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TRACER DETECTION TECHNOLOGY CORP.

DETECTORS, SENSORS & TRACER SYSTEMS

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FINAL REPORT

Grant # 1999-LT-VX-K008
(Grant Period: 6/01/99 to 4/30/00)

"Demonstration of the Use of an Encapsulated Perfluorocarbon Vapor Taggant to Track and Detect Currency or Contraband

"Supported under Award Number (# 1999-LT-VX-K008) from the Office of Justice Programs, National Institute of Justice, Department of Justice. Points of view in this document are those of the author(s) and do not necessarily represent the official position of the U.S. Department of Justice."

OVERVIEW

In June 1999, Tracer Detection Technology Corp. (Tracer) was awarded a grant from the National Institute of Justice for the purpose of conducting a demonstration of the use of an encapsulated perfluorocarbon tracer taggant with the work being performed at Oak Ridge National Laboratory (Tracer and ORNL are referred to herein as the Project Team). The objective of this demonstration was to mark and then identify the existence and location of a "tagged" (or marked) source. The following provides the Final Report for Grant # 1999-LT-VX-K008 (Grant Period: 6/01/99 to 4/30/00), "Demonstration of the Use of an Encapsulated Perfluorocarbon Vapor Taggant to Track and Detect Currency or Contraband."

Appended hereto is the Technical Report provided by Oak Ridge National Laboratory, which conducted work under a Cooperative Research and Development Agreement with Tracer Detection Technology Corp. A reconciliation of the budget is also provided.

BACKGROUND:

Perfluorocarbon tracers (PFT) are safe, volatile, non-reactive, environmentally benign compounds. The ambient background concentrations of the five routinely used PFTs are in the range of parts per 10^{15} of air. The perfluorocarbon tracer technology, by virtue of its high vapor pressure provides the unique ability to permeate closed doors and windows, containers and luggage, yet is impervious to electronic interference and other problems inherent with tagging technologies. Once a location reaches steady state, an actively emitting tagged item should provide vapor traces that are detectable in the vicinity of the item (even temporarily following removal of the tagged item). By extending the detectable life of the PFT taggant materials, this program is expected to provide a unique tool for law enforcement in numerous applications including non-invasive inspection of locations and cargo under surveillance. Longer-term, it is expected that the ability to mix several compositions of PFTs and then selectively detect such mixed compositions will allow several intelligence scenarios to be conducted concurrently without cross-operational interference or contamination (an important evidentiary consideration). It is also possible to postulate applications for future encapsulated PFTs, in which tracer release is intelligently initiated either by the presence of the contraband itself, or when an item has been tampered with.

Highly sensitive laboratory analysis devices like a gas chromatography enhanced with electron capture detectors (ECD) or a Direct Sampling Ion Trap Mass Spectrometer are currently the preferred detection methods for PFTs. However, drawbacks of these devices are:

- severe instability if placed in contact with a burst of PFT vapors
- limited ability to be used in field operations where size, weight, portability and fast response times are critical issues.

SUMMARY OF DEMONSTRATION PROPOSAL

Project Goals and Objectives

The longer-term objective of Tracer Detection Technology Corp. is to develop a Chemical Tracing and Detection system for application in law enforcement and corrections, that are field tested, manufacturable and defensible under the judicial system. The purpose of this demonstration effort was to provide qualitative data documenting the characteristics of existing encapsulated Perfluorocarbon tracer (PFT) formulations. The results reported herein serve as a baseline for anticipated, subsequent scientific review and further research, and for the detailed design of perfected formulations under subsequently funded programs.

Research Design and Methodology

Preliminary work on encapsulated perfluorocarbon taggants had been performed both by Tracer Detection Technology (see Discussion of Historical Perspective) and at Oak Ridge National Laboratory. This previous work served as the basis of the work conducted under this demonstration program. As shown in the attached Technical Report, the stability and durability of a delayed release of the chemical vapor taggants, as well as accurate measurement of its duration were performed. Additionally, the Project Team believes that this demonstration effort will lead to the identification and understanding of the scientific methods that will be used in a more extensive development effort in follow-on funded programs, and a better definition of taggant scenario requirements for subsequent development and eventual deployment by law enforcement.

Project Goal

The goal of this program was to demonstrate that a delayed release perfluorocarbon taggant could be used in key law enforcement applications. It was expected that the principal challenge was to document stability and durability of a delayed release of the chemical vapor taggants and to accurately measure its duration. Secondarily, we planned to begin outlining and identifying encapsulation strategies and methodologies for longer-term delayed release; i.e., determining the relationship between delayed release duration, detectable release rates and range of detection (i.e., distance from the "source").

