory (ITL)
- NIST Manufacturing Engineering Laboratory (MEL)
- Notre Dame University, South Bend, IN
- Society of Automotive Engineers
- University of South Florida, Tampa Bay, FL
- U.S. Secret Service, Washington, DC

meter-wave range concealed weapons imaging and detection systems, and this cost savings would benefit the LEC community.

The system being developed is uses an integral source to form an image, which is based on contrast between a concealed weapon and the human body. The present version operates at a frequency of 95 GHz (3.1mm wavelength). This represents a tradeoff between spatial resolution, which improves at higher frequencies. and penetration of clothing, which improves at lower frequencies. A detailed sensitivity analysis was performed at the start of the project, and revised in June 1999 to incorporate experimental results from the fabricated microbolometers. The present best estimate of the system noise-equivalent reflectance difference (NERD) is 0.40 % in a single frame (frame rate is 30 Hz). The main assumptions leading to this estimate are: peak source power of 1 W (specification of the commercially obtained source), target range of 50 m, primary aperture diameter of 30 cm, source repetition rate of 100 kHz (maximum available from source), detector time constant of 150 ns (measured), and detector noise-equivalent power of 100 pW $Hz^{-1/2}$. All of these are realistic values for each channel of the planned system.

Technical Strategy

We propose to continue with the previous plan, largely unchanged technically, but delayed approximately six months. It is possible that the full-wafer array will require further iteration or debugging to yield an operational standoff imaging system.

Specific tasks are:

- Design and fabricate wafer-scale array, (using 5-element slot-ring results)

  – Fabricate a full wafer on 50 μm thickness substrates.

  – Modify mount design for testing of full-wafer array (120 elements)

- Design front-end circuit boards (within EMI shield)
- Expand EMI shield and enclosure dimensions to provide clearance for above
- Mount for full-wafer array has been designed and built. However, a second version is likely to be required which will interface with redesigned electronics.
- Perform single-pixel measurements of a scanned reflectance target to verify performance and end-to end system feasibility
- Design and fabricate second iteration of wafer-scale array
- Design, model, and fabricate reflective optics for feed of antenna array
- Integrate wafer-scale array with reflective optics
- Design and fabricate front-end electronics for readout of array. First version (5 channels) has been designed and built. However, a new version is needed, and will be designed and built, largely from scratch.
- Integrate wafer-scale array with readout electronics

FY2002 DELIVERABLES: A scanned reflectance map of a "dummy" target, using single pixel; a wafer-scale array of slot-ring,antenna-coupled bolometers, on thin substrate; a physical mount for wafer-scale array, including backing cavities, EMI enclosure, and contact-circuit board; the reflective optics for feed of wafer-scale array, with modeled performance; the front-end electronics for bias and readout of wafer-scale array; system integration of the above.

Development of Evaluation Standards for Still and Video Human Recognition Systems

Goals

The objective of this project is to design methods for the evaluation of systems that identify humans in imagery and define the standards for the collection, dissemination and use of databases of imagery.

Customer Needs

Standard databases and measurement methods (software implementations of evaluation metrics) are needed to allow quantitative performance testing of biometric recognition products over a wide range of highly specific identification and verification applications. The specific application being addressed by this work is human identification of uncooperative subjects at a distance. The reliability and efficacy of biometric system which are candidates for deployment can be evaluated using these methods.

Technical Strategy

In prior fiscal years, NIST has been funded to conduct data gathering efforts, the result of which is a human identification database. Using the

database, NIST has developed the measurement methods for analyzing performance of facial recognition systems and is analyzing gate recognition systems. The techniques are applicable to a wide range of biometrics. This effort will run through FY2002 and is jointly funded by the NIJ and the Defense Advanced Research Projects Agency (DARPA). The NIST database is a multi-modal, multi-site, and multi-biometric collection permitting a broad range of investigations. Among these the Human Identification 1 (HID-1) evaluation protocol addresses performance on imagery from hundreds of individuals taken over many months, both close up and at a distance, on still and video data, obtained using a range of visible and infra-red sensors under varying lighting conditions, both indoors and outdoors.

NIST will continue work to support the evaluation of human recognition systems. This will be a three-pronged approach:

- Statistical Evaluation: NIST will use accepted statistical techniques to advance the field of evaluation science by using results from the statistical literature to allow categorical statements of system performance to be made.
- Data Collection, Dissemination and Testing: We have mostly completed our data collection activities for still face images and will move onto the actual use of such for actual testing of systems. This is already under way.
- XML (Extensible Markup Language) Descriptors, NIST is developing standards and tools for the complete end-to-end description of recognition experiments using XML. The intention is to allow ease of access to the fine details of an experiment and allow other organizations to operate on the same sets.

FY2002 DELIVERABLES: Face Recognition Database; will be released with the cumulative image set from our image collection sessions of 1999 through 2001.

Gait Recognition Database. We will release the second NIST – University of South Florida gait collection of stereoscopically synced video imagery from 80 individuals.

Statistical Aspects: We will report in a series of papers the NIST Statistical Engineering Division analysis of face recognition algorithms. This will formalize the preliminary results.

False Alarm rate: In response to published concerns about alarms generated by recognition systems for people not enrolled in the system we will publish a novel performance characteristic and give statements of performance for those tests conducted by DoD Counterdurg for the FRVT 2000 paper.

We will publish version 0.9 of the XML and RDF (Resource Description Framework) based Human ID Evaluation Reporting Framework; this includes sufficient information for 1. a published experiment to be repeated; 2. intermediate results to be downloaded for analysis.

NIST will assist with the transition of face recognition technology from the laboratory to the field by providing technical assistance to NIJ.

Liquid-Filled Camera for Enhancement of Shadow Detail

Goals

The objective of this project is to develop a simulated-eye-design (SED) camera to reveal deep shadow detail in bright objects and scenes by dramatically reducing veiling glare arising from the lens and camera body.

Customer Needs

The proper rendering of shadow and dark detail is important in any photographic or videographic application for which high brightness and high contrasts are encountered and where attention to details in shadows or dark areas are important, such as surveillance. In many surveillance applications, for example, the cameras often do not render sufficient shadow detail to permit easy identification of the subject. However, when that same scene is viewed with the eye, the eye has no problem revealing all the required detail. To have a camera technology that can reproduce the glare avoidance and dynamic range of the eye would offer many advantages over current technologies. Despite advances in electronic photography, such as in charge-coupled-device (CCD) cameras, all cameras suffer from the effects of veiling glare. In many of these cases, the dynamic range of the eye is sufficient to distinguish between shadow and dark detail in all but the most extreme situations. Even the best cameras cannot reveal the dark detail readily seen by the eye. Often, as with surveillance cameras, it is the shadow or dark details that is required for proper identification and analysis of the scene or object under investigation. Light scattering from the interior of the camera and glare from the lens used in electronic photography introduces veiling-glare corruption of stray light to a scene.

Technical Strategy

This effort will assist in developing a SED camera that will reveal deep shadow detail and bright objects by dramatically reducing veiling glare. The process includes developing a 12 bit to 16 bit CCD camera and investigating improvements such as use of different liquids inside the lens system, internal apertures, thermoelectric cooling gradient mitigation, and wetting the outside of the lens.

Components of the research plan are as follows:

Liquid Suitability Study: Investigate the particulate suspending qualities of different liquids that might be suitable for use against a CCD chip surface. Determine any relationship between Rayleigh scattering (scattering off small particles including the molecules of the liquid) and other properties of the liquid.

Internal Aperture and Iris Study: The advantages of an internal aperture or iris will be compared to the external kind.

Solid Medium Suitability Study: Investigate the transmission properties of candidate solids to be used in place of liquids so that the camera light path is mostly solid. Non-solid regions include a gel or liquid that connects the solid to the CCD chip surface and any areas requiring a liquid fill for mechanical purposes (such as a variable iris or changing volume for focusing). Compare the Rayleigh scattering within solids to that encountered in liquids. Proper thermoelectric cooling (TEC) requires the use of a solid medium.

Internal Black Surface Scattering Study: Internal scattering from the body of the camera can be controlled through use of wetting black surfaces (solid or liquid). Methods to measure the reduction of surface scattering will be developed and comparisons with black surfaces in air will be made.

Wetting of Front Surface Study: Investigate the usefulness of wetting the front surface of the lens. A wet surface will be much smoother on a microscopic scale than a finely polished surface. Scattering properties off such a surface need to be compared to non-wetted surfaces.

FY2002 DELIVERABLES: Camera Implementation: Integrate any of the results of the above research into a SED camera prototype and determine the resulting veiling glare reduction compared to a normal camera of similar detector array quality.

The results of this research will be published in NIST Interagency Reports (NISTIRs) as each component of the plan is brought to completion.

Quality Assessment of Closed Circuit TV (CCTV) Forensic Imagery

Goals

The objective of this project is to develop test charts, digital patterns, and metrics for evaluating the performance of closed circuit TV (CCTV) systems including video image compression. The principal application is to forensic imagery.

Customer Needs

The work will provide the customers with methods for assessing the effects of recording, compression, and storage on CCTV quality. It will provide a sound technical basis for determining the acceptability for forensic uses, of digital video compression technology. It will support standards for forensic imagery.

Digital technology is rapidly finding its way into closed-circuit TV systems for law enforcement. Frequently, this technology arrives in the form of a digital image compression and storage system, offering a promise of "digital quality". Unfortunately, the law enforcement video analyst may be confronted with the reality of digital compression impairments affecting quality to such an extent that the imagery is neither admissible as evidence nor usable for analysis. The Law Enforcement Video Association (LEVA) has a technology committee studying the problem.

Technical Strategy

We plan to work with LEVA find out why digital CCTV compression fails for forensics. Eventually, this work will provide guidance on setting standards for digital CCTV systems.

We propose to develop test charts, digital test patterns, and metrics for validating the performance of CCTV systems. The test chart reveals the end-to-end effects of the CCTV system: from camera, to compression, to recorder, to playout. Because the test chart will be used in various environments with unknown ambient light, we will examine performance under a variety of lighting conditions. The test charts would be used when the system is first installed and then again if the camera captures imagery that is needed for analysis.

To understand the effects of the compression and storage system, we will generate digital versions of the test patterns. In this form, the signal can be streamed to the compression unit, isolating it from camera effects, and directly probing the compression system.

Evaluation of compression quality for forensics must be related to the trained user's assessment of quality. We will conduct tests of the subjective impression of quality. We will also evaluate the applicability of computed measures of quality.

Develop measurement methods and test patterns for assessing the quality of CCTV equipment, including compression and storage systems. These patterns include physical test charts and their electronic equivalents. The research milestones are:

- Assess available electronic imagery and develop new imagery appropriate for forensic video. Stream the patterns to CCTV compression and storage to generate typical impairments. Test patterns will be appropriate to forensic applications.
- Evaluate engineering measures such as signal-to-noise in detecting and measuring compression effects on the imagery.
- Assess available test charts and develop new charts based on the digital patterns for use with a camera in the loop for assessing both capture and compression capabilities of CCTV.
- Develop methodology for assessing viewer response to compression effects. Augment existing industry methods.

FY2002 DELIVERABLES: The test materials that are developed will be delivered to the LEVA Working Group for evaluation and for selecting a method of distribution to law enforcement agencies.

1. Develop electronic/digital test imagery appropriate for forensic video and still imagery. Deliver imagery to collaborators

2. Evaluate compression effects on the imagery for various codecs. Report on generation and engineering measurement of CCTV impairments.

3. Develop and deliver to collaborators hard copy test charts derived from the digital patterns.

4. Develop subjective assessment methodology with collaborators. Conduct validation trials.

5. Evaluate compression effects on the imagery for various codecs. Report on subjective measures of impairments and on results of tests.

6. Define measurements and evaluate effects of ambient light, distance, and other environmental effects. Report on measurement techniques.

7. Develop and evaluate computed measures of quality and correlate with the subjective evaluation of CCTV compression. Report on results.

Identifying and Characterizing Materials That Emulate the Low-Frequency Electromagnetic Properties of the Human Body

Goals

The objective of this project is to develop and measure materials that adequately emulate the dielectric properties of the human body over a frequency range of 80 Hz to 10 MHz.

Customer Needs

Effective modeling and testing of metal detectors requires well-characterized phantom materials and recipes for preparing them.

Safety Issues: There are a plethora of medical electronic devices (MEDs) that are used to assist or supplant poor or absent physiological functions. There also is a steadily increasing number of people who are becoming reliant on these devices to lead a normal life. These MEDs include but are not limited to cardiac defibrillators, cardiac pacemakers, infusion pumps, and spinal cord stimulators. MEDs may be located entirely within the body (implanted), on the outer surface, or both. Some MEDs are programmed magnetically, and all may be susceptible to electromagnetic energy radiated by other electronic or electrical devices. MEDs are frequently exposed to electromagnetic interference (EMI) emitted from other electronic devices. Most emitting devices are not intentional radiators and there exist various regulations to restrict their emitted EMI. However, the interaction between MEDs and intentional radiators is a concern. Commonly encountered radiators are the handheld (HH) and walk-through (WT) metal detectors typically used for security applications. These detectors may emit frequencies close to those used by the MEDs. HH and WT detectors are used at courthouses, correctional facilities, schools, governmental buildings, and at special events. Unlike air travel, which is a voluntary activity, most situations that require an individual to visit a courthouse or governmental building are not voluntary. Consequently, the safety of persons with MEDs is not an avoidable issue. Unfortunately, there is little information, other than anecdotal, about the interaction of MEDs with HH and WT metal detectors.

