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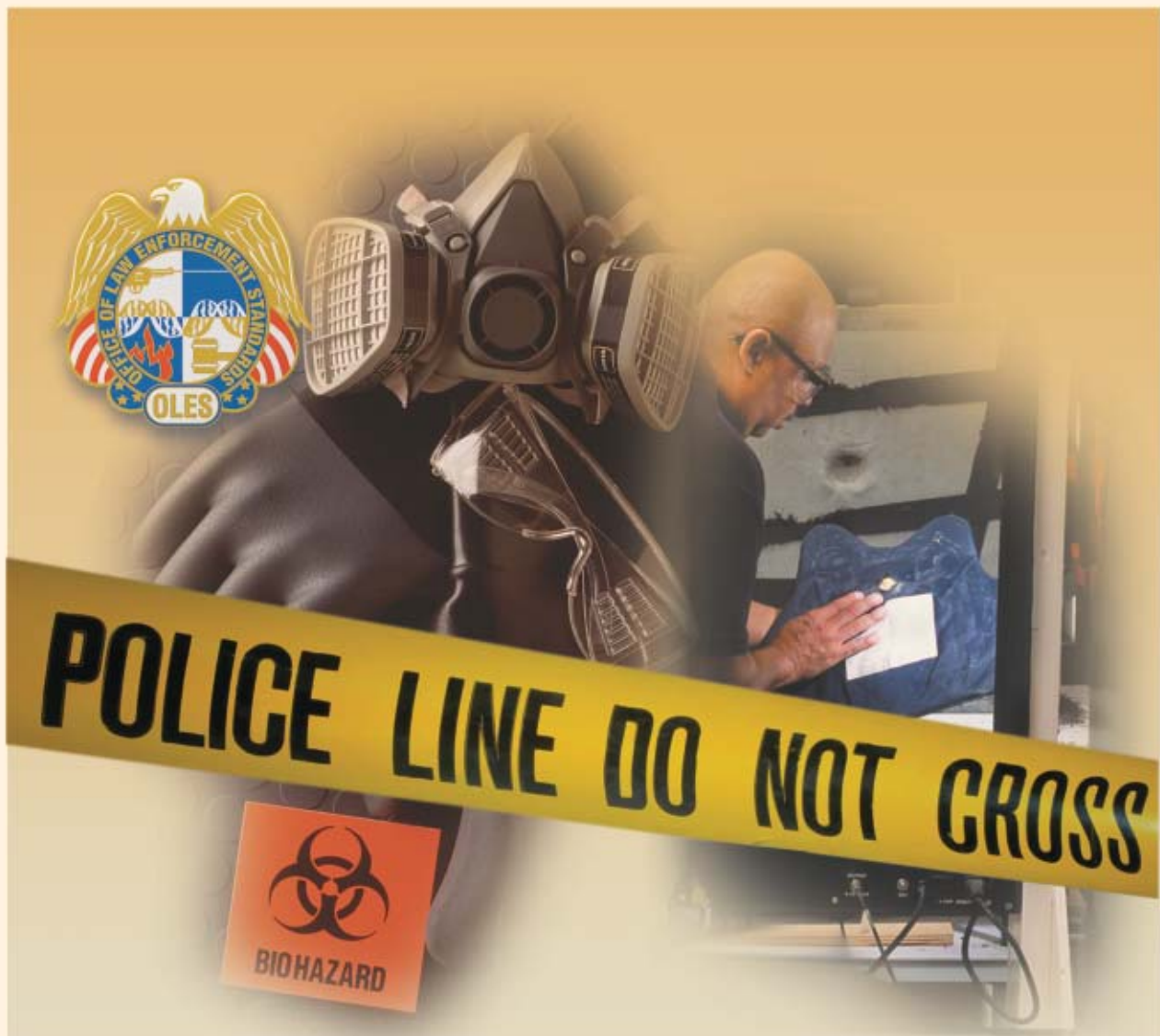
NISTIR 6952

January 2003

**ELECTRONICS AND ELECTRICAL  
ENGINEERING LABORATORY**

# OFFICE OF LAW ENFORCEMENT STANDARDS

**PROGRAMS, ACTIVITIES, AND  
ACCOMPLISHMENTS**



# THE ELECTRONICS AND ELECTRICAL ENGINEERING LABORATORY (EEEL)

One of NIST's seven measurement and standards laboratories, EEEL conducts research, provides measurement services, and helps set standards in support of the fundamental electronic technologies of semiconductors, magnetics, and superconductors; information and communications technologies, such as fiber optics, photonics, microwaves, electronic displays, electronics manufacturing supply chain collaboration; forensics and security measurement instrumentation; fundamental and practical physical standards and measurement services for electrical quantities; maintaining the quality and integrity of electrical power systems; and the development of nanoscale and microelectromechanical devices. EEEL provides support to law enforcement, corrections, and criminal justice agencies, including homeland security.

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 Microelectronic Programs

Office of Law Enforcement Standards

This publication 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, <http://www.eeel.nist.gov>. These publications are updated biennially.

**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 (upper left) reflects some of the projects that we conduct: DNA research, arson research, forensic sciences, and law enforcement weapons and equipment. Shown on the cover are pictures that represent some of the projects in our portfolio: development of standards for ballistic resistance of personal body armor, users' guides for chemical and biological protective equipment, and standards for other types of protective equipment used by first responders to critical incidents. Ballistic vest photo © 2002 Robert Rathe.*

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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**

Arden L. Bement, Director



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## 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 eleven, 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 Transportation Safety Administration (TSA).

**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 250 standards, guides, and technical reports over its 32-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 2003. 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.

## 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.

**FY2003 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

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4.6 professionals  
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### 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 Béclair, 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. Secret Service, Washington, DC
- Wayne State University Detroit, MI

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. 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 two years of the stab resistant body armor Compliance Testing Program have been successful, with over 130 armor models tested and found to be in 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 spike tests 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 the NIJ standard. Not addressed by PSDB then was 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. Since that time, PSDB has specified a spike-style threat weapon that is similar, but not identical, to the NIJ spike. Future studies will consider the possibility of harmonizing this threat implement between the two standards.

The slash threat was not directly addressed in NIJ Standard-0115.00, since it was not believed to be as severe as the stab threats. PSDB has concluded research on slash attacks and has developed equipment and test methods for conducting controlled slash attacks on armor. Future improvements to this standard will focus on incorporating this 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. Additional studies will examine the sensitivity of spike tip geometry to sharpness readings and penetration ability.

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 likely 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 will continue to collaborate with PSDB and conduct in-house studies on spike threats, backing materials, and edge sharpness testing. Additionally, PSDB’s slash test methodology will be evaluated through testing.

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

## **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: 1) other existing national standards can be utilized; 2) upgrading the identified threat levels covered in the current standard is necessary; 3) changing to an ISO “headform” will change the protection levels covered under the old standard; and 4) 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.

**FY2003 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.

## **REVISION OF NIJ STANDARD – 0106.01, “BALLISTIC HELMETS”**

### **GOALS**

A comprehensive evaluation of NIJ Standard-0106.01, “Ballistic Helmets,” the equipment standard that establishes minimum performance requirements and methods of test for ballistic helmets, suggests that helmets meeting the standards’ requirements could still leave the wearer with a significant risk of skull fracture. The objective of this project is to revise the standard, and establish new

performance levels and test methods based on ballistic impact biomechanics research.

### **CUSTOMER NEEDS**

The current NIJ helmet standard is more than twenty years old, has not been regularly updated, and was not based on ballistic impact biomechanical principles. Recent research conducted in the “Study of Head Injuries During Ballistic Loading of Helmets,” performed by the University of Virginia Impact Biomechanics Center for the U.S. Army Soldier and Biological Chemical Command’s Natick Soldier Center (NSC), indicated that requirements in the existing standard may not ensure adequate protection for individuals wearing ballistic protective helmets meeting the standard. Another issue associated with the current standard is the lack of its application in the market place. Few helmets are certified to the existing standard. Common complaints about the standard suggest that the test is difficult to perform and requires specialized equipment, and questions have been raised about the validity of the standard.

The new standard will reduce the risk of serious injury due to ballistic impacts, as well as standardize testing and performance requirements based on modern ballistic impact biomechanical principles. This work will also provide a standard in which the community can have greater confidence. Criminal justice and public safety personnel, helmet manufacturers, and testing laboratories will benefit from this work. The military will also benefit because the NIJ standard is sometimes specified in procurements for helmets.

### **TECHNICAL STRATEGY**

This effort builds upon an Army study conducted by the University of Virginia. Through the U.S.-Canada bilateral agreement, Biokinetics, a Canadian company specializing in helmets, will assist the U.S. technical team with revising the standard. Numerous issues will be addressed: 1) the current revision only addresses threats up to level II, even though helmet technologies allow a higher level of protection; 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; and 4) head trauma research has led to a better understanding of injury mechanisms and injury risk criteria. Through this joint project, the technical team will evaluate the research and develop a new ballistic protective helmet standard, build ballistic helmet test rigs, es-

establish performance criteria, and verify and validate the test methods.

