# Concealed Weapon and Contraband Detection, Locating, and Imaging



Detection, Inspection, and Enforcement

## 1. Concealed Weapon and Contraband Detecting, Locating, and Imaging

OLES presently has two activities related to traditional metal detector devices and additional activities that support other technologies used for detection of concealed objects. These other activities include two passive imaging systems, one directed to short stand-off (1 m to 5 m) imaging in both indoor and outdoor environments and with sufficient thermal resolution to allow rapid acquisition rates (> 20 frames/s), and the other dedicated to long standoff (to 100 m) for suicide bomber detection. The intent of both these systems is to use them to develop minimum performance specifications for commercial and in-development systems, a test bed for evaluation of these systems, and to perform phenomenological studies to understand what is necessary in system design to optimize imaging performance. Both systems use cyro-cooled detector technology, which has become a commercially-viable solution in the last few years because of the development of related medical imaging technology. The short stand-off system uses standard silicon technology thereby significantly reducing the cost of the arrays relative to presently-available indium-phosphide-based detectors and associated low-noise amplifiers. The long stand-off system will leverage the now-mature and reliable technology developed by NIST for astronomical research.

In early 2006, OLES continued its development of metrology as related to detection of dangerous materials by starting an activity directed to rapid and accurate identification of dangerous liquids using microwave techniques. Basically, we are looking at the microwave electromagnetic signatures of liquids to determine if they lend themselves to a go/no-go decision making capability.

Development and improvement of the National Institute of Justice's(NIJ's) metal detector standards has been a mainstay of OLES work. OLES continues to improves the NIJ standards for walk-through and hand-held metal detectors. Three current projects are focused on testing and improving the capabilities of current walk-through metal detectors (WTMDs) and handheld metal detectors (HHMDs). The latest revision of HHMD standard, NIJ Std-0602, was completed in 2006. This revision updated the requirements and improved one of the test methods. The next step is to establish an NIJ test and evaluation program for this standard. The WTMD standard is also being revised. The changes will include updating the requirements, as was done with the HHMD standard, and revising several test procedures bearing in mind the cost of test cannot be prohibitively expensive. One issue, common to both HHMD and WTMD testing, is the materials used to fabricate the test objects. Although the geometry and material specifications are accurately defined, this does not guarantee the electromagnetic properties of the test objects are reproducible, which is important for device assessment. Consequently, we are testing a sample of metals to get mean values and lot-to-lot and between-manufacturer variations for the appropriate electromagnetic properties. In addition, human phantoms will be developed to emulate the electromagnetic properties of humans, thereby removing the last nonquantitative test from the standards.

### 1.1 NIJ Standard-0601.02, "Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection"

Figure 1. Walk-through metal detector in use at controlled entry checkpoint.

## Goals

> *To continue improving the latest revision of the Walk-Through Metal Detector (WTMD) performance standard and provide technical assistance in the establishment of the NIJ Compliance Testing Program.*

## Customer Needs

> *Increasing attention is being given to checkpoint security, and great confidence is placed in walkthrough metal detectors to detect items that might pose a threat to public safety. Routinely, one can find WTMDs being used to screen correctional facility populations and their visitors, as well as to screen people for admission to airport terminals, courthouses, schools, sports stadiums, amusement parks, and political events, and this is only a partial list. It is essential for the WTMD to be adjusted properly to sense the types of threat objects of interest, and that it performs this detection function accurately and reliably. The WTMD performance standard fills an important void in that it is the only reference developed specifically for these products that ties together many important performance requirements (detection performance, electrical and exposure safety, electromagnetic compatibility, and environmental resistance).*
>
> *Historically, WTMD manufacturers were not compelled to design their products to meet a broad array of performance requirements, but rather only a subset of requirements to meet basic electrical safety and perhaps electromagnetic emissions requirements. In consultation with a group of industry, users, and government representatives, OLES developed what has now become the current version of the NIJ "Walk-Through Metal Detector" performance standard, NIJ Standard.0601.02. A formal WTMD Compliance Testing Program based on this standard was initiated in mid-FY2002 and completed in FY2003. NIST worked closely with the National Law Enforcement and Corrections Technology Center (NLECTC) and a commercial test laboratory to implement the WTMD Compliance Testing Program, through which several models of commercially available WTMDs were tested. This test program has proven very valuable, both in terms of generating data on products of interest and in terms of pinpointing areas in the standard that could be improved further. Comments and suggestions for further improvements to the standard were, and continue to be, collected from industry.*
>
> *Since the first series of tests under the Compliance Testing Program, numerous requests have been made by manufacturers and procurement authorities to have units tested against the standard. Presently there are no commercial laboratories recognized by NIJ to do this. This project will start on the next revision of the standard and provide the technical support needed to implement an ongoing Compliance Testing Program.*