NIJ Standards: The draft revisions of the NIJ standards for HH and WT metal detectors contains a body interference test. Although this test is representative of actual use, it is not reproducible or accurate. What is desired is a material

that can mimic the EM properties of the human body over the frequency range of 80 Hz to 10 MHz so that the body interference test can be made reproducible and repeatable. The goal is to develop and characterize a material that has nominally the same relevant electromagnetic (EM) characteristics as the human body. It is proposed that a material will be developed that will simulate the relevant EM properties of the human body over the frequency range of 80 Hz to 10 MHz and temperature range of 36 °C to 40 °C.

Technical Strategy

FY2002 research will focus in the following areas.

- Continued measurements and modification of candidate materials to match published conductivity values.
- Develop mixture equations that yield realistic results for mixtures of carbon black and silicone.
- Increase accuracy of mixture, map electrical characteristics from pre-cured mixture to its solid state.

FY2002 DELIVERABLES: Include further study of the reproducibility, temperature, and time stability of the composite materials.

Develop and study mixture equations that will predict the conductivity from the conductivities and volume fraction of the constituents.

Write a Journal article based on the study of the mixture equations for the carbon-black composites.

Electrical Properties of Metals Used in Hand-Held Weapons

Goals

The objective of this project is to set up measurement apparatus to measure the conductivity and permeability of metals and to identify and characterize the electrical properties of a suite of metals commonly used in weapons.

Customer Needs

The magnetic fields used in metal detector operations interact with metallic objects through eddy currents. In modeling the metal detector it is important to have well characterized metal reference materials. The conductivity and permeability are highly temperature dependent. The characterization of metals is through precise measurement of metal conductivity and permeability. The material parameters must be measured as a function of frequency and temperature. Metals may be ferromagnetic, paramagnetic, or diamagnetic. Ferromagnetic metals such as iron have a permeability much greater than 1, whereas materials such as aluminum and copper have a permeability close to 1. Conductivity is related to the mobility of electrons in a metal under an applied electric field. Conductivity is described theoretically by the Drude model of metals, which predicts only small changes from dc up to the high gigahertz frequencies.

Technical Strategy

For FY2002, the plan is as follows.

The current measurement process requires one sample for the conductivity in the form of a rod and another sample in the form of a toroid for the permeability test. Develop a new permeability test method for the permeability on rod samples so only one sample is needed for both measurements.

Study the field dependence of the permeability as a function of temperature. The idea here is that the permeability depends on the magnetic field strength and this variable needs to be studied for complete characterization.

Increase our accuracy in the conductivity measurement using a new, more accurate voltmeter.

FY2002 DELIVERABLES: Use measurement systems to measure samples sent in from other agencies interested in characterization of specific samples.

Support for Concealed Weapon and Contraband Detection Technology

Goal

The objective of this project is to provide technical support to and representation for OLES regarding concealed weapon and contraband detection (CWCD).

Customer Needs

There are a variety of activities and technologies pertinent to the detection of concealed weapon and contraband in which the OLES is involved. These technologies include chemical weapon detection, drug detection, metal weapon detection, explosives detection, etc. The activities include standards development, writing user guidelines and guides, and funding research appropriate for justice-related programs. The number of technologies covered by the OLES is extensive and it is difficult to maintain the expertise required for providing assistance to the law

enforcement and corrections community without adequate manpower.

Technical Strategy

Provide a technical resource for OLES with respect to concealed weapon and contraband detection for technologies using electromagnetic (EM) detection methods.

FY2002 DELIVERABLES: Participate in the Law Enforcement and Corrections Technology Advisory Council and other pertinent meetings. Review proposals related to EM detection methods for contraband and weapon detection.

Provide technical assistance to OLES staff regarding EM detection methods for contraband and weapon detection.

Represent OLES regarding concealed weapon and contraband detection, such as with the Federal Bureau of Prisons, the Federal Aviation Administration, the Food and Drug Administration, etc.

Emergency Vehicle Sirens Goal

The objective of this project is to provide law enforcement agencies and other users of emergency vehicle sirens, such as emergency medical and fire services, with an improved, comprehensive document (or limited series of documents produced by a single source) that includes test methods, performance criteria, and mounting and installation guidelines for emergency vehicle sirens, which can be referenced in purchasing and other documents.

Customer Needs

In August 2000, a *Guide to Test Methods, Performance Requirements, and Installation Practices for Electronic Sirens Used on Law Enforcement Vehicles, NIJ Guide 500-00* was published. The siren guide informs law enforcement agencies about the contents of existing documents that are currently recognized and used by the siren industry to specify siren tests, performance requirements, and mounting and installation guidelines.

Documents included in the Guide that specify emergency vehicle siren measurement procedures, performance criteria, and mounting and installation techniques include the NIJ Standard-0501.00 Emergency Vehicle Sirens, the California Code of Regulations (CCR) Title 13 Article 8, the U.S. General Services Administration (GSA) Federal Specification for the "Star-of-Life" Ambulance, and the SAE Recommended Practice Emergency Vehicle Sirens- SAE J1849. All of these documents were reviewed and found to have shortcomings. It was also determined that there was little, if any, recognition of the NIJ Standard by the emergency vehicle siren industry or law enforcement agencies. The GSA Specification, which references CCR Title 13 for its test methods, is the only document for which an established siren certification program exists. The only laboratories approved to perform the GSA Specification testing are operated by companies that manufacture siren components. The National Fire Protection Association references the Society of Automotive Engineers (SAE) SAE J1849 in its 1901 Standard for Automotive Fire Apparatus. Not only is an improved comprehensive document needed, but the lack of an independent test laboratory and the references to different documents by different public safety agencies is problematic for the emergency vehicle siren industry and is a source of confusion for consumers.

Technical Strategy

NIST will work with the SAE, a voluntary, private, consensus standards-developing organization, to improve its recommended practice, which has been under continuous management by the SAE's Emergency Warning Lights and Devices Standards Committee. This Committee formed an Emergency Vehicle Siren Task Force to revise SAE J1849.

The Task Force decided that the revision of SAE J1849 should be written in three phases; siren systems with single loudspeakers (phase I), siren systems with multiple loudspeakers (phase II), and individual siren components (phase III). Each phase will likely produce one document in a limited series of documents intended as a revision of SAE J1849.

FY2002 DELIVERABLES: Draft revision of SAE J1849. Initial completion of phase I draft revision of SAE J1849 by the Emergency Vehicle Siren Task Force, forward this draft to SAE Emergency Warning Lights and Devices Standards Committee (parent committee of the Task Force) for its approval.

NIJ Standard 0603.00, X-Ray Systems for Bomb Disarmament Goals

Modernization of the currently obsolete standard for portable x-ray systems used in bomb disarmament operations, and testing several such commercial systems for compliance with the revised standards.

Customer Needs

The current Justice Department standard NILECJ-STD-0603.00, published in June 1973, is grossly out of date. Nothing is known of about the changes in technology, or the changes in safety requirements imposed by other agencies.

The PSDB has considerable expertise and experience in the testing and deployment of portable x-ray equipment. Facilities at Sandridge for testing are very comprehensive, including a large lead-lined laboratory and various x-ray generators. The staff of the Explosives and Weapons Detection Group of the PSDB are familiar with the general requirements of x-ray imaging systems and generators and the associated (UK) health and safety issues. The NIJ standard was written in 1973 and would benefit from revision to include standards for the latest imaging systems.

Revision of the standard commenced June 2000 upon the receipt by the PSDB of project funding. UK and US radiation safety standards are being gathered and assessed; an action plan for development of the portable x-ray system standard is being developed.

Technical Strategy

There are actually two separate tasks involved in this effort. The first is to update the requirements and revise the current standard; the second is to test commercial off the shelf systems. The PSDB will work with OLES to prepare the standard in NIJ acceptable form. The testing report will be issued in a format which has been pre-determined by the National Law Enforcement and Corrections Technology Center in Rockville, MD.

FY2002 DELIVERABLES: Revised NIJ Standard 0603.00 Test and evaluation report.

Accomplishments

Gait Recognition Databases: A 20 GB database of stereoscopic synchronized video of 30 subjects walking a "racetrack" course was released in January 2001.

FERET Face Image Database: A new and final FERET face recognition database was released in March 2001.

Publications

NIJ Guide 201–99, "Video Surveillance Equipment Selection and Application Guide," October 1999.

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NIST Technical Note 1398, "Portable Calibrator for Across-the-Road Radar Systems," May 1998.

NISTIR 5072, "Spherical-Wave Characterization of Interior and Exterior Electromagnetic Sources," December 1997.

NISTIR 5079, "Dipole Moments of Weak, Electrically Small Emitters from TEM-Cell Measurements," December 1998.

NISTIR 5096, "Detection of Quasi-Static Electric Fields Radiated by Electrically Small Emitters," June 2000.

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NHTSA Technical Manual DOT HS 809-239, "Speed Measuring Device Performance Specifications: Lidar Module," July 1, 2001.

NIJ Standard–0227.00, "Digital Intercept System (DIS) for Integrated Services Digital Networks(ISDN)," 2001.

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J. P. Phillips, Matching Pursuit Filters Applied to Face Identification, published in IEEE Transactions on Image Processing, Aug. 1998, and NISTIR 6208, August1998.

S. A. Rizvi, P. J. Phillips, H. Moon, The FERET Verification Testing Protocol for Face Recognition Algorithm, to be published in the Image and Vision Computing Journal.

P. J. Phillips, H. Moon, S. A. Rizvi, P. J Rauss, The FERET Evaluation Methodology for Face-Recognition Algorithms, to be published in the IEEE Transactions on Pattern Analysis: Machine Intelligence, and NISTIR 6264, October 1998.

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P. J. Phillips, A. OToole, Y. Cheng, B. Ross, H. Wild, Assessing Algorithms as Computational Models for Human Face Recognition, NISTIR 6348, June 1999, and to be published in Proceedings of the Neural Information Processing 1999.

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Chemical Systems and Materials

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Staff-Years:
3.0 professionals

Funding Sources:
100% Other Government Agencies

Project Champions:
- NIST Electronics and Electrical Engineering Laboratory (EEEL)
- University of Utah, Center for Human Toxicology (CHT), Salt Lake City, UT
- U.S. Department of Justice
  - National Law Enforcement and Corrections Technology Center, Rockville, MD

OLES' Chemical Systems and Materials program concentrates on research and standards related to chemical technologies used by the criminal justice and public safety communities. The increasing use of less-than-lethal chemicals such as pepper spray (oleoresin capsicum, OC) raises questions about the safety and effectiveness of products currently on the market. The program is examining pepper spray canister products to determine their ingredients, potency, and dose characteristics. This work, coupled with a study to evaluate the dose-related effects of pepper spray on the human body, is in preparation for developing the first standard for pepper spray products.

The criminal justice community and employers in both the private and public sectors have expressed strong interest in less invasive tests than those now used to detect illegal drug use. In response, the Chemical Systems and Materials program is investigating two alternatives: sweat-based drug testing techniques and saliva as a drug testing specimen.

In 1999 the program issued the first NIJ standard for protective gloves for law enforcement and corrections users. Today it continues to provide technical support to the National Law Enforcement and Corrections Technology Center at Rockville, Maryland for its glove testing program based on that standard.

Human and Animal Dose Response, Toxicokinetic and Potency Assessment of Pepper Spray Products Following Topical and Aerosolized Exposure

Goals

The objectives of this 3 year project are: 1) Chemically characterize a series of less than lethal (LTL) oleoresin capsicum (OC) pepper spray products as a method of determining and ultimately predicting product potency; 2) Apply the products and the individual capsaicins identified in the products to human skin to determine response and potency; 3) Investigate the toxicological effects of inhalation of the same products; 4) Determine the extent of absorption and the distribution of these capasicum analogs via dermal and nasal exposure.

The data generated will be utilized to: 1) predict product potency by chemical analysis, dermal response or a combination of the two methods; 2) determine the relative potency of the individual capsaicin analogs; 3) determine and quantify the effects of the products and the individual capsaicins when applied dermally; 4) develop sensitive and specific analytical methods that can be used to identify and quantify capsaicin analogs in pepper spray products and in biological samples; 5) determine the extent of dermal absorption of the major capsaicin analogs; and 6) determine toxicity and the extent of nasal absorption of the major capsaicin analogs following aerosolized exposure and determine if stimulant drug use affects toxicity or absorption.