**FY2003 DELIVERABLES:** Quarterly progress reports, test equipment, and a performance standard.

## **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 explosive ordnance disposal (EOD) personnel.

### **CUSTOMER NEEDS**

Currently, there are no U.S. standards for bomb suits used by law enforcement bomb squads or military 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 specifications and performance requirements for certain types of bomb suits, and these are viewed as an ideal starting point for this effort. A multi-agency technical team has been established. This effort will consist of multiple steps: 1) consult with explosives experts in law enforcement and the military to identify essential features of bomb suits and rating categories; 2) evaluate existing commercial, military, and international standards and/or specifications to determine if any are suitable; 3) conduct a threat assessment to identify those threats for which reasonable protection could be afforded; 4) develop standard threat definitions; 5) establish acceptable performance limits and develop suitable test methods; 6) conduct validation tests; 7) produce a draft performance standard and circulate it for comment and review by the technical community.

**FY2003 DELIVERABLES:** Progress reports, technical reports, and a draft performance standard.

## **EVALUATION OF "SMART GUN" TECHNOLOGIES**

### **GOALS**

The objective of this project is to evaluate smart gun technologies, and if a mature technology is in-

corporated into a fireman, to develop a standard test protocol for evaluating the firearm.

### **CUSTOMER NEEDS**

As evidenced in the news, 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-1990s 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 alternative 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.

**FY2003 DELIVERABLES:** Progress reports, technical reports, and a draft performance standard.

## **SUPPORT OF NIJ STANDARD – 0112.03, "AUTOLOADING PISTOLS FOR POLICE OFFICERS"**

### **GOALS**

The objective of this project is to provide continuing support to the autoloading pistol standard and compliance test program.

### **CUSTOMER NEEDS**

NIJ Standard–0112.03 serves the interests of law enforcement and corrections officers. This performance standard can be used to ensure that firearms under consideration as duty firearms meet certain basic safety, quality, and reliability requirements.

## TECHNICAL STRATEGY

This latest revision of the standard was issued in July 1999. Two commercial test laboratories have been certified by NIJ to conduct testing to the standard. Since the standard was published, some issues have arisen that required technical studies and assessments to resolve. OLES serves in a technical capacity to monitor testing under the formal Compliance Testing Program administered by NLECTC, conduct studies where needed, and maintain the standard.

**FY2003 DELIVERABLES:** Relevant findings will be documented and, if necessary, clarifications will be made to the standard.

## REVISION OF NIJ STANDARD – 0307.01, “METALLIC HANDCUFFS”

### GOALS

The objective of this project is to revise NIJ Standard–0307.01.

### CUSTOMER NEEDS

The classic mass-produced steel handcuff, little changed over the last 90 years, is used for arrests and for prisoner transport. The limitations of traditional handcuffs have become evident, particularly during the transport of prisoners, where prisoners have been known to pick the double lock with a bit of wire, or defeat the pawl directly with a piece of thin material, or break the “cheek plates” apart at the ratchet pivot. An improved standard could force desired improvements in the design of metallic handcuffs.

NIJ Standard–0307.01 serves the interests of law enforcement and corrections officers. With the anticipated improvements, a revision to this standard would provide a better way to test and evaluate handcuffs, resulting in better equipment being available to public safety officers.

### TECHNICAL STRATEGY

OLES previously had investigated handcuff design parameters and performance test options. This work led to the development of force-torque test equipment for evaluating handcuffs and a better understanding of handcuff design theory. Past research also identified shortcomings with the standard, such as the absence of: 1) test methods for longitudinal testing of handcuffs having no tongues on the cheek plates; 2) test methods for handcuffs of “non-standard” size; and 3) identifying factors

that affect the picking of handcuff locks. These shortcomings will be addressed through the development of improved, more versatile, test methods. Validation tests are planned to confirm that the test methods yield acceptable and reproducible results.

**FY2003 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 establish minimum performance requirements and methods of test for shotguns to be used by law enforcement and corrections officers.

### CUSTOMER NEEDS

The current base version of the standard, NIJ Standard–0113.00 was released in March 1989. This standard serves the interests of law enforcement and corrections officers because it can be used to ensure that shotguns selected meet certain basic dimensional, functional, safety, and firing requirements. Within the last decade, the use of less-than-lethal munitions by law enforcement and corrections officers has increased dramatically. Some of these munitions are designed to be fired from shotguns, but not all shotguns function properly with them. The standard will be updated to reflect the types and use of shotguns for law enforcement and corrections applications.

### TECHNICAL STRATEGY

New test fixtures have been built so that the shotguns can be consistently held for controlled firing tests, and studies have been completed to identify the most popular types of shotguns used by law enforcement and corrections personnel. Revised test methods will be developed, validated, and then incorporated into a new revision of the standard.

**FY2003 DELIVERABLES:** Progress reports and a revised draft of the standard.

## DEVELOPMENT OF NIJ STANDARD FOR LESS-THAN-LETHAL WEAPONS

### GOALS

NIJ has a broad program area established to research Less-Than-Lethal Technologies. These

technologies are utilized in weapons that are designed to temporarily incapacitate, confuse, delay, or restrain an adversary in a variety of situations without the use of lethal force. These devices, such as pepper spray, distraction devices (flash-bangs), and kinetic energy projectiles (bean bags, rubber bullets, and ring airfoil projectiles), have been used routinely in certain altercations, riots, prison disturbances, and hostage rescues. Through this broad program, NIJ identifies, develops, and evaluates new or improved devices that will minimize the risk of death and injury to law enforcement officers, corrections officers, suspects, prisoners, and the public. The objective of this project is to develop a performance standard for less-than-lethal weapons.

### **CUSTOMER NEEDS**

Law enforcement agencies, corrections facilities, and the military are relying on various less-than-lethal weapons technologies to diffuse potentially life-threatening situations. Numerous studies have characterized many types of less-than-lethal weapons; however, a standardized method for testing and evaluating these weapons for level of injury has not yet been established. As a result, there is great variability in the manner in which the devices are tested and great variability among products regarding their performance and their potential to cause serious injury, or even death, to the subject. A standard that establishes test methods and acceptable performance levels will lead to less-than-lethal weapons that are less likely to produce unwanted bodily injury.

### **TECHNICAL STRATEGY**

OLES plans to work with the Federal civilian and military agencies that have interests in less-than-lethal technologies — such as the U.S. Secret Service, U.S. Marshals, the Federal Bureau of Investigation, and the Joint Non-Lethal Weapons Directorate — to review existing research and to develop standard test methods for evaluating less-than-lethal weapons. Some research projects have been completed and others are underway to relate human responses and biomechanical surrogate responses to known attack stimuli. These studies will be reviewed to establish acceptable performance levels for less-than-lethal weapons. OLES will then develop a draft performance standard establishing performance levels, test methods, and special test equipment.

**FY2003 DELIVERABLES:** Quarterly progress reports and a draft performance standard.

## **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 false. To rectify this situation, a uniform standard is needed that clearly defines the types of threats being tested and the test methods.

The armored car standard serves the interests of agencies that must purchase armored cars. 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 certain performance levels.

### **TECHNICAL STRATEGY**

OLES has participated with other government agencies to conduct limited testing to identify important factors that should be assessed in the performance standard. The Technical Support Working Group (TSWG) is sponsoring most of the work on this effort. TSWG plans to let contracts to address specialized areas required for this standard: ballistics testing, blast testing, optical qualities testing, automotive performance testing, and quality assurance testing. OLES will provide technical support and oversight of those contracts and integrate the final products of each into a draft performance standard for armored vehicles. OLES will coordinate the standard review process so that the armoring industry can comment on the draft standard.

**FY2003 DELIVERABLES:** A final draft performance standard.

## **TEST PROTOCOL DEVELOPMENT FOR GUNLOCKS**

### **GOALS**

The objective of this project is to develop a standard test protocol for evaluating gunlocks.

## CUSTOMER NEEDS

Several states have recently passed firearms safety measures. For example, Maryland requires that all new handguns be sold with locks to prevent children and other unauthorized users from using the firearm. The Commonwealth of Massachusetts uses consumer protection regulations to prohibit the sale of firearms without tamper-resistant serial numbers, child-protection features, and trigger locks. Michigan and New York have similar firearms safety legislation. 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 year 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.

This test protocol will serve the interest of the general consumer and provide guidance to lock and firearms manufacturers. This test protocol will ultimately promote public safety by establishing a consistent method for assessing the performance of gunlocks.

## TECHNICAL STRATEGY

OLES participates on ASTM International Subcommittee F15.53 on Non-Integral Firearm Locking Devices. This subcommittee is developing a performance-based standard for gunlocks. OLES provides laboratory support to evaluate and validate proposed test methods, assists in drafting the provisional standard, and participates in interlaboratory trials.

**FY2003 DELIVERABLES:** Technical support to ASTM.

## DEVELOPMENT OF A FRANGIBLE AMMUNITION SELECTION GUIDE AND PERFORMANCE STANDARD

### GOALS

This project consists of three parts: (1) producing a Selection Guide of existing frangible ammunition; (2) performing ballistic testing of frangible ammunition against various targets; and (3) developing a performance standard.

## CUSTOMER NEEDS

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 the target. Key performance requirements of frangible rounds are that they remain effective against their targets without causing significant collateral damage.