## Technical Strategy

- Provide technical support to NIJ and the NLECTC, which will administer the Compliance Testing Program, for re-establishing the testing program.
- Revise standard, including the following: 1) revise test procedures; 2) update references to other standards; and 3) revise performance requirements.
- Publish the new test objects document that includes fabrication details for the test object, materials of construction, and required test orientations.

### Deliverables

- Revised standard
- Separate test objects document
- Administrative manual for test program
- Compliance test report form

## 1.2 NIJ Standard–0602.02, "Handheld Metal Detectors for Use in Concealed Weapon and Contraband Detection"

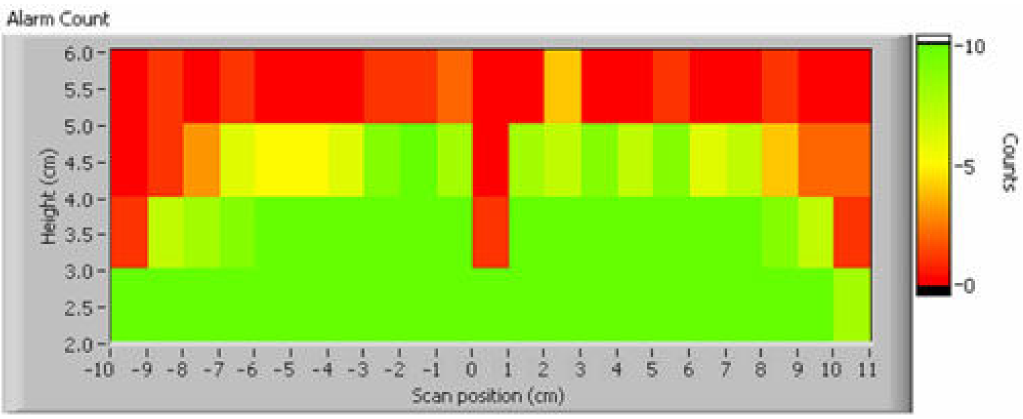
Figure 2. Officer using a handheld metal detector to find weapons concealed on suspect.

### Goals

> *To implement the latest revision of the Hand-Held Metal Detector (HHMD) performance standard, and provide technical assistance to the NIJ's Compliance Testing Program.*

### Customer Needs

> *Hand-held metal detectors are often used to supplement the interrogation provided by walk-through metal detectors (WTMDs), especially if the WTMD gives a positive alarm. The HHMD allows the security screener to pinpoint areas of primary concern and to inspect them more closely to detect items that might pose a threat to public safety. These devices are found nearly everywhere that WTMDs are found, and they are often the last inspection devices used to screen someone; therefore, it is critical that they perform their intended function accurately and reliably. As is the case with WTMDs, manufacturers of HHMDs were not compelled to design their products to meet a broad array of performance requirements, but this standard and a coordinated Compliance Testing Program will fill that void.*




> *Figure 3. Detection performance of a hand-held metal detector (HHMD). The figure shows the alarm map for a given model of HHMD, a given test object with a given orientation, and for 10 passes by the HHMD.*

> *In consultation with a group of industry, users, and government representatives, OLES has developed a draft revision of the NIJ "Hand-Held Metal Detector" performance standard, which will be NIJ Standard–0602.03. Both manufacturers and users have requested establishment of a sustainable test program through which HHMD performance can be certified. A formal Compliance Testing Program based on this standard has not been initiated.*
>
> *With the new revision of the standard and the establishment of a Compliance Testing Program, manufacturers will be able to assess their designs against the full array of performance requirements, make adjustments to improve their designs to address vulnerabilities that might be exposed during testing, and allow users of HHMDs to purchase compliant products with confidence. The standard has been used by quality manufacturers as a developmental aid to achieve improved HHMD performance. The current activities of this project are to publish the draft revision of the NIJ standard and to provide the technical support required to implement an ongoing Compliance Testing Program.*

### Technical Strategy

- Provide technical support to NIJ and NLECTC, which will administer the Compliance Testing Program. Assist in identification of laboratories that can conduct the tests in the standard and work closely with NLECTC to implement the HHMD Compliance Testing Program.
- Publish the new test objects document that includes fabrication details for the test object, materials of construction, and required test orientations.