Customer Needs

OC is an extract of hot peppers. In addition to its use in food and pharmaceuticals, it is an active ingredient in the aerosol sprays used by law enforcement agencies to subdue non-cooperative individuals through skin contact, eyes, and inhalation. Although 1-chloroacetophenone (CN) and 0-chlorobenzylidene malonitrile (CS) have been used for riot control for many years, they are not suitable for use against individuals as is OC. Recent findings have shown that OC is an effective incapacitant, reducing assaults against officers and injuries to officers and suspects, while reducing the number of complaints filed against cities regarding use-of-force by law enforcement officers. At the same time, however, a number of areas of concern have surfaced with regard to the use of OC. These areas include legal and policy issues, technical issues such as product specification and performance, medical issues such as the safety and toxicity of OC, especially with regard to long term use of OC, and operational issues such as training and safety procedures for users.

OLES is particularly interested in addressing the "technical issues" aspects of this problem. Given the product composition and potency, health, safety, ethical and legal concerns surrounding the use of less-than-lethal (LTL) OC weapons, a systematic study is needed to determine product content and effects following the two most common routes of exposure: nasal and dermal. The study will examine the dose response relationship between product OC concentration and incapacitant effects as a measure of product potency. There have been reports of allergic reactions, toxicity and other effects from exposure to OC.

There is also paucity of scientific data relating dermal or aerosolized exposures to physiological effects. The minimum exposure (dose) needed to achieve an intended effect without adverse side effects has not been determined. Any adverse health or safety events carry the additional threat of legal consequences to the officer and law enforcement agency.

Technical Strategy

The goals for Year two of the project are: 1) quantitatively characterize the OC content of the select series (Year one) of pepper spray products; 2) verify that a combination of potency determinations by quantitative and capsaicin analog determination to assess the potency/efficacy of commercially available OC LTL products; 3) assess the effects of the individual capsaicin analogs on skin; 4) complete the studies on respiratory tract toxicities of pepper sprays following aerosolized exposure to the LTL OC products.

FY2002 DELIVERABLES: The deliverables are quarterly reports and the final report of the findings of the study.

Oleoresin Capsicum Canister Study

Goal

At the present time, the "pepper spray" commercial products on the market are not well defined. There is no specification of active ingredients and manufacturers use a wide range of formulations and labeling schemes.

OLES is planning to solicit, through a competitive contract, a qualified laboratory to perform research and conduct a study involving sampling and analyzing the contents of commercial pepper spray canisters from at least five of the major commercial manufacturers, to make quantitative measurements of the internal pressure, concentration of active agent(s) capsaicinoid compounds present in the aerosol spray, the propellants and carriers. The study will also include shelf-life stability studies of the canisters (devices) at specified environments, aerosol firing tests, spray range tests, and drop tests to gauge device mechanical safety and stability. It is hoped that data from this type of study will suggest improvements and serve as the basis for minimum voluntary labeling and performance standards.

Customer Needs

OC is an extract of hot peppers. In addition to its use in food and pharmaceuticals, it is an active ingredient in the aerosol sprays used by law enforcement agencies to subdue non-cooperative individuals through skin contact, eyes, and inhalation. Law Enforcement agencies that have used OC over the last 10 years have found that administration of OC to subjects resisting arrest results in effective incapacitation (which is reversible in 15 minutes to 20 minutes) 85-90% of the time. The reasons for the 10-15% failure include low concentration of OC in the canister, poor delivery owing to low pressure, bad aim, variability of subject responses or a combination of these factors. OLES is particularly interested in addressing some of these product failure issues that face the law enforcement community to help them perform their functions more safely and effectively.

Although CN and CS have been used for riot control for many years, they are not suitable for use against individuals as OC is. Recent findings have shown that OC is an effective incapacitant, reducing assaults against officers, injuries to officers and suspects, while reducing the number of complaints filed against cities regarding use-of-force by law enforcement officers. At the same time, however, a number of areas of concern have surfaced with regard to the use of OC. These areas include legal and policy issues, technical issues such as product specification and performance, medical issues such as the safety and toxicity of OC, especially with regard to long term use of OC, and operational issues such as training and safety procedures for users. OLES is particularly interested in addressing the "technical issues" aspects of this problem.

Technical Strategy

The project will examine a number of commercially available canisters from at least five of the major commercial OC manufacturers that are in use by some of the large law enforcement agencies in the U.S. The study will use analytical methods that have been previously developed and optimized for OC analysis by OLES to examine the vehicles used, propellant pressure, OC concentration and other properties of the canister that may cause the failures observed and reported by some of the law enforcement, agencies. NIJ standard 0110.00, which deals with testing handheld aerosol tear gas weapons, will be used as a guide in measuring spray pattern of canisters and other physical property characterization studies of the commercial OC canisters.

DELIVERABLE: The deliverables are quarterly reports and the final report of the findings of the study. The estimated project duration is 24 months from the official date of contract award.

Protective Glove Project Goals

The objective of this project is to provide technical support work to the National Law Enforcement and Corrections Technology Center at Rockville, Maryland in their testing program for protective gloves that are used by law enforcement and corrections users.

Customer Needs

Law enforcement and corrections officers have been increasingly requesting hand protection as part of their protection equipment package. They need gloves that will provide them protection against sharp objects such as blades and hypodermic needles; the gloves have also to be resistant to pathogen penetration and have sufficient dexterity and tactility such that officers can perform their normal duties while wearing such gloves.

OLES issued the protective glove test protocol as NIJ Test Protocol 99-114, "Test Protocol for Comparative Evaluation of Protective Gloves for Law Enforcement and Correction Applications", June 1999. OLES also helped National Law Enforcement and Corrections Technology Center (NLECTC) in selecting qualified glove testing labs through a competitive process. This resulted

Samples of protective gloves.

in the selection of Touchstone Labs and TRI/Environmental Labs as the two NIJ qualified labs to conduct protective glove testing in accordance with NIJ Test Protocol 99-114. NLECTC is now in the process of testing commercial gloves that will be subjected to qualification testing at the two NIJ qualified labs.

FY2002 DELIVERABLES: OLES will continue to provide technical support to NLECTC, including travel to the testing labs, observing the glove testing, providing technical support to the labs and clarifying to them any questions that they may have with regard to the glove testing protocol and helping NLECTC with interpretation of test data from the labs.

An Evaluation of Innovative Sweat-Based Drug Testing Techniques for Use in Criminal Justice Drug Testing Goals

The current methodology for analysis of drugs involves the use of blood, plasma, and urine as samples. However, obtaining these samples is either invasive or they can be adulterated. In addition, their matrices are relatively complex, thus requiring more intensive and time-consuming sample preparation and/or determination. Sweat, on the other hand, can be obtained non-intrusively, allows protection of privacy, reduces the possibility of adulteration, and has the potential for estimating the actual circulating concentration of drugs. In addition, sweat is less complex and more easily prepared for analysis. This proposal focuses on the development of sweat-based drug testing techniques.

The goals of this project are to: 1) Modify and test innovative, less invasive liquid perspiration collection (LPC) devices, with a particular focus on the Macroduct Brand sweat collection device; 2) adapt drug-testing kits for use in analyzing liquid perspiration samples; and 3) assess the validity and utility of the LPC devices as a method of drug testing for use by the criminal justice populations.

Customer Needs

Criminal justice agencies make extensive use of drug testing to determine if arrestees, probationers, etc., are using illicit drugs. Currently, virtually all drug-testing in the criminal justice system is in the form of urine testing, involving the collection and handling of urine specimens. Although the urinalysis techniques are accurate, agencies are seeking drug-testing techniques that are relatively non-invasive. This project is designed to evaluate the accuracy and utility of liquid perspiration collection (LPC) in drug testing in a criminal justice setting. This technology will provide a non-intrusive method of drug monitoring and detection, which has been indicated as a priority technology area by the Law Enforcement and Correction Technology Advisory Council (LECTAC).

The first two years of the three-year project have been completed and we just started the third and final year. In the first two years, all scheduled tasks were completed, including: (1) the conducting of a pilot test of the liquid perspiration collection (LPC) devices; (2) the preparation of an Interim Report, versions of which are being published in the open literature and as an NIJ report; (3) preparations for the full field test at the DC Pretrial Services Agency; and (4) the implementation of the field test, now in its fifth month.

Technical Strategy

In the third and final year of the study, the field test will be completed and specimens and related data will be analyzed. A report will be prepared describing the procedures used in modifying the liquid perspiration collection device, the results of the field test, and presenting recommendations for future use of the LPC device. Depending on the results of the field test, guidelines will also be prepared for the use of the LPC as a drug testing device.

FY2002 DELIVERABLES: The deliverables are quarterly reports and the final report of the findings of the study.

Evaluation of Saliva as an Alternate Drug Testing Specimen

Goals

Determining the utility of saliva as a valid specimen for non-intrusive testing of drugs of abuse for law enforcement and the criminal justice community has been the overall objective of this research. Specific objectives for this project were: 1) to perform a thorough literature search to establish the state of knowledge about the use of saliva as a testing specimen in forensic applications. Information gathered from that search was used to write a comprehensive report on the current state of the scientific literature about saliva drug testing; 2) to assess the use of the saliva as a specimen for drugs of abuse testing and estimating circulating blood drug concentrations through use of a clinical study; 3) to determine if commercially available immunoassay screen tests could used to detect codeine and metabolites in saliva and plasma; 4) to determine if GC/MS could be used to assess the codeine and morphine concentrations in saliva; and 5) to determine if collection methods had an effect on saliva drug concentration. A University of Utah IRB approved clinical study was used to determine plasma and saliva drug distributions following codeine administration. Saliva was collected using three different commercial collection devices: acidic stimulation, non-acidic stimulation, and by a controlled method.

Customer Needs

This technology will provide a non-intrusive method of drug monitoring and detection, which has been indicated as a priority technology area by the LECTAC.

Historically, forensic drug testing has been performed primarily on blood, plasma or urine. Although alternate specimens such as saliva, sweat and hair may be available in most situations, they are seldom collected. Scientists and practitioners continue to search for specimens that can be easily collected by non-invasive techniques and collected under direct observation. Saliva is a unique specimen worthy of experimentation. It is easily and non-invasively collected, can be collect under direct observation, it is a filtrate of the blood, should 'reflect' blood-drug-concentrations and it is easily processed for testing.

Technical Strategy

A one-year study designed to focus on the issues of collection device efficiency and specimen validity determination is the objective for the final year of this research project. The planned experiments will bring the study to a logical conclusion and assist in making recommendations for the use of saliva as a drug-testing specimen. This will also allow us to establish standards for evaluating commercial saliva collection devices that have recently come to the market.

FY2002 DELIVERABLES: The deliverables are quarterly reports and the final report of the findings of the study.

Accomplishments

Publications

1. The Detection of Drugs of Abuse in Liquid Perspiration", Journal of Analytical Toxicology, Vol. 25, pp. 625-627 (2001).

2. "Determination of Capsaicin, Dihdrocapsaicin, and nonivamide in self-defense weapons by liquid chromatography-mass spectrometry and liquid chromatography-tandem mass spectrometry", Journal of Chromatography A, Vol. 912, pp. 259-267, (2001).

3. "The Effects of Collection Methods on Oral Fluid Codeine Concentration", submitted to the Journal of Analytical Toxicology.

4. "Evaluation of Saliva as an Alternate Drug Testing Specimen", Submitted to NIJ for publication.

Forensic Sciences

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Staff-Years:

13.5 Professionals

Funding Sources:

100% Other Government Agencies

Project Champions:

- Bureau of Alcohol, Tobacco and Firearms (ATF), Rockville, MD
- Department of Defense (DoD), Computer Forensics Laboratory, Linthicum, MD
- Department of Navy, Investigative Support & Forensics Subgroup, Technical Suppport Workng Group (TSWG), Arlington, VA
- Federal Bureau of Investigation (FBI), Washington, DC
- Forensic Technology Incorporated (FTI), Montreal, Canada
- National Center for Forensic Science (NCFS), Orlando, FL
- NIST Building and Fire Research Laboratory (BFRL)
- NIST Chemical Science and Technology Laboratory (CSTL)
- NIST Information Technology Laboratory (ITL)
- NIST Manufacturing Engineering Laboratory (MEL)
- NIST Materials Sciences and Engineering (MSEL) Laboratory (MSEL)

Forensic investigators increasingly rely on technology to do their job, and OLES' Forensic Sciences program works to ensure that they have tools that yield accurate results that will hold up in court.

In the area of high-tech (computer) crime, the program is developing tools for validating investigative software and preventing inadvertent modifications of electronic files under investigation. It has developed a National Software Reference Library that helps investigators identify suspect files on a hard drive more quickly and easily, and is leading development of a series of guides to the proper gathering and handling of evidence related to high-tech crimes.

The Forensic Sciences program is also developing tools in other areas: a standard reference material (SRM) for bullets and casings; a revised standard reference for identifying glass by refractive index and a calibrated refractive index oil for comparing glass specimens; an online database for characterizing hair by chemical analysis; an updated auto headlight database for use in hit-and-run investigations; an SRM for gunpowder and pipe bomb residue; and a revised SRM for blood-and-breath alcohol analysis. Related to drugs of abuse, the program is developing a methodology for determining ratios of amphetamine and methamphetamine in hair, and evaluating an aerosol drug identification kit for possible use in schools. To assist arson investigators, the Forensic Sciences program is conducting projects related to burn pattern recognition, measurement and simulation of ignition sources, and computer simulations of actual fire events. And it is setting up a National Help Line to assist investigators in using the Automotive Paint Database, developing a forensic atlas of hair and an interactive training guide for its use; and consulting on a number of projects related to forensic analysis of DNA.