Objectives

As a precursor to the anticipated full-scale development of a deployable, turn-key system, the Project Team planned to perform a formal demonstration of the ability to achieve stable, delayed release of the PFT vapor taggant. The demonstration involved the tagging of a source (i.e., an amount of currency that might be used in an illegal transaction of kidnapping/ransom scenario) and then, the detection and identification of the source at a different location.

Overview of Proposed Chemical Encapsulation Research Program

The work conducted under this demonstration program built upon the developments already achieved by both Tracer Detection Technology Corp. and Oak Ridge National Laboratory.

The technical foundation for the work conducted under this demonstration comes from the extensive body of literature dealing with molecular recognition/complexation, sorbent technology and microencapsulation. The previously completed demonstrations by Tracer Technology Corp., employing a perfluorocarbon-impregnated β-cyclodextrin provides the starting point for investigating 1:1 molecular complexes for controlled tracer release. Tracer chemical release time profiles will be determined for perfluoromethylcyclohexane complexes with different cyclodextrins and related "molecular pockets." Similarly, the release of structurally related perfluorocarbon tracers (i.e. perfluoro-1,3-dimethylcyclohexane, perfluorobenzene, etc.) will also be examined to ascertain relationships between tracer and host molecular structures. The ultimate goal remains to achieve controlled tracer release rates through the understanding and manipulation of tracer/host molecular chemical interactions, with a minimum detectable life of 30 days.

Workplan
The purpose of the demonstration was to show how an encapsulated PFT taggant formulation could be used in a controlled field demonstration. During this demonstration effort, investigation and identification of a range of potential law enforcement applications, and the formulation implications of these applications, was also conducted. The proposed Technical Development Plan was as follows.

In preparation for the demonstration of the perfluorocarbon tagging technology, several preliminary experiments were conducted to characterize the four perfluorocarbons that were utilized in these tests; perfluorocyclohexane (PFCH), perfluoro(methyl)cyclohexane (PMCH), perfluoro-1,3-dimethylcyclohexane (PF-1,3-DMCH) and perfluoro(methyl)decalin (PFMD). Experiments to measure the emission rates and stability of the materials in both a wax paraffin and cyclodextrin based formulation were conducted. This work is detailed in the Technical Report provided by Oak Ridge National Laboratory that is appended hereto.

Each of the resulting formulations was then evaluated for applicability in a range of anticipated law enforcement scenarios.

OVERALL CONCLUSIONS
The following summarizes the conclusions of the demonstration testing performed by the Oak Ridge National Laboratory, Chemical and Analytical Sciences Division (CASD). Tracer Detection Technology Corp., the National Security Program Office at ORNL, a representative from the City of Knoxville Police Department, the National Institute of Justice, the National Law Enforcement Technology Commercialization Center, the Department of Defense Counternarcotic Technology Assessment Center, and the F.B.I. all attended the demonstration.

Four perfluorocarbons were used in the preliminary experiments; perfluoro(methylcyclohexane) (PMCH), perfluoro-1,3-dimethylcyclohexane (PDMCH), perfluorocyclohexane (PCH) and perfluoro(methyl) decalin (PFMD), representing a range of boiling points between 51°C and 160°C. These were tested for vapor detectability by Direct Sampling Ion Trap Mass Spectrometry (DSITMS) under selected tagging scenarios.

These materials were selected from a larger group of compounds known as perfluorocarbons, because of their amenability to encapsulation in wax crayon and β-cyclodextrin materials which were used to moderate the evaporation rates of the perfluorocarbon. It is noted that many perfluorocarbons are used in environmental and medical applications, even though it is known that some are retained in the human body for certain periods of time. All tests were performed at ambient temperature.

Scenarios included postal tracing, document identification, covert currency marking and associated perpetrator tagging, locker storage detection, and portal (or "chokepoint") detection of luggage, parcels, and containers sealed for shipping. For these tests, selected perfluorocarbons were incorporated into beeswax crayons, β-cyclodextrin complexes, and ink-jet ink as differing marking, dusting and/or other tagging vehicles.

Detection of perfluorocarbon vapor from a bulk chemical solvent tagged at trace levels was also demonstrated. CASD has further performed a toxicity review of perfluorocarbons, which is included in the attached Technical Report.

Results and Conclusions:

1. DSITMS non-invasively detected evaporated perfluorocarbon taggant in every case, also correctly identifying containers carrying marked contents in blind non-invasive testing of multiple containers. DSITMS is sensitive in real-time detection of air samples to low ppbv or upper pptv concentrations of the perfluorocarbons tested.

2. In persistence tests, perfluorocarbon formulations were identified showing a vapor emission half-life of up to ¾ h for wax crayon markings, to of the order of months for tagged ink-jet print. The data presented in the attached Technical Report from Oak Ridge National Laboratory also shows that the wax crayons at 13% perfluorocarbon (w/w) showed no detectable weight loss after month long open-air storage.