### Deliverables

- Revised standard.
- Test objects document.
- Administrative manual for test program.
- Compliance test report form.

## 1.3 User Facility for Metal Detector Testing

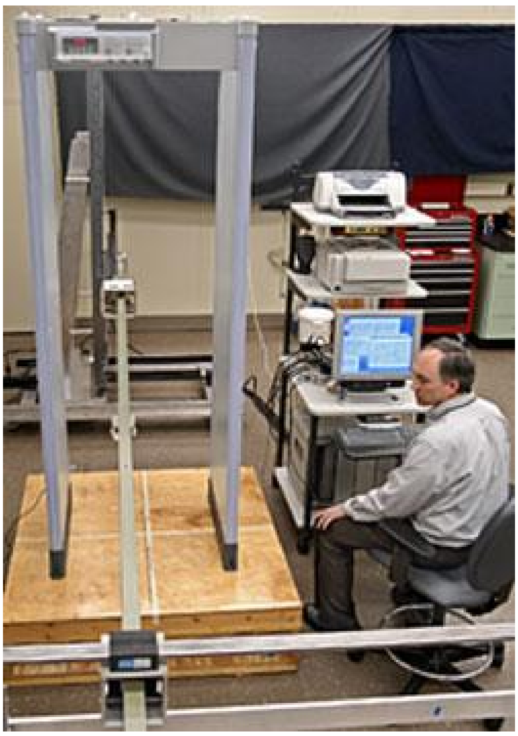


Figure 4. OLES robotic system being used to test the performance of a walk-through metal detector.

### Goals

> *To make improvements to the robot used for WTMD and HHMD performance tests and to its human interface.*

### Customer Needs

> *Many agencies have unique and sometimes proprietary requirements for metal detectors. Consequently, it is not possible to put all of these requirements into a common minimum performance standard, such as those developed by the NIJ. Moreover, not many agencies have the budget nor the measurement expertise required to develop an appropriate test facility. The OLES metal detector test facility*

> *provides these other agencies with a tool they can use to evaluate metal detectors for their agency specific requirements.*

### Technical Strategy

- Modify the OLES robot. Of special interest is the addition of hardware to minimize test object bounce and to improve positional accuracy.
- Implement software modifications to improve the measurement process
- Introduce additional features in the user interface to provide options for selection of test procedures and type of data acquired.