National Software Reference Library (NSRL)

Goal

The objective of this project is to provide a validated database of known software, file profiles, and file signatures ("fingerprints") for use by law enforcement organizations in computer forensic investigations.

Customer Needs

Investigation of computer hard drives requires a tremendous effort in reviewing individual files. A typical desktop computer contains thousands of files, each of which must be reviewed for evidentiary content. To eliminate as many legitimate files from search as possible, an automated filter program would be beneficial that could screen all files for specific profiles and signatures. If the file profile and signature match the profile and signature in a database of known files, then it can be eliminated from review. Those that do not match would be subject to further investigation. The crux of this project is to collect known software, to develop the mechanism for producing the profiles and signatures of known files, and to distribute this information to law enforcement organizations in a cost effective and efficient manner.

Technical Strategy

An automated known file filter (KFF) program has been developed that can screen all files for specific profiles and signatures. The KFF would then automatically compare the profile and signature to a database of validated known files, and the output would be those files that do not match the contents of the validated database. Files that do not match would be subject to further investigation. A prototype implementation of this system has been developed and an extract of this database will be made available through NIST's Standard Reference Database (SRD) Office as Special Database #28. Security and stability of the process and the implementation of the database are top priorities in its development.

Beta-testing organizations are being used to verify the operation and accuracy of the database during a pre-delivery shakedown period.

FY2002 DELIVERABLES: The master database is the primary deliverable. An adjunct to this is the extracted database that will be made available to users in CD format, once the accuracy and stability of the database have been verified. Periodic updates will be released through the NIST SRD Office for purchase on a subscription basis. The master database will be updated with newer versions of software and new releases. Additional software from non-Windows operating systems will be included as software becomes available. Additional sources of software will be sought among vendors and government agencies. An estimate of uncertainty in the production of the database will be reported. Additional functionality for the database will be investigated.

Computer Forensics Tools Testing (CFTT)

Goals

The goal of digital evidence examination is to gain access to and examine the data. The objective of this project is to verify the operation and output of automated software programs, generally termed "tools," used by Law Enforcement agencies to examine computer evidence.

Customer Needs

Processes in a computer examination should be conducted on data that have been duplicated using accepted forensic procedures and, whenever possible, should not be conducted on original evidence. To meet this requirement, automated software programs or "tools" are available for purchase and touted as meeting the needs of a computer investigation, such as creating an exact duplication of a hard drive or to write block. However, presentation of this evidence in court demonstrates a need for verification of currently available tools that advertise forensic capabilities. The contention in court is that some alteration, failure to recover, or tampering with the evidence occurs through the use of these tools. To verify the results produced by these tools, NIST was asked to provide expertise in developing test suites and a testing framework to structure the testing of these software products. The information provided by NIST as a neutral party would be used by law enforcement organizations to determine several factors:

- Whether specific tools should be used in forensics examinations
- How the tools should be used
- The limitations of the tool's capabilities

Technical Strategy

The initial concept is to develop general classifications of functionality in order to group similar testing requirements. For example, we are concentrating immediate efforts on disk imaging, write blocker functions, and selected analysis functions. Further classifications will develop as requirements are identified. The common characteristics of each classification are decomposed into testable requirements. Assertions are derived from these requirements along with assertions from specific capabilities of individual tools. Each assertion is then tested within the overall testing framework to produce results that are repeatable, reproducible, and objectively measurable. Actual test results will be reported to manufacturers and users.

FY2002 DELIVERABLES: Reports describing the overall concept and framework for testing computer forensics tools will be published as web documents and as printed documents. Further reports on each automated tool tested will be produced and published on-line. Additional disk imaging tools will be tested and specification for software write blockers will be published along with test cases.

Two New Quick Reference Guides for Digital Evidence Investigations

Goals

The objective of this project is to produce and distribute quick reference guides to continue to support law enforcement agencies that have or are in the process of incorporating a digital investigation unit. These guides contain information that will assist in national uniformity in the administration of a digital evidence facility; procedure incorporation, collection, examination; and legal applications.

Customer Needs

The increase in Internet use and rapid changes with computer technology have put computers and other electronic devices in every aspect of modern life. These technological advances are being exploited by criminals at an alarming rate thereby putting additional responsibilities on the law enforcement community. Officials are dealing with established crimes such as kidnapping, child pornography, and fraud. These crimes are now committed electronically, through the use of computers. Police departments are finding a considerable lack of trained personnel that have computer knowledge. Due to this deficiency in computer knowledge many criminal cases are being overlooked, improperly handled or, when seized, are then sent to the few qualified laboratories that are overworked and understaffed. Many viable forms of electronic evidence are being overlooked because of investigative personnel's unfamiliarity with sources and depositories of this type of evidence. The proposed guides will provide law enforcement quick access to a wealth of information concerning protocols for investigating high technology crime and investigative interpretation. The published material will also provide reference information for literature review, legal support, and a guide for structured training programs.

Technical Strategy

The Examination of Digital Evidence guide is currently in production. When the final draft document is achieved, the document will be sent for national review, revised and then submitted to the NIJ for publication. Once this guide has been submitted for National review one of the remaining two guides will for be selected for initiation.

FY2002 DELIVERABLES: A series of quick guidance booklets.

Standard Reference Materials (SRM) for Bullets and Casings

Goals

The objective of this project is to provide sets of virtual/physical signature standards for both bullets and casings as NIST SRMs to support Bureau of Alcohol, Tobacco, and Firearms' (ATF) and the FBI's NIBIN (National Integrated Ballistics Information Network). In addition, NIST will demonstrate the practicality of using the NIST proposed algorithm for bullet signature comparisons.

Customer Needs

As with fingerprints, every firearm has unique characteristics that leave identifiable signatures on the bullets and casings that it fires. By analyzing these ballistics signatures, examiners can connect a firearm to bullets or casings discharged during criminal acts. The Integrated Ballistics Identification System (IBIS) has proven extremely effective as an automated tool for this process. IBIS uses techniques of image capture, image analysis, and electronic databases. However, to demonstrate completely the reliability of this system, high quality measurement standards for bullets and casings are required. This project will address this need for standard bullets and casings and will improve the evidentiary collection process of the criminal justice system nationwide.

Technical Strategy

The plan consists of two component projects. First, 20 standard bullets numbered NIST Reference Material, 8240-021 to 8240-040, will be provided and complete measurements of these bullets will be submitted to the ATF and the FBI for further tests and evaluation. Also 40 NIST Reference Material casings will be provided to the same organizations. Second, a Material Laboratory program, using the newly developed NIST algorithm for bullet signature comparisons will be developed.

FY2002 DELIVERABLES: Measurements and tests for 40 NIST Reference Material 8240 bullets and 40 NIST Reference Material casings.

A MATLAB™ program for bullet signature comparisons using auto- and cross-correlation functions.

Burn Pattern Recognition Program

Goals

The objective of this project is to investigate the formation of fire patterns from ignitable liquid spills near the walls and corners of rooms on the interior surfaces of structures.

Customer Needs

Previous research has shown that fire patterns provide useful data in determining the origin of fires. Due to the large number of factors that affect the formation of these patterns, the Burn Pattern Recognition Program has sought to understand fire pattern formation from ignitable liquid spills. During a forensic fire investigation, it is vital to understand the impact of these factors and how they contribute to the interpretation of a particular burn pattern. These factors are assessed when conducting full-scale spill fire experiments in a controlled laboratory environment and by studying the effects of imposed radiant heat flux. Effects of additive fuel source are also a major concern. The extent of these effects is obtained through experiments that include accelerated and un-accelerated fires with and without furniture.

Technical Strategy

The next step in understanding gasoline spill fires is to study spills located near the walls and corners of rooms, since the room boundaries will have an effect on the development of the fire as well as the patterns formed. Spill fire experiments will be conducted with fires located near walls and in the corners of rooms. Floor coverings will include carpet and wood, while wall materials will consist of gypsum board and concrete. The building and furniture materials will be the same as those used in the past in order to keep the number of experimental variables as small as possible. Due to the availability of a large number of suitable structures for conducting the fire experiments, a large quantity of information has been obtained. The next phase

will concentrate on analysis of the experimental data and documenting the results.

FY2002 DELIVERABLES: A technical report will be prepared for publication documenting the results of the study.

Measurement and Simulation of Real Ignition Sources

Goals

The objective of this project is to measure and document the burning characteristics and fire spread potential of common small ignition sources and to develop a tool capable of simulating the major features of the ignition and fire spread.

Customer Needs

Advances in computer hardware and fire modeling technology have, for the first time, made it possible for arson and fire investigators to recreate fire scenarios that appear as animations using ordinary computers. Recently, NIST's Fire Dynamics Simulator (FDS) FDS/Smokeview technology (see www.fire.nist.gov/fds/) has been used in the investigation of fire fighter deaths and injuries that occurred in the Cherry Road townhouse fire in Washington, DC. New and valuable insight about fire flows, temperatures, and timelines was provided to the investigation team through the use of fire simulation and visualization. For this technology to be developed into a reliable tool, accurate inputs are needed to describe the fire characteristics of common ignition sources and the reaction of materials exposed to different heating rates. This information will provide a basis for recreating possible fire scenarios. This will allow the testing of predicted fire development in relation to collected evidence and witness statements.

Possible fire scenarios of interest to fire investigators have been discussed with Bureau of Alcohol, Tobacco, and Firearms (ATF) agents. Taking into consideration the recent investments by NIST to advance the FDS model for thermal radiation heat transfer, radiant sources have been given priority because of the likely success in modeling radiant ignition. The first fire source to be measured and modeled will be radiant space heaters. Other fire sources that might be investigated are flames from large and small sources. These sources in various geometric arrangements are of interest to fire investigators.

Technical Strategy

In consultation with NIJ designated contacts and/or ATF certified fire investigators, ignition sources will be chosen. The sources will be characterized in laboratory scale experiments to be conducted at NIST. Modules compatible with the present public release of the FDS fire simulation model will be developed to duplicate, in fire simulations, the major burning and/or heat transfer characteristics of these sources.

Testing will also be conducted to assess the ability and conditions under which the selected sources can ignite different common materials (cardboard, plastics, wood, fabrics, etc).

FY2002 DELIVERABLES: This project is designed to deliver a database of usable experimental information about the burning characteristics and ignition potential of ignition sources identified as priorities for investigators. In addition, a report will be provided that will include the measured fire characteristics of ignition sources, the results of tests to ignite different materials with those sources, and the ability of the FDS fire model to predict the major features of the fire and ignition process.

Research in Deoxyribonucleic Acid (DNA) Identification Methods and Standards

Goals

The objective of this project is to assist in determining solutions attributed to DNA complications encountered with crime scene evidence. These research programs address the realm of DNA from collection issues to statistical individuality. Six programs will be detailed, each supporting the other by their attributes.

A. Standard Reference Materials (SRM) for PCR-DNA Analysis

The SRMs for DNA Analysis is a program that addresses the issue of mandatory requirements set by the National DNA Advisory Board (DAB) and the American Society of Crime Laboratory Directors-Laboratory Accreditation Board (ASCLD/LAB), concerning the validation of DNA procedures and protocols. To fulfill these requirements, laboratories must put into action a process that will link results to an accepted standard or reference. The DNA SRM provides the necessary tool for PCR procedure and kit validation.

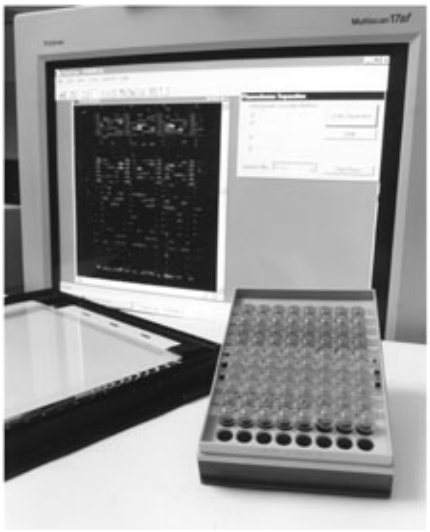
This subproject will continue to evaluate stock depletion of the current SRM production and prepare future plans to maintain supplies. NIST continues to be the technical advisor for laboratories with questions concerning the proper use of the SRM.

FY2002 DELIVERABLES: SRMs for validation, procedural development and method evaluation within laboratories conducting DNA profiling.

B. STR Typing with the ABI PRISM™ 3100 16-Capillary Genetic Analyzer

The evaluation of the ABI 3100 16-capillary array instrument for typing short tandem repeats (STR) kits commonly used in the forensic community to determine the feasibility of coupling multiplex STR and single nucleotide polymorphisms (SNP) assays with capillary array systems for high-throughput DNA testing purposes.