Frangible ammunition is a current and viable option for criminal justice and public safety agencies in certain situations. For example, frangible ammunition is ideal in some tactical applications to minimize collateral damage. In other cases, some training facilities are “lead-free,” and many types of frangible ammunition can be utilized at these facilities.

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. Development of a performance standard will ensure that existing and new choices of frangible ammunition meet recognized minimum safety, quality, and performance requirements.

## TECHNICAL STRATEGY

OLES will produce a “Selection Guide for Frangible Ammunition.” This guide will identify the state-of-the-art in existing frangible ammunition types, models, calibers, and sources. The guide will provide a reference for selection and purchase of frangible ammunition for various criminal justice and public safety applications.

Follow-on efforts will involve conducting performance tests of frangible ammunition against a variety of targets. Eventually, the test methods developed for ammunition performance characterization will be incorporated into a performance standard for frangible ammunition. The standard will also establish performance requirements for the ammunition. Development of a performance standard would allow for implementation of a formal Compliance Testing Program, through which frangible ammunition could be formally tested against the standard.

**FY2003 DELIVERABLES:** “Selection Guide for Frangible Ammunition,” a report describing ammunition performance against standard targets, and a draft performance standard.



## 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

The current revision of the standard, NIJ Standard-0108.01 was released in September 1985. Law enforcement agencies rely on this standard 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. Others have applied the standard to evaluate ballistic-resistant materials used in construction of ballistic-resistant barriers and enclosures. The current standard does not reflect any of the improvements that were recently introduced into the ballistic resistant body armor standard, and harmonizing the test methods and threat levels of the two ballistic standards is important.

### TECHNICAL STRATEGY

Under the current effort, a new draft revision of the standard will be developed 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. Test trials are planned to validate the test methods.

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.

**FY2003 DELIVERABLES:** A revised draft of the standard.

### ACCOMPLISHMENTS

■ **Ballistic-Resistant Body Armor Compliance Testing Program Technical Support** – OLES provided technical support to this program, which is administered by NIJ and the National Law Enforcement and Corrections Technology Center. The pro-

gram utilizes NIJ Standard–0101.04, “Ballistic Resistance of Personal Body Armor,” which was developed by OLES and published in September 2000. Two commercial laboratories were certified to conduct testing under the Compliance Testing Program, and armor manufacturers contract with the laboratories for test services.

■ **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.

■ **Stab-Resistant Body Armor Compliance Testing Program Technical Support** – OLES provided technical support to this program, which is administered by NIJ and the National Law Enforcement and Corrections Technology Center. The program utilizes NIJ Standard–0115.00, “Stab Resistance of Personal Body Armor,” which was developed by OLES and published in September 2000. Two commercial laboratories were certified to conduct testing under the Compliance Testing Program, and armor manufacturers contract with the laboratories for test services.

■ **Gunshot Residue Forensics Project Support** – OLES’ Research Facility was utilized to obtain residue from gunshots in support of NIST’s Chemical Sciences and Technology Laboratory (CSTL) forensics projects.

■ **Research Test Facility Relocated** – In early April 2002, the National Institute of Standards and Technology (NIST) awarded a contract to Stevenson Group Contracting, Inc. to construct for OLES a new Research Test Facility in the Industrial Building on NIST’s main campus. Construction was completed by the end of September and the new Research Test Facility has been commissioned for use. Support of the project was provided by the National Institute of Justice, NIST, and NIST’s Electronics and Electrical Engineering Laboratory. Test activities previously housed in the old facility, an abandoned NIKE missile site adjacent to the NIST campus, are being moved to the new facility. The test facility is used to support work on Weapons and Protective Systems projects requiring ballistics capabilities as well as those that do not.

■ **Gunlock Standard Development Initiated** – OLES has been participating on ASTM International Subcommittee F15.53 to develop a performance standard for “Non-integral Firearm Locking Devices” (gunlocks).

■ ***Scientific Exchange Program*** – OLES hosted a scientist from the Home Office of the Police Scientific Development Branch in the United Kingdom for a week as part of NIJ’s foreign scientist exchange program. While here, the scientist had the opportunity to participate in ongoing research efforts in ballistic-resistant and stab-resistant body armor, autoloading pistols, and gunlocks.

## **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 such project 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 — the electrical properties of metals used in handheld weapons, and the other, of materials that emulate the electromagnetic properties of the human body.

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) mm-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. Further-

more, the ambiguity of simple detection presents liability issues for subsequent search.

### TECHNICAL STRATEGY

Specific tasks are as follows:

- Provide assessment of imaging system considering spatial resolution, frame rate, clarity, and gray scale intensity and projections for improvements in these parameters, if applicable.
- Interact with Raytheon to leverage their efforts in antenna-coupled millimeter-wave microbolometer development.

**FY2003 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 millimeter-wave range concealed weapons imaging and detection systems, and this cost savings would benefit the LEC community.

### Technical Contact:

A. George Lieberman  
Thomas Russell

### Staff-Years:

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

Several delays have been encountered because of unexpected technical difficulties, such as, low yield in mounted arrays, excessive signal (or pixel) noise, and interference. The yield of mounted arrays has been improved and more arrays have been fabricated for back-up. Signal noise, which was due to improper shielding has been resolved. Several static images of a small-caliber handgun have been acquired and these images exhibit interference. This interference is what is observed with coherent illumination techniques but has not been observed with passive techniques. The interference we observed was approximately the same for illumination by a continuous-wave (cw) source, a frequency-modulated cs source, and a pulsed noise source. Because of the lack of coherence in the noise source, the corresponding image was not expected to exhibit interference. Consequently, the effect of illumination on the quality of images from an active imager must be addressed.

### **TECHNICAL STRATEGY**

Specific tasks are:

- Complete development and assessment of 8-pixel readout boards
- Fabricate wafer scale antenna-coupled microbolometer imaging arrays for testing
- Investigate the effects of passive and active illumination on image quality

**FY2003 DELIVERABLES:** Report describing performance of readout boards and imaging arrays. A video image of a moving handgun obtained from an imaging array or, if pixel yield is low in the array, by emulating array imaging via scanning a single pixel.

### **DEVELOPMENT OF EVALUATION STANDARDS FOR STILL 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 systems 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, which have resulted in a human identification database. Using the database, NIST has developed the measurement methods for analyzing performance of facial recognition systems and is analyzing gait recognition systems. The techniques are applicable to a wide range of biometrics. This effort 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:

- eXtensible Markup Language (XML) Standards for Self-Documenting Human ID Evaluation Materials: NIST will refine the current version 0.99 used in Facial Recognition Vendor Testing (FRVT) 2002 and release a definitive human evaluation framework (HEF) suite suitable for use by other members of the Human ID community.
- Department of State Images: NIST will use up to 6.8M images from the Department of State (DOS) images, and possibly supplement those with more from DOS, in an investigation of the effect of gallery size on recognition rates. Particularly, a baseline algorithm such as principle component analysis (PCA) will be used on very large galleries. NIST will attempt to model these processes and explain phenomenological results such as the identification rates dropping as the log of the gallery size.
- FRVT 2002 analysis: NIST will further the analysis of the FRVT 2002 data sets.

**FY2003 DELIVERABLES:** Refined XML Standards for Self-Documenting Human ID Evaluation Materials; results on study of gallery size on recognition rates; results of further analysis of the FRVT 2002 data sets.

## **LIQUID-FILLED CAMERA FOR ENHANCEMENT OF SHADOW DETAIL**

### **GOALS**

Develop a simulated-eye-design (SED) camera for surveillance purposes to reveal deep shadow detail in bright or high-contrast scenes by dramatically reducing the wash-out glare arising from the lens and camera body.

### **CUSTOMER NEEDS**

Often high contrast scenes are encountered in police work that make it difficult to identify people or activities obscured by bright lights or brightly lit areas. Cameras are needed to be able to see the details in shadows or dark areas that can better replicate the performance of the eye. For such situations the SED technology may be ideally suited. For example, many surveillance situations occur with vehicle headlights or area lights that can wash out important details or activities in shadow or dark areas of the scene. But if a person were observing that same area with their eye, they would have no trouble seeing details in the shadowed areas. Similarly, faces can be difficult to identify by surveillance cameras because of bright pavement or floor areas, whereas the eye would have no trouble making the identification if it were in the same place as the camera. To have a camera technology that can better reproduce the glare avoidance and dynamic range of the eye would offer many advantages over current camera technologies for police applications.

Despite advances in electronic photography as with, for example, charge-coupled-device (CCD) cameras, all cameras suffer from the effects of veiling glare. In many of these cases, the eye can see a sufficient dynamic range to distinguish shadow and dark detail in all but the most extreme situations, whereas 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 such as a face or terrorist activities occurring in shadows. The first prototype of the SED camera exhibited a factor of three improvement in reducing the glare from an ordinary camera. It is hoped that by careful attention to construction details that a factor of 10 or 100 improvement can be achieved

making such cameras more like the eye in their ability to discern shadow detail.