3. There was no interference to detection of perfluorocarbon or any masking by the presence of a bulk organic chemical (acetone). Because of the mass spectroscopy signature of perfluorocarbons, it is highly unlikely that a perfluorocarbon signature can be successfully masked by other chemical compounds.

4. A review of toxicity literature revealed that perfluorocarbons have achieved widespread success in human medicine for blood volume augmentation; and eye pressure maintenance during surgery. After weeks of internal eye exposure due to direct medical injection, local irritation has been recorded in some cases, but reversible upon removal of the perfluorocarbon. It was confirmed that where Material Safety Data Sheets (MSDS) documents are available for perfluorocarbons, they are assigned the lowest (*i.e.* safest) chemical rating.

   In animal studies, perfluorocarbons have been found chemically stable, inert, and non-metabolized. They sequester in the fat and liver, and are gradually eliminated by exhalation.

5. It is concluded from these tagging experiments that perfluorocarbons are a practical, covert means of tracing goods and individuals, posing no expected health hazards. It is also expected that effective half-life in a given application can be moderated according to methods utilized in packaging, as may be employed.

6. It is expected that directions for further development may productively include examining a variety of additional perfluorocarbon/carrier formulations for a wider-range of half-life properties, examining materials which may lead to stimulated release of primary or secondary taggant on command (e.g. use of light or sound at a particular wavelength), and/or carriers which degrade predictably.

7. It is recommended that testing be performed to confirm levels and persistence of tracking signal from tagged motor vehicles. Tagging may be via passenger compartments, body, exhaust and/or engine components. Characterization of combustion or other reaction products arising from such application should be performed in the laboratory, for tracking purposes together with toxicity evaluation.

IMPLICATIONS of the DEMONSTRATION

1. Detection Methods/Technologies

All detection for this demonstration was done in real time. It is clear that depending on the application scenario, there are a number of short and longer-term detection technologies available (or to be developed).

a. Contact, close proximity, choke-point

A DSITMS or a gas chromatograph with an electron capture detector (GC/ECD) are now available for close range detection (i.e., yards). It should be noted that while derived from Tracer's experience in Mexico and not in this NIJ funded demonstration, a trace of the PFT was detected from street to building (approximately 100 feet) using a GC/ECD. Further, each of these detection methods are capable of entering an environment in which a perfluorocarbon source has been placed, and detect its presence.

During the course of the demonstration, it was discussed that certain sensors that are currently available within the law enforcement arsenal might be capable of selectively detecting the PFT taggant. Specifically:

- use of an Ion Mobility Mass Spectrometer (subject to confirmation by the F.B.I.)
- a commercially available portable version of a GC/ECD

Also, with some additional development we envision the use of a portable, suitcase-sized version of the DSITMS.

b. Non-Realtime Detection

Field sample collection with delayed laboratory analysis scenarios and field tests was discussed. This would involve the placement of absorbent capture sampling tubes at the site of suspected illegal activity, and the subsequent collection and analysis of the sampling tubes to confirm that a "tagged" source has been in that area. In work conducted by the U.S. Department of Energy (DoE), these capture sampling tubes have been used to measure air exchange between air-handling systems within a building, with PFT measurements at the ppb levels. Additionally, this DoE experience indicated an ability of these capture tubes to discriminate between different PFTs used in the same environment.

c. Possible Future Sensor Developments

Although Tracer is interested in the longer-term development of the Microcantilever sensor, a Micro-electronic machined device (MEMs chip) for close proximity and portable detection of the "taggant," it is considered more prudent to determine the appropriateness of other available detection technologies for these applications.

Within the national security area, it has been discussed that achieving longer-range detection capability is desired. Tracer indicated that a U.S. Patent # 6,025,200 covering the use of a range of light sources to detect the "taggant" was issued on February 15, 2000 and was subject to future funding and development. This is considered to be a longer-term development.

IMPLIED LAW ENFORCEMENT APPLICATIONS

Based on the results of the demonstration conducted at Oak Ridge National Laboratory, we see a number of possible applications. Some are possible with some "fine-tuning" of existing formulations, while others are only possible with additional funding and development.

a. **With "fine-tuning" of existing "taggant" formulations, using available detection technologies, the following applications could be implemented.**

Controlled mail delivery: Packages or envelopes can be marked with a "taggant" using either the wax paraffin crayon or volatile liquid coating form to permit tracking and identification of a "marked" piece of mail or packaging.

Intercepted Contraband: Similar to the description above, we can envision law enforcement marking a suspected package of contraband and being able to track and then identify the location of that package when it arrived at its destination or during its journey (i.e., pre-tagged drug cargo would emit detectable levels of PFTs from cargo holds or vents). This would allow agents to conduct a preliminary search of a suspected vessel by "sniffing" for localized sources of PFT emissions.