Utilizing an ABI 3100 16-capillary system, a



Results from electrophoresis analysis of DNA sample.

successful process has been completed that analyzed a variety of STR typing kits including Promega's PowerPlex® 16 and Applied Biosystems' Identifiler™ 16plex kits. These commercial kits and the development of new research multiplex assays use a variety of fluorescent dye combinations with both 4-dye and 5-dye chemistries; therefore, generating DNA fragment analysis matrices on the 3100 using various combinations of the following dyes: 5FAM, JOE, NED, ROX, 6FAM, HEX, FL, TMR, CXR, VIC, PET, and LIZ. This has been evaluated on both the ABI 310 (single capillary) and ABI 3100 (16-capillary array) instruments.

FY2002 DELIVERABLES: To provide a new high-throughput DNA procedure and expand the use of the ABI 3100 for developing novel Y chromosome STR kits for human identification purposes.

C. Recovery of DNA from aged bloodstains on untreated paper

Evaluate the long-term stability/quality of bloodstains on various substrates when subjected to a range of temperatures. Results enable DNA storage facilities to make a more informed decision on whether or not they should continue to store samples at –20 °C.

Many reference DNA sample repositories or "DNA banks" are now in existence, primarily for support of epidemiological and genetic research or to enable identification of forensic evidence or human remains. The nature of the sample, how it is collected, and how it is stored are critical issues for the ultimate utility of any DNA banking effort. Successful DNA typing requires that samples contain an adequate quantity of DNA and that this DNA can be isolated from polymerase chain reaction (PCR) inhibitors (heme, proteins, and many other whole blood components). Current methods of DNA typing use multiplexes of Short Tandem Repeat (STR) loci detected as PCR amplified products ranging in size from 100 through 450 nucleotide basepairs (bp).

Over 300 anonymous bloodstains have been examined that have been stored on untreated Schleicher & Schuell 903 paper (S&S 903) from two years to 15 years at ambient temperatures with no humidity control. Additional samples that were stored at –20 °C for six years were also examined. Examinations included different methods of extraction (Chelex®, and salting-out) as well as evaluation of the quality of the recovered DNA (yield gel), and typeablity of the DNA obtained.

FY2002 DELIVERABLES: Continue longitudinal studies on aged samples stored on several media and under a variety of conditions and provide a manuscript detailing the findings.

D. Genotyping Single Nucleotide Polymorphisms in the Y Chromosome and the Mitochondrial Genome

Development and evaluation of high throughput technologies for typing Single nucleotide polymorphisms (SNPs) for human identification purposes. SNPs are the most common form of genetic variation in the human genome. SNPs exist in approximately 1 out every 1000 base pairs. The typing of SNPs throughout the ge-

nome can facilitate genetic mapping, disease association studies, and evolutionary studies. Recent analysis of SNP markers located on the non-combining region of the Y chromosome provides information on tracing human migration patterns and evolution.

To design primer extension assays that will type SNPs located on the Y chromosome as well as in the mitochondrial genome in order to evaluate their usefulness in forensic applications. The results of these primer extension reactions are being analyzed using matrix assisted laser desorption-ionization time of flight mass spectrometry (MALDI-TOF MS) due to its inherent speed and accuracy for typing SNPs. The speed and accuracy of MALDI-TOF MS also allows rapid development of large DNA typing databases and population studies.

This work has resulted in tools for the rapid optimization of multiplexed polymerase chain reaction and primer extension reactions to improve throughput for SNP analysis. Further, comparisons have been made with various primer extension assays amenable to mass spectrometric analysis for SNP genotyping. The utility of MALDI-TOF MS to accurately and rapidly type samples is illustrated through results of Y chromosome and mtDNA SNP markers, including M9, M42, M45, M89, and M96.

FY2002 DELIVERABLES: The evaluation of technologies to assist other labs and agencies that are currently involved in typing SNPs. Eventually develop assays that will also be compatible with other instrumentation formats such as capillary electrophoresis, fluorescence polarization, and fluorescent microspheres.

E. Prototype Y Chromosome Standard (SRM 2395)

Providing a Y chromosome SRM for calibration of DNA typing instrumentation. In an effort to support the growing demand for Y chromosome testing, NIST is developing an SRM that can be used to calibrate instrumentation and verify assay performance with Y STR and Y SNP markers.

Over 140 candidate DNA materials for SRM 2395 have been screened. From these samples, five male and one female DNA samples have been selected and extensively characterized. These candidate materials reflect multiple alleles at each Y STR and SNP locus. These six candidate (A through F) SRM samples will be tested with commercially available and research multiplex assays. In addition, all of the DNA samples are being sequenced to confirm exact repeat compositions of the STR markers. SNP markers are being analyzed with multiple technologies to confirm the polymorphic nucleotide present in each sample.

FY2002 DELIVERABLES: Completion of an SRM 2395 and assessing its utility to the forensic community.

F. Development of Y STR Megaplex Assays

The development of high-level multiplex PCR reactions for typing STRs located on the Y chromosome for human identification purposes is achieving high attention in the forensic community. Y chromosome short tandem repeat markers have a number of applications in human identity testing including typing the perpetrator of sexual assault cases without differential extraction and tracing paternal lineages for missing persons investigations. In order for Y STR systems to become more widely accepted within the forensic DNA typing community, robust multiplex assays are required.

The multiplexes being developed are the first to include all of the European 11-locus "extended haplotype" in a single reaction. To improve the power of discrimination for Y chromosome tests, strategies are being developed for rapidly preparing multiplex PCR assays that utilize both four and five dye chemistries for detection and permit simultaneous amplification of 20 or more Y chromosome STR markers in a single reaction. An important design aspect of our multiplex assays is that PCR product sizes are kept under 350 bp in order to ensure a greater success with testing degraded DNA samples. Primer design issues are considered and efforts are undertaken to avoid any homology with X chromosome sequences. Primers have been redesigned from previously published work with these Y STR markers to make them more compatible in a multiplex amplification. The robustness of the multiplex will be tested in three independent laboratories. In addition, allele ranges for each of the Y STR markers have been well characterized in a diverse set of world population samples.

FY2002 DELIVERABLES: The testing of the 20plex PCR primer set for genetic population studies as well as human identification purposes.

Summer Forensic Fellowship Research

Goals

The objective of this project is to provide a technical training experience for post-baccalaureate students in forensic science. In addition, the student's efforts will support research goals on a project of recognized technical importance to the NIJ and OLES.

Customer Needs

Fewer than ten U.S. universities offer post-baccalaureate education in the forensic sciences. The increasing demand for technical sophistication in forensic laboratory personnel has increased the demand for experienced technical staff. Unfortunately graduate fellowship research support from common sources such as the National Science Foundation (NSF) is focused solely on research in the basic sciences.

The OLES summer fellowship provides masters-level students with an internship experience in projects that help advance forensic measurement technology and standardization. This summer's project is evaluating the factors that cause handgun gunpowder residues to be retained on the body and optimizing residue collection protocols. A series of handgun test firing experiments have been conducted to examine the influence of such factors as sweat and static on the retention of gunshot on the hands. A number of methods of residue collection, including vacuuming, tape lifting, and combing were evaluated. Analysis of the organic components in the handgun residues will be used to evaluate the success of the various collection parameters.

Technical Strategy

Firing range experiments are nearing completion, and laboratory evaluation of the samples is in progress. These experiments were designed to allow a means by which to evaluate methods of collecting gunshot residues from the body. Adhesive tape lifting and hair combing are being tested to evaluate their success in recovering organic gunshot residues. A sampling protocol was devised for hair combing, evaluating additive recoveries from combs by solvent extraction and organic analysis by micellar capillary electrophoresis.

Residue collection from the hair of human subjects and wig-hair covered mannequins is also being evaluated. To expand this process the effect of the position of a simulated shooter, victim, and bystander is also being tested. Residue deposition from a revolver, semi-automatic handgun, semi-automatic rifle, and shotgun will be studied.

FY2002 DELIVERABLES: A manuscript on factors affecting residue retention and collection to include experiments from the previous 2000 and 2001 internship research.

NIST Standard Reference Materials (SRM) for Gunpowder and Pipe Bomb Residue

Goals

The objective of this project is to improve forensic laboratories' capability to determine and detect handgun and pipe bomb components through the incorporation of quality gunpowder and residue measurements. To provide a compositional gunpowder SRM (NIST SRM 1928), that will enable the validation of crime laboratory methods and encourage the expanded use of quantitative gunpowder measurements in forensic casework.

Customer Needs

SRM from NIST provides the optimum value for the evaluation of procedures and laboratory techniques. The incorporation of this product into laboratory protocol will assist in accreditation requirements, improving evidence interpretation and providing a statistical basis for inclusion into courtroom presentations.

Forensic laboratories have seen an increase in the requests to provide evidentiary evaluation of residue samples from handgun and pipe bombs. As part of the forensic laboratory accreditation process, the American Society of Criminal Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) has been providing certification for explosives analysis. However, proficiency samples or SRM explosive propellants are not available to meet the ASCLD/LAB requirements. In addition, the quantitative evaluation of gunpowder additives as a means of individualizing residue evidence is under-utilized by many of the smaller local and state crime laboratories. Development of a gunpowder, SRM 1928 Additives in Smokeless Powder, will provide forensic laboratories with measurements that are traceable to NIST, helping to improve laboratory capabilities and meet accreditation requirements.

One of the requirements for SRM certification is to have primary standards of known purity for instrument calibration. To address this, two

stabilizers, diphenylamine (DPA) and ethyl centralite (EC), were selected and examined for high purity. A 5% solution of standard nitroglycerin (NG) was obtained from the U.S. Army Picatinny Arsenal laboratory. The 5 % NG solution agreed with the working standards from a commercial source. In addition, via the army lab at Redstone Arsenal, a pharmaceutical grade nitroglycerin product, 10% NG on beta-lactose was obtained. This material has excellent stability (less than 2% change in 5 years at room temperature) and may be suitable as a primary standard.

These prototype powders were used as test samples for an inter-laboratory gunpowder measurement comparison study amongst nineteen laboratories. This information determined the current state of gunpowder measurement practice, evaluated the selected powder material for its suitability, promoted gunpowder standard utilization, and compared quantitative measurements against other labs.

Technical Strategy

There is a possibility that a variability of ±10% or so in the composition of the two current candidate powders for the SRM exists, therefore the powders may have heterogeneity that is greater than the 5% target. Since all commercial reloading powders are blends of two or more lots with different compositions, heterogeneity may be an inherent characteristic of the two original candidate powders

The intent is to develop a second analytical method for additive certification measurement for the development of a SRM. In addition, the purity of NG, DPA, and EC primary standards will be evaluated using techniques such as mass spectrometry and nuclear magnetic resonance.

FY2002 DELIVERABLES: Development of a rugged analytical method for the determination of NG, DPA, and EC in the rifle powder RM prototype.

Complete and validate analytical method for reference material powder.

Evaluate homogeneity of powder using single particle and graduated sample size experiments and develop a second analytical method suitable for positively identifying the target analystes.

Gunpowder and Handgun Residue Research

Goals

The objective of this project is to examine the compositional characteristics of gunpowder and its post-firing residues as a means of detecting handgun use and investigating pipe bomb crime. Quantitative determination of the propellant (nitroglycerin – NG), stabilizer (diphenylamine – DPA and ethyl centralite – EC) additives contained in smokeless gunpowder is being investigated as a means of associating evidentiary residue and gunpowder samples with unfired powder exemplars.

Customer Needs

Current gunshot residue methods, based on the detection of the metallic firing primer particles, barium, antimony, and lead, use such techniques as Scanning Electron Microscopy/Energy Dispersive X-ray Analysis that are costly to perform and are seldom successful at determining handgun use. The move toward replacement of these characteristic "heavy" metal primers with more common metals may render the current test obsolete. Our approach examines the incompletely burned gunpowder as a means of residue detection. The organic propellant NG stabilizers DPA and EC (additive content of gunpowder) are characteristic features that can be used to individualize powders. In handgun residue collection experiments, quantitative analysis has shown that residues often contain much of the compositional characteristics of the unfired powders. We have developed a numerical factor, the ratio of propellant to stabilizer - the P/S ratio - to aid in individualizing powder and residue samples.

Quantitative evaluations of the organic additive composition as a means of associating unfired gunpowders and handgun residues have demonstrated both the strengths and limitations of the approach.

Technical Strategy

The long-term goal is the development of an integrated approach to organic gunshot/explosives residue evaluation through effective sample collection, optimized analytical measurements, and rigorous graphical/statistical evaluation of the data. The following research elements will assist in achieving this goal.

- Graphically Evaluating Questioned Samples and Exemplars: Develop a graphical approach to the evaluation of gunpowder compositional measurements. This approach will allow the forensic investigator to provide a visual and numerical presentation on how well a questioned measurement agrees with a defined portion of measurements from exemplar samples.

- Sampling for Organic Gunshot Residue: New experiments on the determination of organic gunshot residue were designed to evaluate factors that affect the collection of handgun residues by the body, including the effect of sweat, oily skin, and static electricity, using microscopy and organic analysis. Protocols for the forensic collection of organic gunshot residues using adhesive tape lifts (such as forensic evidence tape) and fine toothed combing were tested for the collection of handgun residues from the hand, head, and head hair.