### **TECHNICAL STRATEGY**

In the first phase of the research several different technologies (CCD and CMOS) were evaluated and an astronomical CCD camera was selected. Several cameras and the appropriate software were purchased and characterized to obtain a performance baseline. The CCD chip was then tethered and placed within an in-house built camera housing with a simple lens and aperture, and the system tested for vacuum integrity. An internal aperture was used, since it was determined to be advantageous over an external aperture.

Several different liquids were investigated to determine the effect of their particulate suspending qualities in use against a CCD chip surface. The Rayleigh scattering and refractive index mismatching were the principle properties examined. A pumping and filtering system, along with a special viewing cell, were constructed for this purpose. The camera was tested for three conditions: air-filled, ethanol filled, and immersion oil filled. The best case was provided by filling the camera with ethanol, giving a 7x increase in the measurement of contrast ratio.

The next phase of research will be the following:

- **Use of a Scientific Grade CCD:** A system in which the CCD is tetherable or at least socketable (where we could tether the camera ourselves) and that provides the required 16-bit dynamic range, is still desirable. Thus a search for a higher-grade CCD camera will continue.
- **Internal Aperture Design:** Internal apertures with different reflective properties will be investigated to determine which if any provide an improvement in overall system performance.
- **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. A proper hermoelectric cooler requires the use of a solid medium.
- **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.

- Verification using NFS probe: An independent method for verification of the performance of the liquid-filled camera is required for establishing its validity. A photodetector mounted with a narrow-frustum slet (stray-light elimination tube) will be used to measure the same contrast patterns as the camera. Similar results will further corroborate the camera's measurement capabilities.

**FY2003 DELIVERABLES:** The results of this research will be published as NIST Internal Reports (NISTIRs) as each component of the plan is brought to completion. Annual, quarterly and monthly progress reports will be generated as requested.

## **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 hand-held (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.

**FY2003 DELIVERABLES:** 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

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. Our goal is to 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. 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.

**FY2003 DELIVERABLES:** Use measurement systems to measure samples sent in from other agencies interested in characterization of specific samples.

## 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.

**FY2003 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.

## ACCOMPLISHMENTS

■ **Gait Recognition Database** – A 20 GB database of stereoscopic synchronized video of 30 subjects walking a “racetrack” course was released in January 2001.

■ **Facial Evaluation Recognition Test (FERET) Face Image Database** – A new and final FERET face recognition database was released in March 2001.

■ **Large Scale Face Testing** – Obtained 6.6M face images from the Department of State. And selected a large scale test sample containing 37,000 individuals with four images each.

■ **FRVT** – Conducted the FRVT 2002 test in which 14 vendors participated. Approximately  $10^{12}$  match scores were generated and analyzed.

■ **Simulated-Eye Design Camera** – A simulated-eye design (SED) camera, a prototype liquid-filled charge-coupled-device (CCD) camera system, was constructed to improve the ability to capture high-contrast images. This design dramatically reduced the stray light effects (veiling glare) arising from light scattering off of the lens surface, iris, and other components, thus increasing the contrast when acquiring an image. When compared to a simple air-filled camera system, the SED camera demonstrated a seven-fold improvement in the measurement of contrast. Often high contrast scenes that are encountered by surveillance cameras make it difficult to

identify people or activities obscured by bright lights or in brightly lit areas. Cameras, such as the SED, are needed to be able to see the details in shadows or dark areas.

■ **Lidar Performance Standard** – *Technical Manual DOT HS 809 239, Speed Measuring Device Performance Specifications: Lidar Module* was recently revised by OLES and released for distribution. Lidars are laser-based devices used by police to enforce traffic speeds in situations requiring rapid and unique speed determinations on congested roads where radar devices are less useful.

■ **Walk-Through Metal Detector Testing** – The latest revision of NIJ Standard-0601.02 was finalized by OLES and is being prepared for publication. A formal Compliance Testing Program for walk-through metal detectors, modeled around those used for other products such as body armor, is being established. To kickoff the Compliance Testing Program, walk-through metal detectors from several manufacturers will soon be tested to the standard at a commercial test laboratory. In addition, NIJ and OLES coordinated detection performance tests specified in the Standard on two metal detectors of interest to the TSA, as part of the TSA's Advanced Metal Detector Program.

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# CHEMICAL SYSTEMS AND MATERIALS

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## 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.

In regard to standards, the forensic science community has an inherent need for standard reference materials (SRMs) and reference materials (RMs). Currently NIST supplies industry, academia, government, and other users with over 1300 reference materials of the highest quality and metrological value. SRMs are used for three main purposes: to help develop accurate methods of analysis (reference methods); to calibrate measurement systems; and to assure the long-term integrity of measurement quality assurance programs. To provide this support in the forensic science laboratories, OLES initiates projects that will create SRMs and RMs where the community determines that a void exists.

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.

## REFERENCE MATERIALS (RM) FOR BULLETS AND CASINGS

### GOALS

The objective of this project is to provide sets of virtual and physical signature standards for both bullets and casings as NIST RMs to support Bu-

reau 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 ballistic 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, establish bullet signature measurement traceability to NIST and the National Laboratory Center at ATF utilizing the 20 standard bullets numbered NIST Reference Material, 8240-021 to 8240-040. From this establish 2D and 3D virtual and physical bullet signature standards. The same process will be conducted on 40 NIST Reference Material casings. Second, a computer software program, using the newly developed NIST algorithm for bullet signature comparisons will be developed.

**FY2003 DELIVERABLES:** Virtual signatures and 40 NIST Reference Material 8240 bullets and 40 NIST Reference Material casings.

## A REVISED REFRACTIVE INDEX GLASS STANDARD REFERENCE MATERIAL

### GOALS

To support Federal, State and Local Crime Laboratories through the production of a glass refractive index standard reference material.

### CUSTOMER NEEDS

Associating a sample of glass to a potential source can involve a number of different examinations, in-

cluding the determination of chemical composition, refractive index and density. The instrumentation for these measurements rely upon high quality and quantitative standards in order to be properly calibrated. The past glass NIST SRM has been discontinued, creating a void in the necessary standards thus and thereby the need for the creating of a new glass SRM.

### **TECHNICAL STRATEGY**

Determine a suitable glass source, its' chemical properties and the form that would support the forensic analyst. Process this material and statistically analyze the quantitative results to ensure that adequate accuracy and precision have been attained.

**FY2003 DELIVERABLES:** A NIST Standard Reference Material for glass Refractive Index.

### **REVISED ETHANOL-WATER STANDARD REFERENCE MATERIAL FOR BLOOD-AND-BREATH-ALCOHOL ANALYSIS**

#### **GOALS**

To create a revised Standard Reference Material for blood and breath alcohol analysis to benefit Federal, State and Local Law Enforcement Agencies in their respective alcohol testing programs.

#### **CUSTOMER NEEDS**

A current SRM product of NIST (SRM 1828a) contains 4 ampoules with a 96 % (w/w) of ethanol. However most blood alcohol levels in driving under the influence (DUI) cases fall in a range different than the percentage provided in the NIST SRM set, not ideal for analysis purposes. These standards must be diluted in order to prepare the required concentration levels for the laboratory's analytical methods. The laboratories therefore require a revised set of concentrations to ensure technical accuracy.

#### **TECHNICAL STRATEGY**

The overall design of the project will closely follow that of SRM 1828a and its subsequent recertification to ensure consistency. Two independent analytical methods will be used to develop, confirm, and report the ethanol concentration in sample lots. The quantitative results from this analytical work will be statistically analyzed to ensure accuracy and precision has been attained.

**FY2003 DELIVERABLES:** Certified ampoules containing the new SRM with all requisite documentation will be available.

### **NIST REFERENCE MATERIAL (RM) 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 and to provide compositional gunpowder RM that will enable the validation of crime laboratory methods and encourage the expanded use of quantitative gunpowder measurements in forensic casework.

#### **CUSTOMER NEEDS**

A reference material (RM) from NIST provides the optimum value for the evaluation of procedures and laboratory techniques. The incorporation of this product into laboratory protocols will assist in accreditation requirements, improve evidence interpretation and provide 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 establishing requirements for conducting 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 reference material will provide forensic laboratories with measurements that are traceable to NIST, helping to improve laboratory capabilities and meet accreditation requirements.

#### **TECHNICAL STRATEGY**

A smokeless powder combination has been selected for its stability and desirable composition. This material will be packaged in approximately 300 units in 5 gram quantities after which a statistical design for subsampling the bottled material will be determined. The Statistical Engineering Division

will assist in the statistical design and data evaluation for the final certified values.

**FY2003 DELIVERABLES:** Development of a rugged analytical method for the determination of NG, DPA, and EC in the rifle powder RM prototype.

Prepare a document on the certification and availability of the Reference Material.

## **A STANDARD REFERENCE MATERIAL FOR DRUGS OF ABUSE IN HUMAN SERUM**

### **GOALS**

To produce a Standard Reference Material (SRM) of drugs of abuse in a human serum matrix.

### **CUSTOMER NEEDS**

Drug abuse remains a significant social problem in the United States and determinations of drugs of abuse in seized contraband or in bodily fluids is one of the most common types of analyses carried out in crime laboratories. In forensic toxicology, both urine and blood are tested for drugs of abuse. The SRM should be composed of the same matrix for which the testing is being conducted. The current available SRM is in a freeze-dried urine matrix, causing the analyst to extrapolate test results done in blood to the urine standard. Combining drugs of abuse analytes with a serum matrix is necessary to meet stringent testing requirements present in the laboratory environment.