Currency of Illegal Transactions: Using the wax paraffin formulation, a quantity of currency being used by Law Enforcement in a "sting" operation (i.e., drug purchase) or money laundering operation; using existing detection methods, Law Enforcement could then track and/or locate the currency as proof of perpetrator involvement in the illegal activity or confirmation of the location in which the currency is being kept.

Kidnapping Money: Similarly, in kidnapping scenarios, law enforcement official will be able to determine the location of ransom money. Clearly, the surreptitious detection of the location of such money will enable the earlier (and more likely, safer) retrieval of kidnapping victims. Based on the successful demonstration of the F.B.I application, Tracer sees this and the money laundering application described above, as a natural extension of the work now being conducted (see discussion of Mexican Ransom Exchange activity).

Vehicle Tracking: Based on the demonstrated ability of PFTs (PFCH) to be mixed with acetone, it is possible to envision law enforcement coating the bumper or other part of a vehicle with an imperceptible (to the perpetrator) marker that would enable tracking and identification of the subject vehicle by the authorities.

Precursor Chemicals: Based on the demonstrated ability of PFTs (PFCH) to be mixed with acetone, it is possible to envision law enforcement selectively tagging a quantity of precursor chemicals suspected of future use in drug processing facilities. Law Enforcement would then be able to detect the emitted chemical signal from the street using available, semi-portable sensors.

b. **Subject to additional funding and development, the following applications are feasible.**

Confirmation/Identification of Clandestine Drug Labs: PFT taggants that react to the presence of another chemical (i.e. "off gasses" of drug processing, or refuming nitric acid) could be formulated in a paint that would be covertly used to cover the air vents of suspected processing facilities. When in contact with these known "off gasses" the encapsulated PFT material would be released in quantities

Identification of Airplanes and other transports involved in illegal activities: The objective would be to identify modes of transport that had been at a suspected clandestine location once they had returned to the U.S. This would entail the covert spraying or coating of a clandestine airfield or building surface with a PFT taggant that would adhere to the wheels of the vehicle and withstand the travel period back to the U.S.

In summary, the Project Team continues to anticipate that a turnkey system including a sensor for the detection of PFTs and that subject to additional funding, that a family of encapsulated PFTs in various forms can be developed. Generically, we see these possible product forms to include:

liquid/coatable forms for printing onto cash/currency used in illegal drug transactions and in money laundering or for use in marking other surfaces. This would be accomplished with by marking the currency with a wax paraffin-based encapsulated PFT directly onto the surface of the currency, or by printing a self-degrading liquid (i.e. similar to the acetone suspension using PFTs in the demonstration) onto the bills. The encapsulated PFT would permit the tracking of currency used in these transactions for measured period of time. Similarly, it is expected that by using the self-degrading form of encapsulated PFT, that a thin coating of "taggant" could be placed onto the surface of a vehicle under surveillance.

spray forms for the application of chemical vapor tags to vehicles or packaging. Using a self-degrading form, the PFT taggant would provide a constantly emitting vapor that would be trackable through densely populated areas.

powdered forms for the tagging of individuals or objects that would produce a constantly emitting vapor signal. Government or law enforcement agents would apply this "powder" form taggant covertly to suspects under surveillance and be able to track and detect these subjects as they moved about, both in the open and through check points.

"triggered" release taggants for use in applications where packages containing drugs or other illicit material could be tracked or identified by agents equipped with the "triggering" mechanism (i.e., acoustic or light "guns") that would activate and allow detection.

POTENTIAL FOLLOW-ON WORK

Pending subsequent funding, Tracer Detection Technology Corp. and Oak Ridge National Laboratory *would begin to*:

Formulations

- investigate the reproducibility for manufacturing and shelf-life of the crayon and cyclodextrin formulations under varying environmental conditions. The purpose of this work would be to understand and provide documentation of quality assurance issues for achieving judicial acceptance of evidence derived from this technology.

- develop a wider selection of formulations to facilitate field trials of this technology; improve encapsulation formulations to ensure greater stability and determine duration of detectable vapor emission.

- plan for field studies by understanding the stability of the formulation(s) under real life conditions and identify any possible chemical transformations that could occur when interacting with the environment or other materials.

Additional formulation related issues that will need to be addressed in subsequent funded programs are:

- the determination and analysis of products generated from PFTs in an internal combustion engine for possible application in monitoring the movement of vehicles; in the laboratory prior to field testing, determine the toxicity of these by-products

- investigate and then evaluate applications that make use of longer-term active or passive sampling (non-realtime, unattended monitoring with stimulated release formulations)

- determine the extent to which certain packaging materials may absorb and slow the release of the PFTs, and thus prolong the release of the vapor from the "tagged source." Conversely, other materials may serve as barriers to vapor release and thus negatively effect the detection of the vapor.