FY2002 DELIVERABLES: Manuscripts detailing the work product, one titled, "A Graphical Approach to Questioned and Known Sample Comparisons of Smokeless Powder" and the other addressing the bodily retention and collection methods for organic gun shot residue.

On-Line Chemical Analysis of Human Hair

Goals

The objective of this project is to provide a definitive method for characterization of unknown hairs found at crime scenes.

Customer Needs

This method offers a statistical accounting of distinguishing features present in hair. Therefore providing a definitive means for associating a suspect to the victim or crime scene. Presently, the most common form of hair examination relies on microscopic comparisons. These comparisons can only detail the strength or weakness of a "match" between a known and unknown hair. This is no longer an acceptable result to the legal community; courts are now demanding statistical accountability for all forms of physical evidence.

Human hair has distinguishable chemical characteristics. To determine if these characteristics can be associated to an individual, hair from human volunteers have been analyzed. Two specific compounds have been targeted for ratio comparisons, squalene and cholesterol. Squalene was not detected in appreciable amounts in four of the children's hair so this compound could not be consistently used in comparisons. Cholesterol is present as a prominent peak in the children's hair samples, however, not in the adults. This may offer a means for determining an individual's age when examining an unknown hair. Further research is required along several avenues; utilizing a larger data base of hair samples, determining the chemical components of an individuals blood in relation to those components found in their corresponding hair sample, relative time factor between when a hair is deposited at a scene or on a person to the time the hair is analyzed using this technique.

Technical Strategy

Progress has proceeded in two directions related to this project. First, a method for injecting larger volumes of extracts onto a gas chromatography/mass spectrometry system have been pursued. Work in this area will possibly enable on-line extraction/analysis of trace evidence hair using more aggressive solvents than the supercritical carbon dioxide presently used in the supercritical fluid extraction – gas chromatography/mass spectrometric (SFE-GC/MS). These more aggressive solvents may extract additional species from the surfaces of hair, which could serve to distinguish samples from suspects and victims.

The second effort area has been directed toward obtaining additional hair samples from individuals to increase the breadth of SFE-GC/MS of trace evidence scale analyses.

FY2002 DELIVERABLES: The large volume injection (LVI) method, described in the manuscript indicated above, will be applied to hair samples that have been previously characterized by the SFE-GC/MS technique (see NIJ Report 600-99, "Trace evidence analysis of human hair by on-line supercritical fluid extraction – gas chromatography/mass spectrometry: a feasibility study"). Comparisons of the results of the hair samples by SFE with carbon dioxide as the fluid and LVI with several aggressive solvents should suggest which method is most amenable to on-line trace evidence analysis of hair. A manuscript describing the technique and all results will be provided.

Use of Enantiomeric Composition to Study Incorporation of Drugs Into Hair

Goals

The objective of this project is to develop analytical methodology for the determination of enantiomeric ratios of amphetamine and methamphetamine in hair, and to utilize this knowledge to certify reference materials containing these compounds for use in the forensic and medical-legal community.

Customer Needs

This reference material offers several uses; supply a confirmed protocol for conducting hair/drug examinations; provide a substance that can be used to validate current laboratory protocols and

instrumentation; and possibly provide statistical analysis between an individual ingesting illicit drugs versus extraneous external absorption onto the hair. Amphetamine and methamphetamine are commonly abused stimulants that can be prepared through a variety of synthetic pathways. Both compounds have been detected in the hair samples of drug users. Because amphetamine and methamphetamine are chiral molecules, they can exist as pairs of enantiomers. The (R)-enantiomer of methamphetamine is found in legitimate pharmaceutical products, but clandestine synthesis often yields racemic products. Therefore, proof of illicit use requires an examination of enantiomeric composition of the compound of interest. Current analytical methods for the measurement of enantiomers of these stimulants typically involve derivatization with enantiomerically pure derivatizing agents to form diastereomers that are separated by gas chromatography (GC). However, most chiral derivatizing agents are not enantiomerically pure, and impure reagents may perturb the initial enantiomeric composition of the sample, leading to erroneous results. In addition, the possibility of differences in the reaction rates of the enantiomers also exists. The derivatization scheme has been evaluated on standard solutions and seems to provide adequate sensitivity for the levels of amphetamine and methamphetamine likely to be found in hair. Good separations of the enantiomers of both amphetamine and methamphetamine have been obtained using liquid chromatography in conjunction with a chiral stationary phase. Preliminary extractions of spiked samples also indicate that the drugs can be recovered from hair by extracting with methanol.

Technical Strategy

The approach used involves isolation of the target compounds from hair samples and derivatization with a fluorescent tag to improve detection. The fluorescent tag also introduces a functional group that facilitates separation of the enantiomers on a chiral stationary phase in liquid chromatography. Additional work that will be completed includes identification of an appropriate internal standard and evaluation of the methodology for quantification of drug levels in hair. Some fine-tuning of the extraction procedure may be necessary to reduce the likelihood of interferences.

FY2002 DELIVERABLES: A methodology for the separation of meth/amphetamine enantiomers isolated from hair samples is available and some additional work on known samples is necessary to validate the liquid chromatographic method for quantitative purposes. The final goal is to add to an existing SRM with multiple drugs of abuse, the enantiomer ratios as additional information to the certificate of analysis for the material.

Auto Headlight Database for Forensic Utility

Goals

The objective of this project is to replace the obsolete NBS Special Publication 480-17, 1978 (SP 480), on Glass Auto Headlights for Forensic Utility, with a database on contemporary automotive headlights; in addition, to develop collaborations with the principal automakers and parts suppliers in order to generate and establish a running system for data collection on automotive front lighting, from present to future production and application.

Customer Needs

The new database will provide an effective and fast investigative tool for the identification of vehicles involved in hit-and-run crimes (e.g. personal injury, homicides, civil suits). Publication 480-17 has served the forensic community and law enforcement as an effective tool in investigations aimed at determining specific vehicle identification from fragments of headlights left at the scene of crimes. However, this publication is presently of very limited use because it covers only headlights of the sealed-beam type, which were installed in passenger-type vehicles made between the years 1962 and 1974. Therefore, a replacement for this forensic publication with a computerized database that reflects the present state of auto headlights is warranted.

Significant progress has been made in familiarizing the auto manufacturers to NIST's intent with the purpose to create a new database on headlights. These collaborations now include major automakers, parts suppliers, and the SAE International Committee on Headlights. These contacts also serve to gather information on the status of headlamp production and innovation to enable NIST to make any necessary database design updates in the most constructive way possible.

Technical Strategy

Concentrate on actions to generate and establish a on-going system for data collection on automotive front lighting, from present to future production and application. Specifically, principal activities will focus on efforts:

- To strengthen and expand NIST collaborations with the automotive industry, to collect data and information on the identifying characteristics headlights for 2000 and 2001 high volume "car" models sold in the U.S.
- To develop and widen the network of contacts with law enforcement, forensic labs and associations, and to participate in forensic meetings to learn and exchange information on the forensic aspects of automotive headlights.
- To catalog and enter in the database data and information on lighting systems for "2000 and 2001 top-selling models."
- To investigate methods to create 3D images of headlights will be investigated.

The new database encompasses the identification details, visual characteristics, and information of single headlights and front lighting assemblies, for both the right and left positions. Covered data comprises the headlamp, materials, inner and outer lens, park and turn signals, side marker, side reflex, and daylight running lights (DRL).

FY2002 DELIVERABLES: A database on automotive front lighting to replace the obsolete SP 480. This database will provide a significantly improved diagnostic tool in forensic investigations as compared to the use of the previous SP 480, which covered only sealed-beam headlights.

Accomplishments

Maintenance of a short tandem repeat DNA database commonly referred to as STRBase (http://www.cstl.nist.gov/biotech/strbase). The site is continually updated with new training materials and literature sites and by expanding the contents of the database in regard to variant alleles.

NIJ Guide NCJ 187736 "Electronic Crime Scene Investigation: A Guide for First Responders" was published. This guide contains detailed information that is useful to law enforcement and other responders who have the responsibility for protecting an electronic crime scene and for the recognition, collection, and preservation of electronic evidence.

A Reference Material Database on CD-ROM: The National Software Reference Library (NSRL) Reference Data Set (RDS) is available for ordering. Go to http://www.nist.gov/srd/nistsd28.htm to order NIST Special Database 28. The cost will be $90 per year and will entitle the purchaser to receive up to four distributions per year. The NSRL is designed to collect software from various sources and incorporate file profiles computed from this software into a Reference Data Set (RDS) of information. The RDS can be used by law enforcement, government, and industry organizations to review files on a "suspect" computer by matching file profiles in the RDS. This will help alleviate much of the effort involved in determining which files are important as evidence on computers or file systems that have been seized as part of criminal investigations.

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Public Safety Communication Standards

The ability of law enforcement and public safety agencies to communicate and exchange data in critical situations is fragmented by equipment incompatibilities and the lack of standards to provide a common, nationwide approach to telecommunications and information sharing. To resolve the situation, the National Institute of Justice, developed the AGILE program -- Advanced Generation of Interoperability for Law Enforcement -- to develop and implement interoperability standards.

OLES' Public Safety Communications Standards program is dedicated to supporting AGILE. The program is developing standards for voice, data, image, and video transfers, drawing on existing standards, discussions with end users regarding their requirements, and participation in IT and wireless standards committees. To meet the needs of law enforcement and public safety agencies until standards are in place, the program is evaluating commercial devices and services that can provide interim interoperability.

NIJ Standardization Efforts Related to Telecommunications and Information Technology (IT) Interoperability

Goals

As part of the AGILE (Advanced Generation of Interoperability for Law Enforcement) Program, provide engineering support, scientific analysis, technical liaison, and test design and implementation to allow the identification/development and validation of interoperability standards for the criminal justice and public safety communities, and other communication system products and services supporting wireless telecommunications and IT needs. Further, provide technical assessments and evaluations of existing and emerging commercial products and services that may provide interim solutions for various interoperability scenarios.

Customer Needs

This project is geared toward solving public safety interoperability and information sharing problems by developing and adopting NIJ standards for voice, data, image, and video information transfers.

The ability of an officer to communicate with other local agencies and emergency responders is critical to efficient and safe operations.

With the explosion of telecommunications and information technologies has come a disturbing trend – a lack of interoperability among systems. This is demonstrated most dramatically in the public safety community, as police and other agencies (such as fire departments, emergency medical services, etc.) fail to communicate with each other during multi-jurisdictional events (such as the Columbine High School tragedy). Even when local or regional calamities do not occur, however, daily interoperability problems continue to plague public safety agencies nationwide.

Effective communication is a critical aspect of both law enforcement and corrections operations. Dispatch is the nerve center of the agency.

The Implementation Phase of the AGILE Program was begun for IT interoperability. Close coordination was begun, and sustained, with NIJ, the Office of Justice Programs (OJP), the Bureau of Justice Assistance (BJA), the GLOBAL Infrastructure/Standards Working Group (I/SWG), I/SWG Technical Working Groups, the XML

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Technology Focus Group, and individuals representing various practitioner groups at the local, state, Federal, and international levels. To facilitate progress of national-level committees, strategic and tactical planning documents for OJP, I/SWG, and technical working groups were developed. Also, detailed structures and methodologies for the formal standardization process were constructed. Intensive technical leadership and support was provided to analyze and reconcile three dissimilar XML (eXtensible Markup Language) specifications developed by different practitioner groups. A justice community data dictionary was developed as a draft standard for use by all practitioner groups, and a "Principles and Procedures" report was written to document the process used. The XML "technical reconciliation" process was recognized as a successful model to use for other salient interoperability issues that involve conflicting technical approaches and/or implementations.

Technical Strategy

The Implementation Phase of the Project can be seen as falling into the follow functional support areas:

A. Information Technology Interoperability Standardization

This work builds upon the work performed, and accomplishments achieved, via FY2001 funding. Continue to work closely with the GLOBAL Infrastructure/Standards Working Group to validate users' requirements; validate the current assets and plans of local, state, and Federal public safety agencies; update the characterization of current and emerging technologies; validate internal and external factors that may impact standardization options; establish and validate data models and schema for sharing information among agencies; and validate the strategic plan for moving the entire standardization process forward. In addition, provide overall planning and operational support to the GLOBAL Infrastructure/ Standards Working Group as it functions as the IT Technical Committee. Provide detailed technical review and analysis of thousands of standards developed by standards development organizations, and recommend standards to the IT Working Groups and IT Technical Committee. As part of that activity, classify all standards that were considered by general subject area (e.g., architecture/data model, protocol, data composition, performance, security, etc.), and track the status of all those standards using categories such as: "rejected as not being relevant", "being reviewed", "reviewed and rejected", and "reviewed and recommended". Act as the Secretariat for the IT interoperability standardization process by keeping detailed records of: (1) the content and status of proposed standards, (2) the IT Technical Committee's discussions and ultimate decisions made regarding each standard, (3) the standards recommended by the IT Technical Committee to NIJ for adoption, and (4) the standards adopted as NIJ Interoperability Standards. On an ongoing basis, validate (through simulation and/or demonstration/testing) that the chosen standards are compatible, fit together as an entire package, and specify effective and efficient interfaces for local, State, and Federal systems.