### **TECHNICAL STRATEGY**

Determine the number and identity of analytes that should be included, their respective concentrations; optimum methods for their analysis and potential matrix compositions to mimic commonly encountered samples in crime laboratories. Sealed ampoules of the selected drugs and their metabolites will be analyzed and subjected through the certification process.

**FY2003 DELIVERABLES:** A SRM in a human serum matrix in ampoule form.

## **A STANDARD REFERENCE MATERIAL FOR ARSON ANALYSIS**

### **GOALS**

Previous work at NIST had developed Standard Reference Materials (SRMs) for various petrochemicals and fuels. However, no standard mixture for the identification of hydrocarbons in petro-

leum-based materials is offered. A new SRM for arson analysis containing a homologous series of hydrocarbons with additional aromatic constituents that would be amenable to gas chromatography is being developed.

### **CUSTOMER NEEDS**

One of the many determinations at a fire scene is whether ignitable liquid was utilized in the spread of the fire. The presence of ignitable liquid residues can infer that the fire was an act of arson, a serious crime that is responsible for significant losses of personal property and human lives each year. A part of the residue analysis is the identification of the class of the liquid that is largely based on the carbon number of the various hydrocarbon solutes found in the sample mixture. A number of fuel SRMs are offered at NIST. However, these SRMs are intended for analysis of trace inorganic and organic components in various petrochemicals and do not contain reliable and quantitative information regarding the carbon number distribution of solutes. The solute concentrations will be varied as necessary to best suit the needs of arson analysts.

### **TECHNICAL STRATEGY**

Analytes of interest will include even numbered, straight chain hydrocarbons from n-hexane ( $C_6$ ) to n-tetracosane ( $C_{24}$ ), toluene, *p*-xylene, *o*-ethyltoluene, *m*-ethyltoluene, and 1,2,4-trimethylbenzene in a solvent such as carbon disulfide or dichloromethane. This action will satisfy the ASTM specifications covering the range of volatile liquids commonly found in fire debris.

**FY2003 DELIVERABLES:** Complete statistical analysis of analytical results providing certified ampoules of analytes.

## **HUMAN AND ANIMAL DOSE RESPONSE, TOXICOKINETIC AND POTENCY ASSESSMENT OF PEPPER SPRAY PRODUCTS FOLLOWING TOPICAL AND AEROSOLIZED EXPOSURE**

### **GOALS**

The objectives of this three 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;

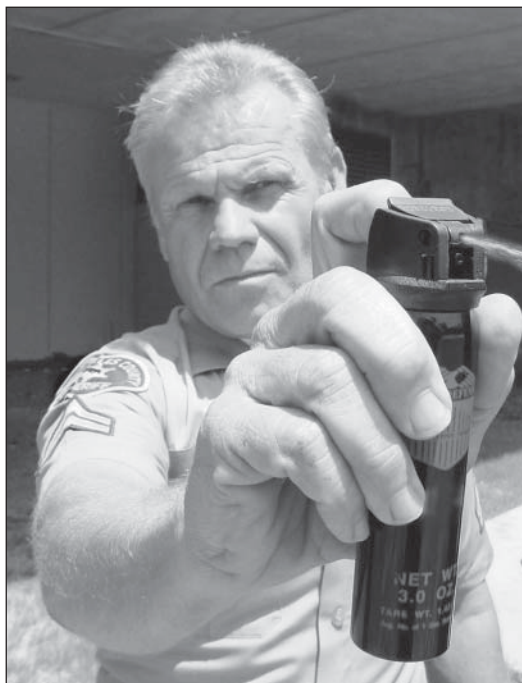
3) investigate the toxicological effects of inhalation of the same products; and 4) determine the extent of absorption and the distribution of these capsaicin analogs via dermal and nasal exposure.

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



*OLES is helping to characterize and establish performance standards for pepper spray.*

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 objectives of the third and final year of this research project are to: 1) chemically characterize a series of LTL OC spray products as a method for determining — and ultimately predicting — product potency; 2) apply the products and the individual capsaicinoids identified in the products to human skin to determine response and potency; 3) investigate the toxicological effects of inhalation of the same products; and 4) determine the extent of absorption and the distribution of these analogs following dermal and nasal exposure of drug free and drug treated rats. With these data, it will be possible to: 1) predict product potency by chemical analysis, dermal response or a combination of the two methods; 2) determine relative potency of the individual capsaicin analogs; 3) determine and quantify the effects of the products and the individual capsaicinoids 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, finally, 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.

**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 in-

terested 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 hand-held 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.

**FY2003 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 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 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.

**FY2003 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.



*Samples of protective gloves.*

## 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.

**FY2003 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 immu-



*OLES assessment of use of saliva as a non-intrusive forensic test may lead to more accurate drug testing results.*

noassay screen tests could be 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 collected 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.

**DELIVERABLE:** The project has been completed and the final report delivered to OLES. The report entitled "NIJ Report 605-00, Evaluation of Saliva as an Alternate Drug Testing Specimen" is now going through internal review, the report will be forwarded to NIJ for approval and publication as an NIJ Technical Report.

### ACCOMPLISHMENTS

- **A Standard Bullet** – A standard reference bullet was created at NIST with NIJ funding, through



OLEES, as a means to establish both national and international uniformity between all law enforcement agencies utilizing the Integrated Ballistics Identification System (IBIS). The manufacturer of the IBIS system has had a chance to “play” with the NIST bullet and found surprising results. The NIST bullet assists in maximizing the best acquisition of the bullet image, the orientation of the line pattern and the statistical properties of the cross correlation scores, all factors of the numerical scoring of a match. They are considering equipping each IBIS system with the standard reference bullet.

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# 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 Support Working 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 support 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, handling and examination of evidence related to high-tech crimes.

The Forensic Sciences program is also developing tools in other areas: a revised standard reference for identifying glass by refractive index and a calibrated refractive index oil for comparing glass specimens; a revised SRM for blood-and-breath alcohol analysis as well as an SRM for fire debris analysis. Related to drugs of abuse, the program is developing a reference material containing select drugs in a human serum matrix and evaluating an aerosol drug identification kit for possible use in schools. To assist fire 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. The program is also at the forefront of 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 is beneficial to screen all files for specific profiles and signatures. If the file profile and sig-

nature 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 output a list of 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 helping to verify the operation and accuracy of the database during a pre-delivery shakedown period.

**FY2003 DELIVERABLES:** The master database is the primary deliverable. An adjunct to this is the extracted database that is available to users in CD format, through the NIST SRD Office for purchase on a subscription basis. The master database is continually updated with newer versions of software and new releases. Additional software from non-Windows operating systems will be included as it becomes available. Additional sources of software will be sought among vendors and government agencies. 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 duplicate 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 approach is the development of 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.

**FY2003 DELIVERABLES:** Reports describing the overall concept and framework for testing computer forensics tools are published as web documents and as printed documents (for tests go to; <http://www.cftt.nist.gov>) (for reports go to; [http://www.ojp.usdoj.gov/nij/sciencetech/ecrime\\_pub.htm](http://www.ojp.usdoj.gov/nij/sciencetech/ecrime_pub.htm)). Further reports on each automated tool tested will be produced and published on-line when completed. 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 increasing use of the Internet have enabled the integration of computers and other electronic devices into nearly every aspect of modern life. These same 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 ready for publication pending final National Institute of Justice (NIJ) review. The guides addressing high technology will be initiated in the near future. Individuals that will compose the working group for these new guides will be determined by a selection process initiated by the Office of Law Enforcement Standards. Private, Federal, State and Local entities will be contacted to provide names of interested individuals from which a select number of participants will be chosen.

**FY2003 DELIVERABLES:** A series of quick guidance booklets.

## **BURN PATTERN RECOGNITION STANDARDS**

### **GOALS**

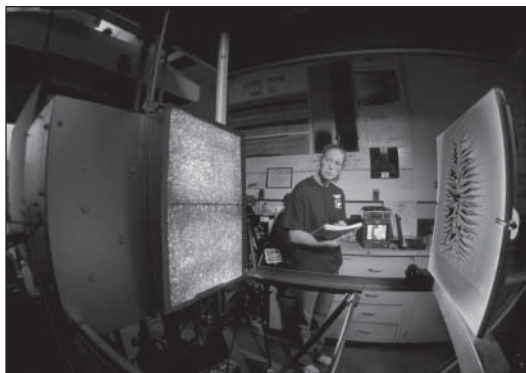
The objective of this project is to investigate the formation of fire patterns from ignitable liquid spills near the walls and corners of rooms on the interior surfaces of structures.

### **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



*NIST staff examine infrared image resulting from a fire test of a wall board sample. © 2002 Robert Rathe*

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. A large quantity of information has been gathered on the response of gypsum board to varying degrees of temperature. This information will be incorporated into a fire simulation software program allowing better modeling of fires.

**FY2003 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, such as candles and electric heaters.

### **CUSTOMER NEEDS**

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 and 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 Fire Dynamics Simulator (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 followed by candles.