Detection/Sensors

Survey, evaluation and testing of currently available detection technologies and sensors to permit future work on application specific PFT-"taggant" formulations and companion detection methods.

Applications

Gain consensus across local, state and federal user groups on a common application platform (or group of related applications). The results of this survey would become the focus of subsequent, further development through appropriate sources of funding.

MANAGEMENT ACTIVITIES

During the course of this demonstration effort, Tracer Detection Technology Corp.:

- negotiated and finalized the Cooperative Research and Development Agreement under which this demonstration effort was performed.

- traveled to Oak Ridge National Laboratory on four separate occasions to work with the ORNL team

- traveled to Tampa, Florida to discuss and review this demonstration and expected follow-on research with representatives of the United States Strategic Operations Command

- were in contact with representatives of the F.B.I., ONDCP and local law enforcement agencies to determine appropriate demonstration scenarios.

- performed background research regarding the potential toxicity issues relating to the use of perfluorocarbon materials as taggants.

- worked directly with the scientists at ORNL to plan and finalize the demonstration scenarios.

PFT TECHNOLOGY: HISTORICAL PERSPECTIVE

In 1993, Tracer Detection Technology Corp. concluded that the PFT technique could form the basis of a unique, highly sensitive and precise tactical tool in the surveillance of illicit drug related activities, and in a range of other law enforcement applications. In November 1993, Tracer presented a paper at the Tactical Technologies and Wide Area Surveillance Symposium in Chicago, Illinois. Subsequently and as follow-up, a number of U.S. Law Enforcement Agencies (LEA) expressed interest in a proposed system to Tag and Detect Drugs, Crops, Chemical Compounds and Currency with Perfluorocarbon. Tracer Detection Technology is the sole licensee of U.S. Patent # 5,409,839 covering a "Method for the Tagging and Detection of Drugs, Crops, Chemical Compounds and Currency with Perfluorocarbon Tracers.

Although this and a subsequent real-life demonstration show the potential robustness and practicality of this technology for a range of possible PFT applications in law enforcement at the local, federal and international levels, it should be understood that neither were conducted with appropriate scientific controls, and are therefore, the results are only qualitative in nature.

However, based on these demonstrations and the one conducted under N.I.J. funding, it is likely that some limited use, real-life applications are currently feasible (using the current PFT formulations and available detection equipment).

A. DEMONSTRATION AT THE FBI

In May 1994, the Company was invited by the Federal Bureau of Investigations to perform a demonstration of one of the applications implied above in a letter that was received from Dr. Kenneth Nimich, Director, Forensic Sciences, F.B.I., Quantico, Va.

In September of 1995, Tracer conducted a proof of concept demonstration at the FBI training facility at Quantico, VA. that illustrated that the PFT technology could offer an important tool to enhance law enforcement's ability to track, monitor and detect items, people, and places under surveillance.

- the location of PFT-tagged currency within a specific room of a motel, was successfully determined by virtue of the tracer's unique emissions

- the PFT source was detected quickly (within 45 minutes of the start of the search)

Scope of Work Performed

A series of experiments and studies were completed leading to the ability to detect the existence of cash, tagged with PFT, within a designated facility at the room level. No "refined" solutions to the **delayed** emission of the PFT from the currency were shown at this stage.

1. Description of Pre-Demonstration Activities

"Scientific" Exploration

Among the encapsulation approaches explored was the use of a super absorbent material in combination with a membrane to form a pouch within the dollar bill through which the PFTs could be released. A range of potential materials was explored. For this demonstration, Tracer developed a rudimentary pouch. This conceptual implementation was composed of an amount of super absorbent material being sandwiched within the layers of a one dollar bill. This super absorbent material was then injected with 1 cc. of pure PFT (perfluoro-1,3-dimethlycyclohexane) as provided by the chemical manufacturer. No measurements of mass absorption of the PFT into the bill were performed. During the demonstration itself, nine such bills were interspersed with approximately 190 other bills (an estimated total of 10 cc. in the sample of approximately 200 one dollar bills).

Tracer conducted R&D on issues including dispersion rates, effects of air handling systems and temperature, as well as duration of sample release and time to achieve steady state were identified.

Conclusions From Testing Leading to the F.B.I. Demonstration
In July and August 1995, a series of experiments and studies were performed.