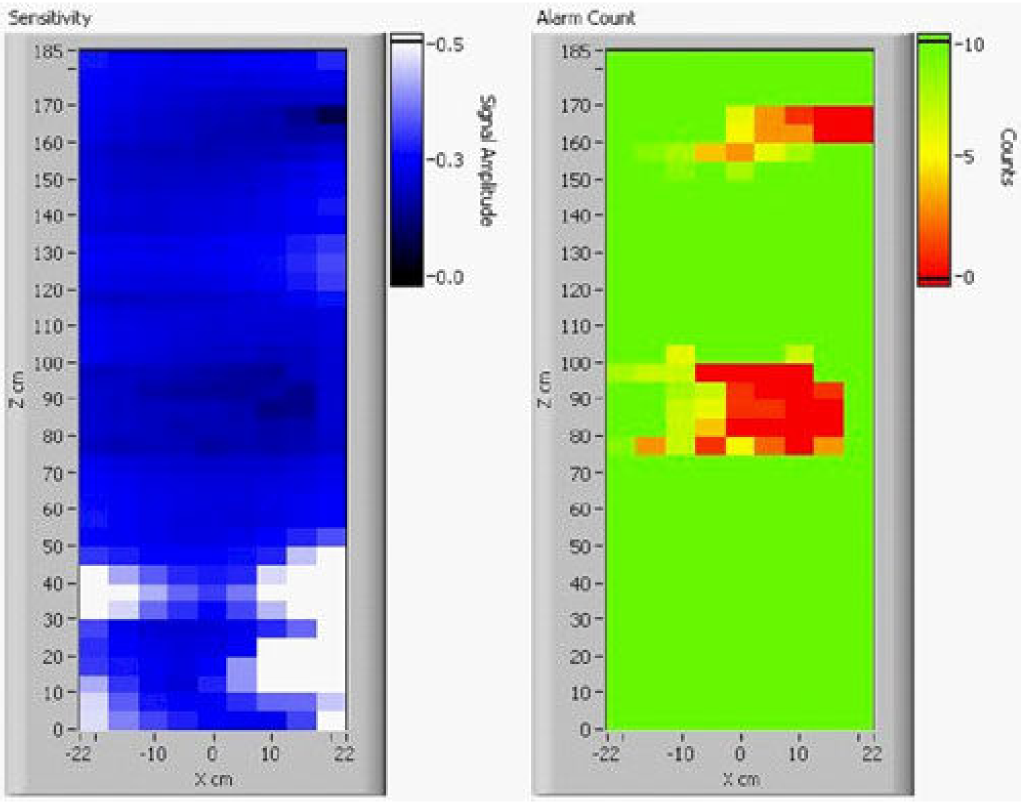



Figure 5. Detection performance of a walk-through metal detector (WTMD). On the left is a representative detection sensitivity map, taken using the OLES measurement system, for a hypothetical WTMD and a given test object with a given orientation. On the right is the alarm map for the same conditions as for the detection sensitivity map, for a given signal amplitude threshold, and for 10 passes through the WTMD.

### Deliverables

- Implemented change in robot design.
- Additional software to introduce improvements to measurement process and user interface.

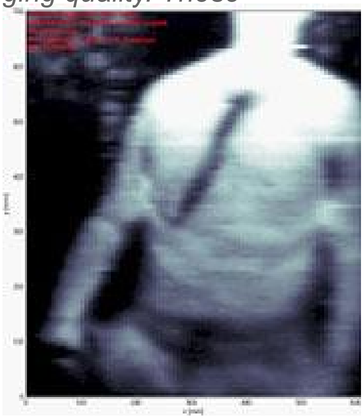
## 1.4 Concealed Weapon and Contraband Imaging

Figure 6. Millimeter-wave image of a person with a ceramic knife concealed under a jacket.

### Goals

> *To develop reference imaging systems that can be used to 1) develop the metrology to support characterization of the performance of these types of imaging systems and 2) develop greater*

> *phenomenological understanding of system performance parameters on imaging quality. These reference systems will focus on imaging concealed objects under clothing at distances from 1 m to 100 m.*



### Customer Needs

> *Law enforcement and military personnel require the ability to identity suicide bombers at long stand-off distances (to 100 m) and smaller weapons (handguns and knives) at shorter stand-off distances (1 m to 5 m).*

### Technical Strategy

> *Develop a real-time (>20 frames/s) imaging system that can be used to detect large concealed objects for identifying suicide bombers at distances up to 100 m. The imaging will use a staring array developed by NIST for astronomical research over that last couple decades.*
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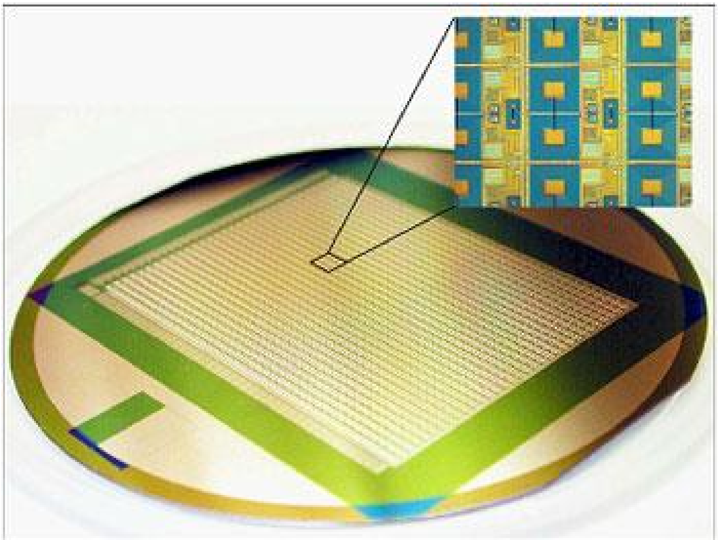
> 
>
> *Figure 7. Wafer-scale array of millimeter-wave sensors.*

### Deliverables

- Assembled optical subsystem.
- Assembled cryo-head subsystem.