### **TECHNICAL STRATEGY**

Sources such as candles and electric heaters are being characterized in laboratory scale experiments 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).

**FY2003 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.

## **DEVELOPMENT OF INTERACTIVE FIRE PATTERN STANDARD DATABASE**

### **GOALS**

To assist in the understanding of the fire behavior in a number of “line of duty death” (LODD) incidents through the use of a computer based fire simulator.

### **CUSTOMER NEEDS**

When faced with the difficult task of investigating a death associated with a fire, the need for scientifically based calculations is imperative. 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/Smokeview technology (see <http://www.fire.nist.gov/fds/>) has been used in the investigation of fire fighter deaths and injuries. The fire simulations provide insight into fire growth and the spread of fire and hot gases through the structures. This information educates, provides investigative support and offers a demonstrative capability for court.

### **TECHNICAL STRATEGY**

Information from controlled fires is compared with the computer model predictions of temperature and heat flux of the fire gases. Model results are compared with patterns (thermal damage) caused by real fires. Results from other research projects related to burn pattern and ignition sources are also inserted into the software program.

**FY2003 DELIVERABLES:** Technical report validating the capabilities of fire pattern generating capabilities of FDS for use in court. A standard protocol for the use of FDS to recreate fire simulations. The report will include comparisons of computer model results with physical evidence that can be documented in the field.

## **EVALUATION OF NARCOTIC DETECTION AND IDENTIFICATION FIELD TEST KITS**

### **GOALS**

To evaluate the sensitivity and specificity of field test kits for drugs of abuse commonly found within an academic environment. To determine any false positives or false negatives and to provide a list of those agents that initiate the response.

### **CUSTOMER NEEDS**

Field test kits are important tools for law enforcement officers to screen suspected materials for the determination of whether such materials might contain controlled substances. At the completion of the test, a color reaction may develop and if the appropriate color is observed in the correct time frame, a determination can be made that the material may contain the target drug. Such color tests involve a reaction with a particular functional group, which may be present in materials that are not controlled substances. The law enforcement office requires guidance on the limitation and specifications of the available field tests.

### **TECHNICAL STRATEGY**

The project strategy consists of purchasing the detection kits from a third party vendor and subject them to testing. Sensitivity tests will utilize known quantities of pure standards of the target drugs that will be subjected to testing according to the manufacturer’s instructions. Amounts of the standard drug will be applied from 10x the limit of detection down to 0.5x and lower if measurable signal is still found at the 0.5x level.

**FY2003 DELIVERABLES:** Technical report stating the obtained results.

## **RESEARCH IN DEOXYRIBONUCLEIC ACID (DNA) IDENTIFICATION METHODS AND STANDARDS**

### **GOALS**

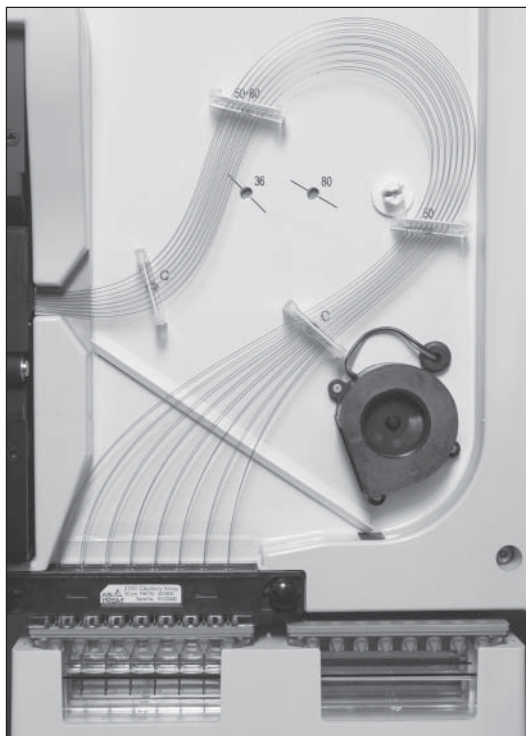
The objective of this project is to assist in finding solutions to DNA problems that occur with crime scene evidence. These research programs address the realm of DNA from collection issues to statistical individuality. Various programs will be detailed, each supporting the other by their attributes.

## 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.

**FY2003 DELIVERABLES:** SRMs for validation, procedural development and method evaluation within laboratories conducting DNA profiling. SRM 2395 Human Y Chromosome DNA, SRM 2391b PCR-based DNA Profiling Standard.



*Sixteen capillaries enable high DNA throughput, allowing more samples to be simultaneously analyzed.*  
© 2002 Robert Rathe

## 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 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.

**FY2003 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. MINISTR SYSTEMS

A new set of DNA tests were developed to help with analysis of degraded DNA samples recovered from the World Trade Center disaster. Primers have been moved in close to the repeat region of common STR markers to aid analysis of degraded DNA that has been broken up into small pieces. A set of six primer pairs, dubbed "Big Mini" was provided to various agencies for validation experiments.

**FY2003 DELIVERABLES:** To provide a new test method for inclusion with DNA procedures to expand the capabilities of utilizing degraded DNA.

## D. 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 varying temperatures with and without humidity control.

**FY2003 DELIVERABLES:** Continue longitudinal studies on aged samples stored on several media and under a variety of conditions and provide a manuscript detailing the findings.

### **E. 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 1,000 base pairs. The typing of SNPs throughout the genome 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 a SNP assay that can simultaneously detect 10 informative sites from around the entire mtDNA genome. The assay uses multiplex PCR to amplify small PCR products around each variable site. The 10plex assay using the SnapShot approach should be presented soon in a publication format.

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 ac-

curately and rapidly type samples is illustrated through results of Y chromosome and mtDNA SNP markers, including M9, M42, M45, M89, and M96.

**FY2003 DELIVERABLES:** Evaluate 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.

### **F. 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.

**FY2003 DELIVERABLES:** Completion of an SRM 2395 and assessing its utility to the forensic community.

### **G. 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 receiving a high level of 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



*NIST staff with robotic station utilized in the STR primer development. © 2002 Robert Rathe*

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.

**FY2003 DELIVERABLES:** The testing of the 20plex PCR primer set for genetic population studies as well as human identification purposes.

## **H. DEVELOPMENT OF NON-HUMAN MULTIPLEX**

DNA has found a way to assist in criminal investigations through unconventional methods. No longer does DNA testing require the finding of a bloodstain, saliva or human hair at the scene or on the victim to connect the suspect to the crime. Other unique aspects found as part of the criminal investigation are being put into action. The MeowPlex, is a new DNA test using tetranucleotide STR Markers for the domestic cat. NIST is assisting the National Cancer Institute in the creation of a robust multiplex STR assay for cats and the development of population databases for various cat breeds.

Already, one criminal case was solved utilizing this method of showing a hair found on the suspect could be associated to the victim's particular cat breed.

**FY2003 DELIVERABLES:** The creation of a robust multiplex STR assay for cats and the development of population database for various cat breeds.

## **I. RESULTS FROM THE INTERLABORATORY MIXTURE STUDY**

NIST has coordinated a series of interlaboratory examinations of multiplexed STR systems. Part of the purpose has been to evaluate the influence of DNA quantitation accuracy on STR multiplex signal intensity. A total of 74 laboratories responded with data from seven samples that were provided for analysis. Over 100,000 data points have been generated for evaluation during this challenging exercise. The initial report focuses on the linkages connecting the measurement of the concentration of the DNA to the observed STR multiplex signal intensities. Further scientific detail will be expounded in each released report.

**FY2003 DELIVERABLES:** Publications

## **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 evaluated the factors that cause handgun gunpowder residues to be retained on the body and optimizing residue collection protocols.



## TECHNICAL STRATEGY

Through an established selection process, obtain potential participants that have a forensic science background specifically in analytical chemistry. The project selection depends upon current research funding as well as current requirements in the forensic science community.

**FY2003 DELIVERABLES:** A manuscript on the retention and collection of GSR from hair and wigs as the result of the combing process.

## 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 research also expands into the area of collection with promising results favoring combing of human or synthetic hair. The type of comb, number of passes and method of extraction will be available for processing into a usable protocol.

## 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. Firing range experiments are completed and laboratory evaluation of the samples is in progress. Various types of hair combings are being evaluated for their

success in recovering organic gunshot residues. Residue collection from the hair of human subjects and wig-hair covered mannequins are part of the evaluation process. 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.

**FY2003 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 gunshot residue.

## ACCOMPLISHMENTS

- **DNA Data Base** – 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** – 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.

- **Reference Material Database** – 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 is \$90 per year and entitles the purchaser to receive up to four distributions per year. The NSRL is composed of software from various sources and incorporates 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.

- **Computer Forensics Tool Testing** – The Computer Forensics Tool Testing (CFTT) project’s Disk Imaging Tool Specification reports can be found at the following website: [http://www.ojp.usdoj.gov/nij/sciencetech/ecrime\\_pub.htm](http://www.ojp.usdoj.gov/nij/sciencetech/ecrime_pub.htm). The test results

provide information for toolmakers to improve tools used in computer forensics investigations, users to make informed choices, and the legal community and others to understand the tools' capabilities.