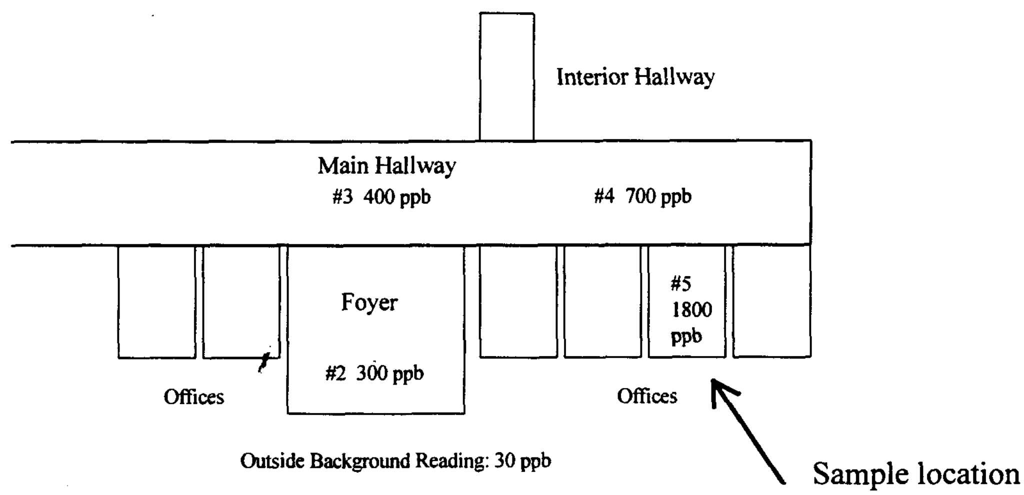
a. Rogers Hall, Polytechnic University, Brooklyn N.Y. (July 10 - September 1, 1995): These tests indicated that room ventilation has an appreciable effect on PFT dispersion rate and signal duration on the sensor. As expected, when the room was ventilated by an air conditioner, the PFT dispersed considerably faster than when the room air was still. This work also showed that outdoors, PFTs were immediately sniffable with the experimental device. Subsequent experiments involved placing a sample of PFT in a room previously unexposed to PFTs. During this test, Tracer was able to demonstrate the ability to follow a plume of PFT in an enclosed facility, and to identify a room in which the sample was placed. Additionally, it became clear that to determine the PFT concentration from within a room it was necessary to "suck" air from within the room into the sniffer using a tube under the door.

b. Dispersion Time Test: To gauge the length of life of the samples to be used the Quantico test, Tracer placed a single bill with a pouch (as described above) in a room, measured the initial concentration reading and then allowed the sample to stay overnight. The detector was left on automatic analysis, providing for a full course degradation of the PFT in the sample. Tracer determined that the concentration of the single dose (approximately 1 cc) of PFT in one bill degraded over a period of more than 4 hours until the concentration dropped below the ppb tolerances previously set.

c. Bassett Research Laboratory, Polytechnic University, Long Island (September 1995): In this experiment, a U.S. Mail bag containing five tagged bills and approximately 95 other bills was placed in an office at the Long Island campus of Polytechnic University. Prior to placing the sample in the office, a background reading was taken. A trace reading was found upon initial calibration and analysis in the office (approximately 4 ppb). Within ten minutes after placing the tagged bills inside the room, a probe was placed underneath the door of the office and reading of over 100 ppb (measured relative to the initial background level). This burst of PFT caused the column to become saturated. A period of three hours then elapsed during which Tracer ran the device on automatic analysis to clean the instrument column.

A background reading was then taken outside of the building that revealed a reading of approximately 30 ppb of PFTs detectable from outside of the building, as expected, since the entry doorway was active. The detector was then moved inside of the building to the inner foyer and received a reading over 300 ppb. The detector was then moved to a position at the top of the main hallway where a reading of 400 ppb showed that we were approaching the sample room. As the device was moved to a position outside of the subject room, a reading of 700 ppb was obtained. This concentration reading actually increased (to approx. 1200 ppb) when the door was inadvertently opened. When the device was placed inside of the room, a total concentration of over 1800 ppb was measured, confirming that the sample had been placed in that room.

Schematic of Experiment
Bassett Hall - September 7, 1995



d. Farmingdale Motor Lodge (September 14, 1995): On Thursday, September 14, 1995 the team went to a local motel (the Farmingdale Motor Lodge, Route 110 at Republic Airport). A sample of PFT-tagged currency (approximately 100 bills) was placed in a mailbag and then placed in a room. After waiting a period of one-half hour, background readings were taken from outside of the building, revealing minimal traces of PFT. This was attributed to the winds that day dispersing the PFTs. Readings were taken from the door seals, around the window and at the air conditioner vents. Each of these analyses confirmed that PFTs could be detected through various air vents from a subject room. Similar to the demonstration that followed at Quantico, the detector, a GC/ECD was placed on a cart to allow for greater mobility.