B. Technology Evaluation and Engineering Support

Provide technical observations, analyses, demonstrations, and testing as part of technical evaluation activities aimed at determining the utility of commercial interoperability products and services. Technical evaluation efforts will address products and services identified by NIJ, but also those various technologies determined (through OLES research) to have great potential as interim interoperability solutions, over the short and long-term. Recommend emerging technologies worthy of NIJ Grant assistance, as required.

Respond to the immediate needs of the AGILE Program by performing other research and applied engineering activities as requested. These activities may include strategic and tactical planning, system engineering, technical analysis, economic benefit studies, etc. Develop formal documents such as guides or handbooks, and also presentations, white papers, and other documentation to support existing program tasks and/or proposed initiatives. Evaluate proposals, designs, approaches, and other technical overtures submitted/offered to NIJ, as requested.

C. Support IT and Wireless Standards Committees Participants

Provide travel/subsistence support to those representing local and state public safety agencies at the meetings of the IT and Wireless Standards Working Groups and Technical Committees.

D. Wireless Telecommunications Interoperability Standardization

Work closely with those chosen to represent the wireless telecommunications users within the public safety community to validate users' requirements; validate the current assets and plans

of local, state, and Federal public safety agencies; update the characterization of current and emerging technologies; validate internal and external factors that may impact standardization options; and validate the strategic plan for moving the entire standardization process forward. In addition, provide overall planning and operational support to those representing the wireless telecommunications users as they function as the Wireless Technical Committee. Provide detailed technical review and analysis of thousands of standards developed by standards development organizations, and recommend standards to the Wireless Working Groups and Wireless Technical Committee. As part of that activity, classify all standards that were considered by general subject area (e.g., architecture, protocol, performance, security, etc.), and track the status of all those standards using categories such as: "rejected as not being relevant," "being reviewed," "reviewed and rejected," and "reviewed and recommended". Act as the Secretariat for the Wireless interoperability standardization process by keeping detailed records of: (1) the content and status of proposed standards, (2) the Wireless Technical Committee's discussions and ultimate decisions made regarding each standard, (3) the standards recommended by Wireless Technical Committee to NIJ for adoption, and (4) the standards adopted as NIJ Interoperability Standards. On an ongoing basis, validate (through simulation and/or demonstration/testing) that the chosen standards are compatible, fit together as an entire package, and specify effective and efficient interfaces for local, State, and Federal systems. Provide close technical liaison with the IT Technical Committee to ensure that data transfer issues are addressed consistently by the wireless and IT standardization activities, and that the two activities ultimately converge.

FY2002 DELIVERABLES: NIJ Standards, Reports, Guides, Guidelines, Handbooks, White Papers, and other products required to advance the AGILE Program and other interoperability-related efforts within NIJ will be provided.

Accomplishments

- Successfully coordinated with OJP and BJA to advance standardization objectives of the Global Justice Information Network Program (GLOBAL) and its Advisory Committee (a Presidential Advisory body).

- Provided technical support to GLOBAL's Infrastructure/Standards Working Group (I/SWG) by: (1) developing I/SWG processes and procedures outlining salient technical issues to address relative to information sharing and (2) working with practitioners to create effective standardized solutions.

- Worked closely with diverse members of the Justice community to reconcile three different implemention standards applying XML (eXtensible Markup Language) and to develop a "Justice XML Data Dictionary" that contains over 135 data elements that can be used commonly across the Justice community.

- Coordinated with Department of Transportation and other "Justice Partners" to share Justice work results and establish common interoperability schemes.

Publications

No formal publications in Journals, etc. However, available to the justice community via websites:

1. The XML Justice Data Dictionary, a "living," evolving database, currently containing over 135 reconciled data elements.

2. The XML Justice Standards Development "Principles" Report, describing the lessons learned in reconciling the 3 XML standards and providing the procedures that were used.

Critical Incident Technologies

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Funding Sources:
100% Other Government Agencies

Project Champions:
- Interagency Board for Equipment Standardization and Interoperability, Arlington, VA
- National Institute for Occupational Safety and Health (NIOSH), Morgantown, WVA
- U.S. Army Soldier, Biological and Chemical Command (SBCCOM), Aberdeen, MD
- U.S. Department of Justice, Washington, DC
  - National Institute of Justice (NIJ)
  - Office for Domestic Preparedness

Before September 11 and the war on terrorism, OLES was already involved in America's domestic preparedness and homeland security efforts. The Critical Incident Technologies program, established as a separate program area in 2001, consolidates existing projects with new initiatives under a single administrative banner.

The program is currently continuing OLES' work on developing chemical and biological (CB) protection equipment standards, including standards for respirators and CB detection and decontamination technologies; investigating and validating advanced lightweight protective clothing systems; and devising a test laboratory certification program. It has already published the first of a series of CB protection equipment guides for emergency first responders.

New programs since September 11 include developing standard, secure cockpit isolation systems and both a testing standard and selection guide for frangible ammunition to be used aboard aircraft.

Developing Chemical and Biological (CB) Protection Equipment Standards

Goals

The objective of this project is to develop a suite of national chemical and biological protective equipment standards and to facilitate the adoption of these standards so that local, state, and Federal emergency first responders and other public safety workers can use them. To accomplish this mission, strong working relationships must be established and maintained with the public safety user community, to the point where the community's representatives play a key and integral role in all facets of the standards development process. This is accomplished primarily through the Interagency Board (IAB) for Equipment Standardization and Interoperability. The suite of equipment standards will consist of: 1) Detection equipment (for both chemical and biological agents); 2) decontamination equipment; 3) personal protection equipment (PPE), including suits, boots, gloves, and respiratory equipment; and 4) interoperable communications equipment. The IAB identified the respiratory equipment standards as the first priority for development.

A typical protective mask for first responders, law enforcement officers, corrections officers, and EMS providers.

The CB standards development program involves many agencies and activities. The program for FY2002 consists of six main project areas: 1) Respiratory Equipment Standards; 2) development of CB Personal Protection and Detection Equipment Standards; 3) evaluation of Lightweight Protective Clothing Systems; 4) test Laboratory Certification; 5) support of Domestic Preparedness Programs; and 6) development of Chemical and Biological Protection Equipment Guides for Emergency First Responders.

A. Respiratory Equipment Standards

The objective of this subproject is to develop National Institute of Occupational Safety and Health (NIOSH) approved respiratory protection equipment against hazardous agents for emergency first responders and public safety workers. To develop these, the following tasks will be performed: 1) Determine applicability of existing industrial and military warfare agent standards; 2) Develop key chemical/biological design and performance requirements; 3) Modify and/or develop terrorism agent-specific test methods; and 4) Prepare final evaluation, testing, and certification standards.

The purpose of these standards is to provide CB equipment minimum performance standards for the emergency first responder community when evaluating and purchasing CB defense equipment.

Multiple agencies including the NIOSH, NIST, NIJ, National Fire Protection Association (NFPA), Occupational Safety and Health Administration (OSHA), and the U.S. Army Soldier and Biological Chemical Command (SBCCOM), have generally agreed that the following activities are necessary for development of a CB respirator standard and sustainment of a continuing certification program.

The major tasks to develop and implement the respiratory protection standards are as follow: 1) Hazards analysis/vulnerability assessments; 2) standards development; 3) test method validation; 4) maintenance of CB equipment databases; 5) publication of user guides, user-friendly decision aid systems regarding respiratory protection issues at chemical/biological terrorism incidents; 6) provide technical assistance domestic preparedness programs, partners, stakeholders, and civilian organizations as requested; and 7) certification and testing of CB equipment.

FY2002 DELIVERABLES: The major deliverables include periodic (quarterly and annual) progress reports, reports on major milestones such as the hazard/threat analysis, draft and final performance standards, hosting of public hearings on proposed standards, staffing and equipping a suitable standard testing laboratory, publication of user guides, and other products required to fully implement the CB respiratory protection standards.

B. Development of Chemical and Biological PPE/Detector/ Decontamination Equipment Standards

The objective of this subproject is to develop standards for personal protection equipment (PPE--including suites, boots, gloves, etc.), detection equipment and decontamination equipment for chemical and biological agents for emergency first responders and public safety workers.

The purpose of these standards is to provide CB equipment minimum performance standards to the emergency first responder community when evaluating and purchasing CB defense equipment.

The following specific efforts are necessary for the development of CB standards for all types of PPE (other than respirators), detectors, and decontamination equipment: 1) Hazards analysis/vulnerability assessment; 2) standards development – This involves review of existing test methods, analyzing these test methods for applicability, providing a matrix of prospective standards with preliminary analysis and selection of the appropriate standards test; 3) testing of equipment; and 4) publication of user guides.

FY2002 DELIVERABLES: Performance Standards for PPE, Detection and Decontamination Equipment; this will take at least 3-years to complete, depending on the funding level for each year through FY 03.

C. Evaluation of Advanced Lightweight Protective Clothing Systems

A chemical/biological protective suit

The goal of this subproject is to further develop and demonstrate selectively permeable fabric systems that have been proven to provide excellent protection against CB warfare agents, and to provide protection against toxic industrial materials (TIMs) in liquid, vapor, and aerosol forms. Ultimately, a Level A protective ensemble will be produced for protection against not only CB warfare agents but also protection from exposure and for the safe handling of TIMs.

This work is expected to culminate in the development of significantly lighter weight TIM, chemical warfare agent, and biological threat protective clothing for emergency response and public safety professionals.

The following tasks will be accomplished in this program: 1) Leverage industry and academia to further the development of novel selectively permeable membranes as TIM barrier properties; 2) work with industry and academic partners to

assess, develop, and demonstrate the required resistance to TIMs with minimal interference to moisture vapor transport through the membrane for evaporative cooling of the users; 3) evalute membrane properties, such as resistance to agent simulants, and moisture vapor permeation characteristics; 4) conduct physiological testing of human subjects in controlled environments; 5) investigate and test current military protective clothing; 6) compile a list of CB protective garment technologies that could meet the NFPA 1994 performance requirements and a list of industrial hazards for different missions will be also identified; 7) for FY2002, assess the barrier properties of current SPM fabrics to TIMs, further engineer SPM technologies to provide the needed protection to TIMs as necessary and to produce limited garments for field assessments.; and 8) for FY2002, demonstrate the effectiveness and durability of TIM resistant SPM garments in limited field tests.

FY2002 DELIVERABLES: SBCCOM will produce and deliver quarterly progress reports to OLES. A final, comprehensive test report will be produced at the end of the study.

D. Test Laboratory Certification

The goal of this subproject is to provide program management, technical, and administrative support to facilitate the process to certify test laboratories and agencies to conduct testing in accordance with the approved CB suite of standards.

Once standards have been approved, the next step is to certify testing facilities to conduct tests to the standard. This is the final step to ensure that equipment meets the stated performance standard. The standards will be administered through the appropriate agencies; NIOSH will administer the respiratory protection equipment standards and NFPA will administer the appropriate standards for PPE. In some cases, where existing agencies do not have oversight or responsibility for a standard, the standard may be published by NIJ.

The primary steps to be conducted in this process are: 1) Conduct planning and management functions necessary to support laboratory and test agency certification to test to the CB standards suite; 2) issue progress reports to the funding agency and to the IAB; 3) certify, in collaboration with other standards team members, qualified laboratories that are capable to conduct equipment testing and certification in accordance with the national suite of standards; 4) maintain pertinent agreements, standards and guides to include review and updates.

FY2002 DELIVERABLES: Project milestone updates, staffing and coordination of procedures for lab certification.

E. Support Of Domestic Preparedness Programs

The goal of this subproject is to provide program management, technical, and administrative support to domestic preparedness programs, in particular to the activities related to the development of national standards and guides for Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) protective equipment.

The initial set of standards and guides developed will focus on chemical and biological (CB) agent protection in the areas of detection, personal protection, decontamination, and communication. These standards and guides will assist the emergency first responder community when evaluating and purchasing CB defense equipment. Developing a coherent and comprehensive set of standards and guides requires a dedicated effort. Without technical expertise and management of the program, the end result may be fragmented and fail to provide the products required by the first responder community.

OLES is the executive agent for the IAB, responsible for implementing a national suite of responder CBRNE equipment standards.

OLES has established interagency agreements with the National Institute of Occupational Safety and Health (NIOSH) and the U.S. Army Soldier Biological and Chemical Command (SBCCOM) to develop a suite of national CBRNE protection standards; the first of these guides was published in 2000 and the remaining guides are in the various stages of review and comment before publication. These guides will be distributed to the user community and also posted on the web and hence will be available on-line.

The primary tasks of this subproject are: 1) Conduct planning and management functions necessary to support development; and implementation of CBRNE standards suite; 2) provide user needs and requirements to standards development process; 3) canvass literature both in the U.S. and worldwide for existing applicable standards that can be used or adapted to the standards development process; 4) coordinate with other standards players on providing forums for soliciting input for the standards agencies and organizations on development process from users and

industry; 5) attend conferences and forums related top weapons of mass destruction (WMD) threats, protection equipment standards and counterterrorism threat scenarios that will be helpful in standards development effort; 6) issue progress reports to the funding agency and to the IAB; 7) promulgate relevant standards and guides; 8) develop standards user guides; 9) certify, in collaboration with other standards team members, qualified laboratories that are capable to equipment testing and certification in accordance with the national suite of standards; and 10) maintain pertinent agreements, standards and guides to include review and updates.