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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 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.

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



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

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.

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 Technology Focus Group, and individuals representing various practitioner groups at the local, state, Federal, and international levels. To facilitate progress of



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

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**Staff-Years:**  
10.0 professionals

**Funding Sources:**  
100% Other Government Agencies

### Project Champions:

- Institute for Telecommunication Sciences, the research and engineering branch of the National Telecommunications and Information Administration (NTIA), Boulder, CO

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 effort builds upon the work performed, and accomplishments achieved, via FY2001 funding. This subproject will 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, the subproject will 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.” The subproject will act as the Secretariat for the IT interoperability standardization process by keep-

ing 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, the project will 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 tech-

nologies; 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.

**FY2003 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 implementation 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**

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

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

**Technical Contact:**

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**Staff-Years:**

28.5 professionals

**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

Long before the September 11<sup>th</sup> attacks 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, consolidated existing projects with new initiatives under a single administrative banner. The Critical Incident Technologies program is being significantly expanded in fiscal year 2003.

This year's program continues 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. The program has already published the first of a series of CB protection equipment guides for emergency first responders.

New programs introduced last year as a result of the September 11<sup>th</sup> attacks included developing both a testing standard and selection guide for frangible ammunition to be used aboard aircraft. The Critical Incident Technologies program is being expanded this year to initiate development of radiological and nuclear detection equipment standards, explosives detection equipment standards, revision of NIJ Guide 100-00, "Guide for the Selection of Chemical Agent and Toxic Industrial Material Detection Equipment for Emergency First Responders, published in June 2000 and development of a radiological/nuclear equipment detection equipment guide. The program has been restructured and reorganized to better facilitate development of the suite of chemical, biological, radiological, nuclear and explosive protection equipment standards. This suite of standards includes development of performance standards for personal protective and respiratory protection equipment, detection equipment, decontamination equipment, selection care and maintenance guides and the support programs to facilitate equipment certification such as laboratory selection and certification programs.

## DEVELOPING CHEMICAL, BIOLOGICAL, RADIOLOGICAL, NUCLEAR, AND EXPLOSIVES (CBRNE) PROTECTION EQUIPMENT STANDARDS

**GOALS**

The goal of the CBRNE Equipment Standards Development Program is to enhance public safety by promulgating standards for CBRNE protective equipment that ensure minimum performance, quality, and reliability. This suite of standards and subsequent performance evaluations will be disseminated to the public safety community to help them make informed equipment purchases and to guide manufacturers, developers, and the test and evaluation community to ensure product compliance. The ultimate goal will be to link equipment certification and compliance to minimum performance standards and Federal equipment grants programs.

**CUSTOMER NEEDS**

The objective of this project is to provide the criminal justice and public safety community a suite of national chemical, biological, radiological, nuclear and explosives (CBRNE) protective equipment standards and to facilitate the adoption of these standards. Implementation of these standards is important to ensure that the criminal justice and public safety communities procure and use equipment that achieves a minimum acceptable level of performance. To accomplish this mission, strong working relationships must be established and maintained with the criminal justice and public safety user communities, to the point where the communities' representatives play a key and integral role in all facets of the standards development process. One primary means of accomplishing this is through the Interagency Board (IAB) for Equipment Standardization and Interoperability. The suite of equipment standards will consist of: CBRNE personal protective and respiratory protection equipment, CBRNE detection equipment, CBRN decontamination equipment, and 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.*

## **TECHNICAL STRATEGY**

The CBRNE standards development program involves many agencies and activities. These agencies include the National Institute of Justice (NIJ), the Department of Justice's Office for Domestic Preparedness (ODP), the National Institute for Occupational Safety and Health (NIOSH), the U.S. Army Soldier and Biological Chemical Command (SBCCOM), the National Fire Protection Association (NFPA), the InterAgency Board for Equipment Standardization and InterOperability (IAB), the Office of Homeland Security, the Environmental Protection Agency (EPA), the Federal Emergency Management Administration (FEMA), and other Federal agencies and professional organizations. The CBRNE standards development program has been restructured for FY03, and new initiatives have been introduced. However, all the elements from last year's program remain in the current program. The CBRNE standards development program consists of seven main project areas: 1) CBRN Respiratory Equipment Standards; 2) development of CBRNE Personal Protection Equipment Standards; 3) development of CBRNE Detection Equipment Standards; 4) development of CBRN Decontamination Equipment Standards; 5) development of Selection, Care and Maintenance Guides; 6) development of CBRNE Protective Equipment Testing and Test Laboratory Certification; and 7) support of Domestic Preparedness Programs. Additionally, a number of new CBRNE standards-related initiatives have been proposed for further development, depending upon the availability of funding. The

specific tasks required to accomplish this program are as follows.

### **A. DEVELOPMENT OF CBRN RESPIRATORY PROTECTION EQUIPMENT STANDARDS**

The objective of this task is to develop National Institute of Occupational Safety and Health (NIOSH) approved respiratory protection equipment standards against CBRN 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/radiological/nuclear 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 CBRN equipment minimum performance standards for the emergency first responder community when evaluating and purchasing CBRN 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 CBRN respirator standard and sustainment of a continuing certification program: 1) hazards analysis/vulnerability assessments; 2) standards development; 3) test method validation; 4) maintenance of CBRN equipment databases; 5) publication of user guides, user-friendly decision aid systems regarding respiratory protection issues at chemical/biological/radiological/nuclear/explosives terrorism incidents; 6) provide technical assistance to domestic preparedness and homeland security programs, partners, stakeholders, and civilian organizations as requested; and 7) certification and testing of CBRN equipment.

The subtasks within this year's efforts include continuation of previous efforts and a new task. These efforts include the NIOSH development of CBRN respiratory protective equipment standards for air purifying respirators and escape masks, a new effort to identify potential surrogates for chemical warfare agents, continued testing of existing respiratory equipment by NIOSH, and SBCCOM support to NIOSH for development of respiratory protective equipment standards and continued certification testing with live chemical warfare agents.

**FY2003 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 CBRN respiratory protection standards. The standard for Self Contained Breathing Apparatus (SCBA) was implemented in January 2002. This year, the standards for Air Purifying Respirators (APR) or gas masks and escape masks will be developed.



*A chemical/biological protective suit.*

## **B. DEVELOPMENT OF CHEMICAL, BIOLOGICAL, RADIOLOGICAL, NUCLEAR AND EXPLOSIVES PERSONAL PROTECTION (PPE) EQUIPMENT STANDARDS**

The objective of this task is to develop standards for personal protection equipment (PPE) which includes the suits, boots, gloves, etc., all additional elements of PPE excluding respiratory protection equipment. This task is separate from the respiratory protection equipment, since this effort is being conducted by agencies other than NIOSH. The purpose of these standards is to provide CBRNE equipment minimum performance standards to the emergency first responder community when evaluating and purchasing CBRN defense equipment.

The following specific efforts are necessary for the development of CBRNE standards for all types of PPE, other than respirators: 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.

Additional subtasks include a new initiative to study existing military protective equipment effectiveness against toxic industrial chemicals, and development of CBRNE PPE communications interfaces. A project for field validation and certification of advanced lightweight Chemical/Biological Agent/Toxic Industrial Chemical clothing systems will continue this year.

**FY2003 DELIVERABLES:** Performance Standards for PPE, and communications interfaces

## **C. DEVELOPMENT OF CBRNE DETECTION EQUIPMENT STANDARDS**

This task has been significantly expanded this year, to include development radiological/nuclear detection equipment standards, and to begin examination of standardized procedures for calibration of explosives detection equipment. The focus of the chemical and biological agent detection equipment standards program is to: 1) initiate investigation into the relative capability of commercial chemical detectors to adequately detect, identify, and quantify the toxic risk of aerosolized chemicals; 2) initiate and investigation of interferants that commonly occur in cities, rural areas, suburban areas, seaports, etc.; and 3) development and implementation of a test certification program for the detection equipment.

Radiological detection equipment technologies are much further developed and widespread throughout the non-DoD community than are chemical or biological detection equipment, and there are existing standards that may directly apply. However, these existing standards generally apply to Department of Energy or health physics functions, and may not always support the emergency first responder's needs. The radiological/nuclear detection equipment standards effort will assess the use, threatened use, or threatened detonation of a nuclear device or bomb, in which the energy is released through the fission or fusion process, or the detonation of a device used to disperse radiological material (a radiological dispersion device



(RDD)). This effort includes the following tasks: 1) determine the applicability of existing standards or test methods; 2) determine if existing standards or procedures require modification before adoption; or 3) determine if new standards require development; 4) develop a testing and certification program; and, finally, 5) develop user selection, care and maintenance guides for the equipment.

Another new initiative is related to conventional explosives detection equipment. Two potential tasks to be initiated this year are to develop procedures for the calibration and standardization of trace explosive detection devices, and for the development of explosives standard reference materials.

**FY2003 DELIVERABLES:** SBCCOM and other collaborating/contributing agencies and organizations will produce and deliver quarterly progress reports to OLES. Participation and contribution to interagency working groups and Standards Developing Organizations.