2. **Conduct and perform demonstration at the F.B.I. training facility in Quantico, Va.**
The project team arrived at the Quantico facility on Monday to set-up for the demonstration on the following day. During this "walk through" and in the subsequent re-calibration of the sensor, it was agreed that the device would be tuned for trace detection in the very small parts per billion. This greater sensitivity was to provide an ability to read escaping PFT traces from outside of the motel facility.

a. Preparation of Samples: Prior to conducting the demonstration and analyses discussed below, Tracer Detection Technology Corp. prepared a sample of PFT tagged currency. This tagging was achieved by injecting a measured amount of Perfluorocarbon into the absorbent material representing the "pouch" approach to delayed release. This preparation was done in the parking lot adjacent to the test site, and resulted in no contamination of the site itself. A total of nine specially prepared one dollar bills were included in the total sample of 200. The total PFT load was approximately 9 cc. Once the samples had been injected, the bills were placed within a U.S Mail bag. This in turn was placed within a plastic bag and tied off to limit diffused emissions of PFTs. The sample was taken by Dr. Fetterolf (F.B.I. Special Agent supervising the demonstration), and then placed within one of the motel rooms.

b. <u>Finding the Sample</u>: Prior to placing our sample within the subject room in the motel at Hogan's Alley, background readings were taken. All of the relative concentration readings were based on and are comparable to this first reading.

In the first sampling taken in the parking area, the background level of PFT was shown to be negligible, only 0.432 ppb. Background levels of PFT in Room 126 were also negligible, at only 1.25 ppb. Approximately 30 minutes following the placement of the sample in the room, a relative reading of "x" ppb was determined. A sample taken from outside of Room 126 showed 4.12 ppb.; a subsequent sample was taken from outside of Room 125. Comparing the results to the background reading of first sample, there was a considerable increase shown from in front of these rooms. As Rooms 125 and 126 were adjacent to each other, some cross-contamination of the sample was expected to have occurred. Another sample was taken from in front of Room 127. As no trace of PFT was detectable at that point it was concluded that no contamination in Room 127 had occurred (i.e., the sample was not in that room). It should be noted that Room 127 lies approximately 30-40 feet from Rooms 125 and 126.

A 10 second sample was taken from the door surface of Room 125. A reading of over 20 times the background resulted. A confirmation that the sample was in this room was received when a second sample of only one second duration was taken. This result showed a level of PFT more than 150 times that of the background following the placement of the sample bag into the room. We were also able to detect PFT levels 60 times that of the original background levels were detectable at the air-conditioning vent of Room 125.

Air samples obtained in Room 126, which is adjacent to the subject room, confirmed the location of the PFT tagged currency. In Room 126, the PFT concentration was approximately (ninety) 90 times the background levels previously established. This sample was taken inside of the adjacent room, and underneath the connecting door between the two rooms. It should be noted that the sample bag had been placed inside of the room by the F.B.I. The bag was hidden within a bureau drawer; a large wall mirror was placed on the floor in front of the bureau.

Following the successful test, Tracer team members met with a number of Government agency representatives to discuss applications of this technology. Based on discussions with Customs, there are a number of specific problems that could be addressed by utilizing this technique including money laundering.

MEXICAN KIDNAPPING

On Wednesday, March 25, 1998 Tracer (at 0940 hrs. EST.) was asked by the "Special Operations Team" (Ops Team) to participate in an operation to recover ransom money in a kidnapping in Central America. The son of a wealthy newspaper publisher had been kidnapped and had been held for one month prior to the operation in an unknown location.

The specific request was for the supply of chemical taggants (based on perfluorocarbon tracers -- PFTs) that would have an emitting life cycle of up to 48 hours, and for a detection method for same. Tracer supplied a cost estimate and promise of delivery on Thursday afternoon, March 26 to the Ops Team. Tracer immediately contacted scientists at Oak Ridge National Laboratory for assistance in providing the taggants; Sentex Systems Inc. (Ridgefield, NJ) was contacted and requested to prepare a Gas Chromatograph (equipped with an Electron Capture Detector -- "ECD") to detect this taggant.

By 1500 hrs. EST., Oak Ridge had prepared, and was ready to ship four (4) wax crayons. In each crayon, a gram of PFT was encapsulated (captured). Although not tested beyond laboratory, it was anticipated that the lifetime of emission for each crayon was approximately 36-48 hrs. (see notes below). Tracer requested that the taggants be shipped to Sentex to facilitate deployment the following day. Note that at that time, there was no certainty that the operation would be approved by the customer. No provision had been made at that point for the GC/ECD to be prepared for operational deployment. At 1900 hrs. EST., Tracer management received a call from the Ops Team giving approval of the budget. Discussions and planning ensued with the Ops Team operatives who planned to arrive at Sentex offices at 0900 hrs. EST. on Thursday.