FY2002 DELIVERABLES: Interagency agreements, project milestone updates, staffing and coordination of draft standards/guides, and promulgation of approved standards and guides.

F. Development of Chemical and Biological Protection Equipment Guides for Emergency First Responders

The goal of this subproject is to develop chemical and biological protection equipment guides for emergency first responders. The equipment guides include chemical agent and toxic industrial material detection, biological detection, communications, personal protective, and decontamination.

The guides will focus on CB agent protection equipment in areas of detection, personal protection, decontamination, and communication. The purpose of these guides is to provide CB equipment information to the emergency first responder community when evaluating and purchasing CB defense equipment. This sharing of information is critical to the many emergency first responder communities who have received or are in the process of receiving CB equipment grants funding from the U.S. Department of Justice's Office of State and Local Domestic Preparedness (OSLDPS).

The heightened national concern that terrorists will employ chemical agents, toxic industrial materials (TIMs), and/or biological agents against domestic targets is prompting state and local first responders to enhance their response capabilities. NIJ is the focal point for providing support to state and local law enforcement agencies in the development of counterterrorism technology and standards, including technology needs for CB defense. In recognizing the needs of state and local emergency first responders, NIST, supported by NIJ, TSWG, SBCCOM, and IAB's Equipment Standardization and Interoperability Subcommittee, is developing CB defense equipment guides. The guides will focus on CB equipment in areas of detection, personal protection, decontamination, and communication. The purpose of these guides is to provide CB equipment information to the emergency first responder community when evaluating and purchasing CB defense equipment. This sharing of information is critical to the many emergency first responder communities who have received or are in the process of receiving funding from the Office of State and Local Domestic Preparedness (OSLDPS).

To date all guides have been completed. The Guide for Chemical Agent and Toxic Industrial Chemicals Detection Equipment for Emergency First Responders has been published and issued to the emergency responder community. The other guides are in various stages of editorial review for approval before publication and issuance as NIJ Guides.

The plan to complete this effort required working with the emergency first responder community, NIST, SBCCOM, NIJ, and TSWG to get their thoughts and comments on the equipment guides. The guides were then be submitted to NIJ for a legal review. Following the legal review and incorporation of all comments, the guides were finalized and resubmitted to NIJ for final approval and publication. Thus far, the decontamination, communication and biological agent detection guides have been through the NIST review process and have been submitted to NIJ for final approval and publication.

FY2002 DELIVERABLES: Drafts and finals (paper and electronic) of each guide, monthly reports, and a final comprehensive summary report are the required deliverables. It is critical that annual updates to each guide be made. These updates will allow the emergency first responder community to stay aware of new equipment as it becomes available, as well as, old equipment that is no longer available. The first update to the Chemical Detection Guide is tentatively scheduled for first quarter of 2003. It would be best to have the updates made electronically and be made available through NIJ's Justice Technology Information Network (JUSTNETR).

Development of Standard, Secure Cockpit Isolation Systems

Goals

The objective is to develop a system to ensure airliner cockpit physical security. The proposed effort includes development of a fully tested

prototype cockpit isolation barrier, production engineering specifications, and an interim performance standard.

Customer Needs

Denial of commercial aircraft as potential terrorist-guided weapons is an important action that can be taken at this time to protect the security of the United States. The most cost effective means of doing this is to prevent access to the cockpit. We may assume that regardless of measures taken at airports, security will not be 100% effective in identifying every potential terrorist passenger. But we can insure that they are denied the ability to guide the plane by removing all possibility of access to the cockpit during flight. This has the added benefit of compartmentalizing air travel security by limiting intensive background security checks to the cockpit crew while allowing passenger and baggage scanning systems to focus only on identification of devices that would compromise the entire aircraft (e.g. a bomb).

The traditional role of the cockpit door separating the pilots and the controls of the aircraft from the main cabin must change because of the recent hijackings and use of commercial aircraft as WMDs. A Cockpit Isolation System (CIS) must now be considered a critical component of the physical security for all commercial aircraft. Interior bulkheads adjacent the access pathway to the cockpit should also be viewed as critical physical security barriers from assailants and are thus an integral part of the CIS. Effective "hardening" of these structures will require consideration of several types of threats to their integrity. Principle among these are blunt force, projectile impact, small explosive (shaped) charges, edged weapon attack, and arguably, liquid and gaseous chemical resistance.

It is imperative that industry and government collaborate to develop common designs, performance criteria, and test procedures, and to see physical implementation of the CIS in all commercial aircraft at the earliest possible date. Solutions to these threats will require novel materials and structural designs, ultra-secure locks and joining mechanisms, and incorporation of environmental seals and controls. And they must be able to be retrofitted into existing vehicles without affecting their flight characteristics.

Solutions to the hardening of cockpit doors are already under investigation at a number of companies with the intention of rapid deployment. Yet, there is no cross-cutting organization to oversee these efforts nor any effort to establish neutral measures of performance for such systems that encompass the threat-array described above. Performance standards and testing serve not only to produce effective guidelines and selection criteria for the users who procure the items, but as design and manufacturing criteria for producing consistent, dependable items that meet, in this case, Federal Aviation Administration (FAA) requirements and specifications for function, safety, and performance. NIST proposes to work with the aircraft industry, the FAA, and Department of Transportation (DOT) to develop standardized designs, to test initial prototypes, and to develop a first generation FAA performance standard that will provide aircraft-interior-barrier-specific threat definitions and resistance criteria, threat-specific functional and performance requirements, selection and certification test methods, materials, fixtures, and procedures. The proposed NIST contribution will focus upon the CIS function and performance against the previously described threat mechanisms. Other threats may be identified during the course of the systems design and standard's development and will be included as appropriate.

Technical Strategy

1) NIST will convene and chair a General Advisory Committee that will include representatives of the FAA, DOT, aircraft industry and other appropriate organizations to provide oversight and design guidance to the President's stated initiative for CIS. This group will study potential structural, mechanical, access security and manufacturing concepts against the performance requirements to be provided by the FAA, DOT, and security agencies and it will recommend concepts to proceed to prototype test and evaluation on an accelerated schedule.

2) NIST will develop a comprehensive performance standard for evaluating CIS candidate designs. This standard will provide security performance requirements to the aircraft industry, ensuring future development of FAA-approved barriers and manufacturing sources. NIST will utilize its highly specialized expertise in law enforcement equipment, weapons, ballistics, structures and materials, including using its own structures, materials, and ballistics testing laboratories for the research and evaluation required to produce a relevant performance standard. This

standard will ensure quality and consistency in the security barriers developed, procured, and used in the nation's aircraft.

3) NIST will then provide continuing neutral test services and laboratories for the routine evaluation of CIS designs for existing and future aircraft that will operate in U.S. airspace.

In FY2002, NIST will be revising several standards for NIJ. Among them are NIJ Standard-0108.01, "Ballistic Resistance of Protective Materials," and NIJ Standard-0104.02, "Riot Helmets and Face Shields," both of which are relied upon by law enforcement agencies to ensure the quality and reliability of protective equipment. Because the nature of the tests and equipment in these NIJ standards are similar to what is needed for this project, much of the effort to revise these two NIJ standards can be leveraged to expedite the development of this proposed performance standard for aircraft interior protective barriers. Likewise, NIST maintains world-class structural design, evaluation, and test facilities and already has programs underway in composite structures and blast resistant design – both capabilities that will strongly figure in any CIS design.

FY2002 DELIVERABLES: Development of a prototype security bulkhead (cockpit isolation system), production engineering specifications, and publication of an interim performance standard.

Performance Standards for Aircraft Security: Frangible Ammunition Selection Guide and Performance Testing Standard

Goals

Frangible ammunition can be simply defined as any round possessing a bullet or projectile that, upon impact with hard structural surfaces, will "shatter" or deform without perforating. This project consists of three parts: (1) Producing a Selection Guide of existing frangible ammunition; (2) perform ballistic testing of frangible ammunition against current and planned FAA aircraft and airport security program body armors, to identify any injury potential; and (3) developing a first generation performance standard that will provide aircraft application specific definitions and performance criteria; ammunition characteristics; interior, exterior, and terminal ballistics functional and performance requirements; selection and certification pf test methods, materials, fixtures, and procedures.

Customer Needs

To improve airline security, Air Marshals are being deployed to counter attempted hijackings of commercial aircraft. This project will ensure that the frangible ammunition used by the Air Marshals meets minimum safety, quality, and performance requirements specific to the airliner environments; thereby improving the safety of air travelers and reducing the vulnerability of aircraft to this ammunition.

The anticipated renewal of the Air Marshal program for airliner security during flight operations will result in the use of frangible ammunition in the firearms carried by these individuals. Key performance requirements of frangible rounds are that they remain effective against assailant targets and that they can be fired from a standard firearm without compromising the firing function of the firearm. Aircraft fuselages are highly vulnerable to conventional bullet impacts, fuselages are typically made from engineering thermoplastics and lightweight aluminum structural members and plating ("skins"). Cabin windows in particular are highly vulnerable to perforating impact from high energy projectiles. Complete perforation of the fuselage or window(s) by a projectile would lead to gradual or rapid cabin depressurization, possibly endangering passengers, and potentially impairing control of the aircraft. Partial perforations of the fuselage could negatively or catastrophically affect aircraft control and communication systems should damage be done to wiring or hydraulic system components. Frangible ammunition is a current and viable option for use by the FAA and Air Marshals program, having been available from commercial sources for several years. It is currently used by several government agencies, including the Secret Service and military Special Forces. OLES believes that an immediate increase in demand for existing frangible ammunition will occur, leading to a dramatic increase in the number of choices of this type of product. Ensuring that existing and new choices of frangible ammunition meet recognized minimum safety, quality, and performance requirements in aircraft and airport environments necessitates that a performance standard be developed and implemented.

Technical Strategy

OLES will produce a "Selection Guide for Frangible Ammunition Used in Aircraft Security Applications." This guide will identify the state-of-the-art in frangible ammunition types, models,

calibers, and sources; and serve as a much-needed reference for selection and purchase of frangible ammunition for the emerging FAA Air Marshal and Aircraft Security programs and related uses. Annual or biennial updates to the guide should be performed in addition to the initial publication to reflect advances in the technology.

OLES will perform NIJ Standard-0101.04 Compliance Testing of body armor models to be worn by FAA security personnel, both in airport and aircraft security roles. OLES is the originator and continuing authority for the development and application of the well known NIJ test standard for personal body armor. OLES would conduct body armor testing to this standard using all frangible ammunition types and calibers that are of relevance to the FAA security programs. Such data has not been produced to date, and it is well known from law enforcement history that armor protection from the wearer's firearm is critical to safety. Compliance testing to the NIJ standard would ensure that FAA security personnel wearing body armor would have the highest assurance of protection – for over 30 years to date, no law enforcement officer has been killed by a ballistic impact when wearing NIJ compliant body armor tested to the applicable threat level.

OLES will develop a comprehensive performance standard for evaluating frangible ammunition for use in aircraft applications. This standard will provide performance, safety, and quality guidelines, requirements, and selection criteria to the FAA for procurement, as well as provide minimum performance requirements to the manufacturing industry, ensuring development of ammunition and manufacturing sources of FAA approved or recognized frangible ammunition. OLES will utilize its highly specialized expertise in law enforcement equipment, weapons, ballistics, and materials including using its ballistics laboratory for the research and evaluation required to produce a relevant performance standard. This standard will ensure long-term consistency in the specialty ammunition developed, procured and used in the FAA aircraft security programs. A possible follow-on activity could involve implementing a formal Compliance Testing Program through which commercial test laboratories would be certified to conduct testing consistent with the standard. Such a program would provide a convenient means for ammunition manufacturers to have their products certified to the standard.

FY2002 DELIVERABLES: "Selection Guide for Frangible Ammunition Used in Aircraft Security Applications," test report describing compliance testing of FAA body armor with frangible ammunition, frangible ammunition performance standard.

Accomplishments

The following guides have been completed and have either been published or are in NIJ for publication. In addition, all these guides are posted on-line at the Justice Information Network Web Site (http://www.nlectc.org/) so that emergency first responders and other public safety workers can have direct access to these documents:

Publications

1) NIJ Guide 101-00, October 2001, "An Introduction to Biological Agent Detection Equipment for Emergency First Responders."

2) NIJ Guide 102-00, October 2001, "Guide for the Selection of Personal Protection Equipment for Emergency First responders."

3) NIJ Guide 103-00, October 2001, "Guide for the Selection of Chemical and Bio logical Decontamination Equipment for Emergency First Responders."

4) NIJ Guide 104-00, October 2001, "Guide for the Selection of Communication Equipment for Emergency First Responders."

Office of Law Enforcement Standards Organization (810.02)

For additional information about the Office of Law Enforcement Standards, please visit our Web sites at http://www.eeel.nist.gov/oles or http://www.nlectc.org. Staff may be contacted at the following telephone extensions (301–975–XXXX):

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