#### **D. DEVELOPMENT OF CBRN DECONTAMINATION EQUIPMENT STANDARDS**

The program consists of the development of national certification and testing standards for chemical, biological, and radiological/nuclear decontamination equipment and materials. Partners will include U.S. Army SBCCOM, the Environmental Protection Agency and the Centers for Disease Control.

Specific tasks to be performed include: 1) define chemical and biological agent and radiological/nuclear (CBRN) contamination detection levels required to meet acceptable airborne monitoring values, residual surface contamination levels, and PPE selection; 2) assess available CBRN decontamination processes, materials and technologies; 3) develop test criteria and parameters for the recommended CBRN decontamination processes, materials and technologies; 4) recommend CBRN decontamination processes, materials and technologies to meet the user's requirements; and 5) initiate the development of the equipment evaluation program.

**FY2003 DELIVERABLES:** SBCCOM and other collaborating/contributing agencies and organizations will produce and deliver quarterly progress reports to OLES. Participation and contribution to interagency working groups and Standards Developing Organizations.

#### **E. DEVELOPMENT OF SELECTION, CARE AND MAINTENANCE GUIDES**

User-friendly decision aid systems, and selection, care and maintenance (SCAM) guides will be published to provide guidance to the users. By design and necessity, the standards and test protocols are very technical. This is to ensure that reproducible test results can be obtained at different test sites. The SCAM guides provide important information to the user on the appropriate uses and limitations of the equipment, selection guidelines, maintenance and decontamination guidelines, and other critical information. These guides, in most cases, will be developed by the agency that is developing the standard and test protocols, in conjunction with the standards development.

**FY2003 DELIVERABLES:** SBCCOM and other collaborating/contributing agencies and organizations will produce and deliver quarterly progress reports to OLES. Participation and contribution to interagency working groups and Standards Developing Organizations.

#### **F. DEVELOPMENT OF CBRNE PROTECTIVE EQUIPMENT TESTING PROGRAM AND LABORATORY CERTIFICATION**

The purpose of this task 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 CBRNE 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; e.g., NIOSH will administer the respiratory protection equipment standards. 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 CBRNE 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.

A new element to this task in FY03 is to facilitate the expansion of the live chemical warfare agent testing program through upgrading the testing capabilities at other sites.

**FY2003 DELIVERABLES:** Project milestone updates, staffing and coordination of procedures for equipment certification programs and test laboratory certification.

## **G. SUPPORT OF DOMESTIC PREPAREDNESS PROGRAMS**

The goal of this task is to provide program management; and 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.

OLES is the executive agent for the IAB, responsible for implementing the national suite of responder CBRNE equipment standards. OLES's efforts were instrumental in the IAB adoption of the first six standards in the National Suite in September 2002.

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) canvas 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 organizations 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 CBRNE 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; 10) maintain pertinent agreements, standards and guides to include review and updates; and 11) coordinate efforts with the Department of Homeland Security.

**FY2003 DELIVERABLES:** Interagency agreements, project milestone updates, staffing and coordination of draft standards/guides, and promulgation of approved standards and guides.

## **DEVELOPMENT OF CBRNE PROTECTION AND COMMUNICATION EQUIPMENT GUIDES FOR EMERGENCY FIRST RESPONDERS**

### **GOALS**

The goal of this project is to develop chemical, biological, radiological, nuclear and explosives (CBRNE) protection equipment communication equipment guides for emergency first responders. The currently published equipment guides include chemical agent and toxic industrial material detection, biological detection, communications, personal protective equipment, and decontamination equipment. OLES has established interagency agreements with the National Institute of Occupational Safety and Health (NIOSH) and the U.S. Army Soldier and Biological 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.

### **CUSTOMER NEEDS**

The guides will focus on CBRNE agent protection equipment in areas of detection, personal protection, decontamination, and communication. The purpose of these guides is to provide CBRNE equipment information to the emergency first responder community when evaluating and purchasing CBRNE 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 CBRNE equipment grants funding from the U.S. Department of Justice's Office for Domestic Preparedness (ODP).

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 CBRNE defense. In recognizing the needs of state and local emergency first responders, NIST, supported by NIJ, TSWG, SBCCOM, and the IAB's Standards Coordination Committee, developed the first set of CBRNE defense equipment guides. The guides focused on

CB equipment in areas of detection, personal protection, decontamination, and communication. The purpose of these guides is to provide CBRNE equipment information to the emergency first responder community when evaluating and purchasing CBRNE 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 for Domestic Preparedness.

## **TECHNICAL STRATEGY**

The initial editions of the guides have been completed, and have been published and issued as NIJ Guides. 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.

This year the plan is to revise the chemical/biological detection equipment guide, develop and publish a new radiological detection equipment guide, and begin the work to revise and update NIJ Guide 100-99 on explosives detection equipment.

**FY2003 DELIVERABLES:** Drafts and final versions (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).

## **THE EFFECTS OF IONIZING RADIATION USED IN MAIL STERILIZATION ON MICROELECTRONIC DEVICES**

### **GOALS**

To investigate the impact of mail sterilization using electron beam irradiation on the functionality and performance of microelectronic devices.

## **CUSTOMER NEEDS**

The U.S. Postal Service has decided to use a sterilization process using electron beam irradiation to destroy possible contamination with anthrax spores. The typical dose used in the process can exceed 70 kGy. Smart cards, including debit and pay cards, use standard silicon integrated circuit (IC) technology similar to that used in personal computers and consumer electronics. This dose has already been shown to destroy the functionality of "smart cards" with embedded microchips used by many banking institutions. It is also expected that such a dose will destroy or seriously degrade the functionality of other electronic devices sent through the mail system. Initial studies suggest that magnetic stripe cards may be unaffected. Manufacturers of electronic products are now faced with the prospect of finding another way to deliver their products. For many of the products, the dose at which devices fail is not known. Furthermore, it is not known whether design or process changes could be implemented in the products to "harden" the electronics to withstand the sterilization process.

Smart cards are only one part of a larger problem. Personal computers and consumer electronics if subjected to the same sterilization process will also become inoperable. This proposal will only address the IC technology used in smart cards, but the results could be used to assess the vulnerability of other consumer electronics products.

## **TECHNICAL STRATEGY**

The first step of the project is to determine the maximum permissible dose that the electronics in smart cards can tolerate before failure. This step can be performed in collaboration with the manufacturers of the smart card electronics, the manufacturer of the sterilization equipment, and the U.S. Postal Service. Sample test cards or chips can be obtained from the manufacturers and subjected to increasing doses of ionization radiation at the manufacturer of the sterilization equipment or at NIST using gamma irradiation. The NIST irradiation facilities will be used if detailed studies need to be conducted that cannot be accomplished by the manufacturer of the sterilization equipment. If needed, the effects of the e-beam irradiation will be correlated to the effects of gamma irradiation using NIST supplied microelectronic samples. The cards could be returned to the manufacturers or to NIST for functional testing. The results of this first phase is important to determine if some chips will survive the minimum dose required to kill anthrax spores.

The second step is to assess the effects of increasing levels of ionizing radiation on individual devices that comprise the chips in smart cards. This could be accomplished by using test chips supplied by the chip manufactures. Results will point to specific areas in the microchip that are most vulnerable to parameter drift and failure. Information from this phase of the project could be used by the manufacturers to implement design changes in the architecture of the chip to harden the chip against the dose levels determined to kill anthrax spores. Such design changes would provide a long-term solution.

**FY2003 DELIVERABLES:** Smart card chip survival data as a function of dose level for e-beam and gamma irradiation. Correlation study between e-beam irradiation effects and gamma irradiation if needed. Device parameters, such as the parameters that characterize the operation microelectronic transistors, drift as a function of radiation dose. Experimental data for field oxide and inter-layer dielectric charging.

## ACCOMPLISHMENTS

■ ***Guides for First Responders*** – A series of first responder equipment guides was developed by OLES and published by the National Institute of Justice (NIJ). These guides provide comprehensive listings of personal protective equipment, chemical and biological detection equipment, chemical and biological agent decontamination equipment and emergency first responder communication equipment. These guides have been published in hard copy format, and are available for download from the NIJ website: <http://virlib.ncjrs.org/LawEnforcement.asp>. They guides will also be issued in a user friendly electronically searchable CD-ROM.

■ ***CBRNE Protective Equipment Standards*** – A number of key milestones were achieved in the NIJ-funded program to develop CBRNE (chemical, biological, radiological, nuclear, and explosive) protective equipment standards for emergency first responders. The first standard, for the certification of Self Contained Breathing Apparatus (SCBA) in a CBRN environment, was implemented by the National Institute for Occupational Safety and Health (NIOSH) and equipment certification testing has begun. This effort was funded by NIJ, with the program managed by OLES, and accomplished by NIOSH in conjunction with the U.S. Army Soldier and Biological Chemical Command. Additional milestones included the publication of a detailed threat analysis to support the development of these standards, and a comprehensive re-

view of international and other standards relating to CBRNE protective equipment.

## PUBLICATIONS

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

NIJ Guide 102-00, October 2001, “Guide for the Selection of Personal Protection Equipment for Emergency First responders.”

NIJ Guide 103-00, October 2001, “Guide for the Selection of Chemical and Biological Decontamination Equipment for Emergency First Responders.”

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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