Tracer arrived at Sentex at 0940 hrs. EST. on Thursday, meeting the Ops Team (members #1 and #2) operatives. Preparation of the GC/ECD and training of Ops Team personnel (Ops Team member #2) on the operation of the equipment began by 1000 hrs. EST. After briefing on the application of the taggant to the money, Ops Team member #1 left for Newark Airport on-route to Central America.

Following a day of training at Sentex on the operation of the Gas Chromatograph, Tracer escorted Ops Team member #2 to Newark Airport for his flight to Central America at 1600 hrs. EST.

At 1800 hrs. CST on Thursday, the kidnappers phoned the operations center to discuss the terms and conditions of the money drop. At 0700 hrs. CST on Friday, March 27, the Ops Team was given the final "go ahead" by the victim's father to employ Tracer's tag and detect technology. At 1755 hrs. CST on Friday, the kidnappers phoned the victim's family (at the operations center) and instructed them that the "drop team" had to leave the operations center by 1815 hrs. CST. Not until the final call came from the kidnappers was the currency tagged. On Saturday, March 28 at 0700 hrs. CST the Ops Team was instructed to prepare for deployment of the tracking operation. At 0930 hrs. CST the Ops Team went to the "drop site" (located below a power line between two highways -- conditions at the time were hot, gusty winds and high humidity). No trace signal was detected at that time. The Commander of the Organized Crime Task Force (OCTF) was in constant communication with the Ops Team during the tracking operation, and suggested that known gang hideouts be checked to provide a "starting point" for the tracking operation. The OCTF possessed prior intelligence on possible gang hideouts; the Ops Team was taken to three suspected locations where no signal of the tag was detected. At 1145 hrs. CST the Ops Team was driven to a fourth location; upon analysis, the detector confirmed that this location had been involved in the kidnapping as a strong signal was detected from outside of the location (this location was described as the residence of the gang's second in command). Approximately 30 minutes later, a second suspected location was then tested (suspected of being the money counting station); a strong signal was again detected, and the Ops Team withdrew to a safe distance from the location. The Commander of the OCTF was then contacted. He suggested that the Ops Team test one more site while he deployed to their location. The suggested target showed a very strong signal (this location was a municipal police station). The Ops Team reported to the Commander of the OCTF and was instructed to proceed to a "safe area" to await the Commander and his staff. Upon arrival, the Commander asked if the Ops Team could perform another check on the suspected police station, after his men were re-positioned. Two hours later, the Ops Team and OCTF went back to the police station where a signal was again detected (later, the Commander of the OCTF indicated that they had suspected police involvement in the kidnapping). The Ops Team left Central America on Sunday afternoon, March 29, 1998.

As a result of the use of Tracer Detection Technology Corp.'s tagging system, and the expertise of the Ops Team, the full ransom was retrieved, and all perpetrators were arrested by the authorities.

NOTES on Tagging

Four (4) wax crayons of encapsulated taggant and three (3) ounces of unencapsulated material were supplied to the Ops Team. The tagging portion of the operation was conducted by three people ("taggers") in less than 15 minutes. A total of 1.3 Million pesos were tagged, with one to three swipes of the crayons being applied to approximately one of every two bills. Following application of the encapsulated taggant to the currency, one of the taggers applied the unencapsulated (pure) material to the currency by handling the currency with sterile gloves. Approximately one-half of a crayon remained unused at the time of the deployment.

APPENDIX – GLOSSARY OF TERMS

Tracer: Tracer Detection Technology Corp.

ORNL: Oak Ridge National Laboratory

N.I.J.: National Institute of Justice

PFT: Perfluorocarbons

GC/ECD: Gas Chromatograph augmented with an Electron Capture Detector

DSITMS: Direct Sampling Ion Trap Mass Spectrometer

DoD: Department of Defense

DoE: Department of Energy

DoE/NN: Department of Energy, Nuclear Non-Proliferation

ORNL/CASD: Chemical and Analytical Sciences Division of Oak Ridge National Laboratory

PMCH: Perfluoro(methylcyclohexane)

PFDMCH: Perfluoro-1,3-dimethylcyclohexane

PFCH: Perfluorocyclohexane

PFMD: Perfluoromethyldecalin

Grant #: 1999-LT-VX-K008
Period: 6/01/99-4/30/00 (**)

	Budget (*) ($)	Actual	Difference	
Personnel	34467	34533.99	66.99	
Fringe Benefits	0	0	0	
Travel	5820	2487.33	-3332.67	Reflects no two-man trips/lower than budgeted airfares
Equipment	0	0		
Supplies	0	0		
Contractual	54000	54000	0	
Other	5440	8705.68	3265.68	Reflects extension of Grant Period from 4 mos. To 11 mos.
Total Project Cost	99727	99727		

(*) Revised Budget Per Grant Adjustment #1 (Sept. 24, 1999)
(**) Per Grant Adjustment #3 (Feb. 8, 2000)