## 1.5 Microwave Identification of Dangerous Liquids

### Goals

> *To determine the feasibility of using microwave electromagnetic signatures of dangerous liquids to determine if these signatures lend themselves to a go/no-go decision making capability. Dangerous liquids are liquids, including mixtures or precursors, that can be explosive, flammable, toxic, noxious, caustic, or reactive.*

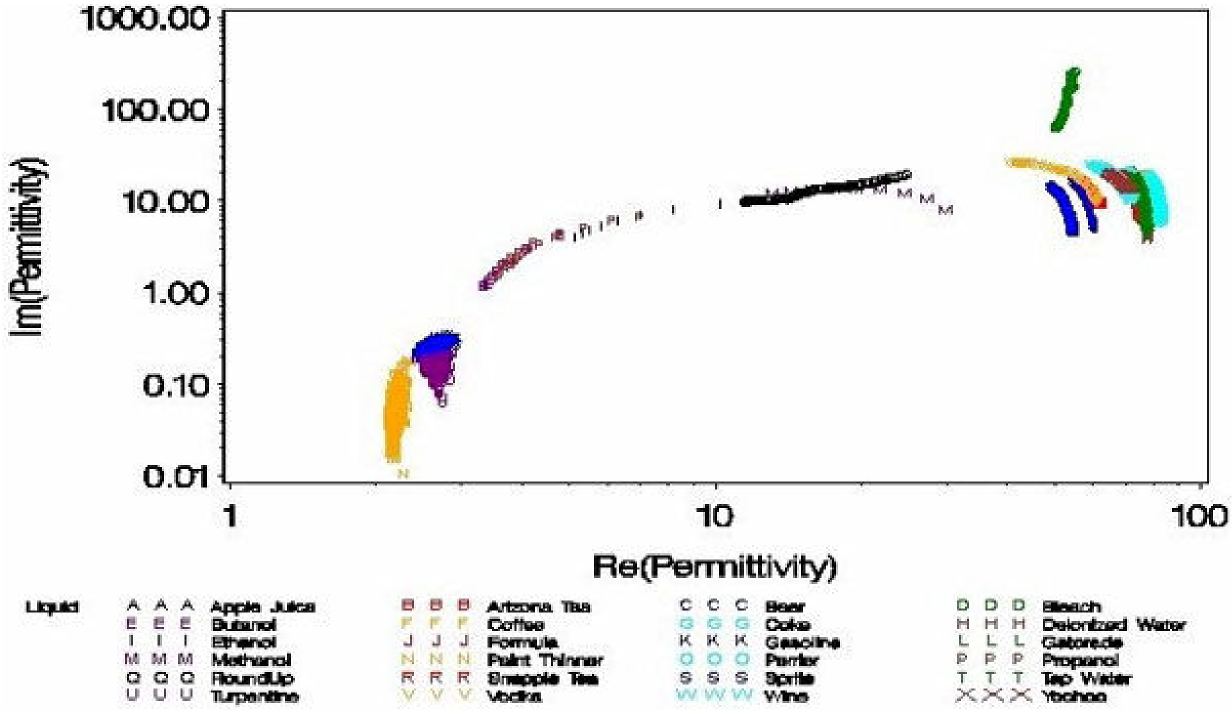



*Figure 8. A plot of the imaginary vs real part of the dielectric permittivity of various liquids measured at different frequencies.*

### Customer Needs

*As has become apparent in the past year, the ability to identify dangerous liquids is important to public safety. Although most threats and associated responses thus far have been associated with air transportation, it will likely not take long for these types of threats to reach the general public. As with air transportation safety, the ability to recognize potential threats and respond immediately and appropriately is of paramount importance.*

*Figure 9. Measurement system used to determine dielectric properties of liquids.*

### Technical Strategy

- Examine the microwave signatures, such as the frequency-dependent complex permittivity and frequency-dependent dielectric relaxation, of liquids to determine if they can be used to classify liquids as dangerous.
- Examine the effects of temperature on the accuracy and efficacy of the identified classification scheme.
- Examine the effects of mixtures of dangerous and innocuous liquids, such as alcohols and water, on the efficacy and accuracy of the identified classification scheme.
- Design of measurement instrument.

### Deliverables

- Identification of microwave signatures that can be used to identify dangerous liquids.

- Understanding of the effects that may impact the accuracy and efficacy of using these microwave signatures to identify dangerous liquids. .