



Rapid Technologies for Drug Interdiction: Research and Development

July 10, 2023

Fiscal Year 2023 Report to Congress



**Homeland
Security**

Science and Technology Directorate

Message from the Office of the Under Secretary for Science and Technology

July 10, 2023

I am pleased to present the following report, “Rapid Technologies for Drug Interdiction: Research and Development,” which has been prepared by the Science and Technology Directorate (S&T).

This document has been compiled pursuant to a requirement in the Joint Explanatory Statement, which accompanies the Fiscal Year (FY) 2023 Department of Homeland Security (DHS) Appropriations Act (P.L. 117-328).

Pursuant to congressional requirements, this report is being provided to the following Members of Congress:



The Honorable David Joyce
Chairman, House Appropriations Subcommittee on Homeland Security

The Honorable Henry Cuellar
Ranking Member, House Appropriations Subcommittee on Homeland Security

The Honorable Chris Murphy
Chair, Senate Appropriations Subcommittee on Homeland Security

The Honorable Katie Britt
Ranking Member, Senate Appropriations Subcommittee on Homeland Security

Inquiries about this report may be directed to the DHS Office of Legislative Affairs at (202) 447-5890.

Sincerely,

A handwritten signature in black ink, appearing to read "Dimitri Kusnezov". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Dimitri Kusnezov, Ph.D.
Under Secretary
Science and Technology

Executive Summary

S&T is working to develop state-of-the-art capabilities for rapid screening and detection of illicit drugs, like fentanyl, to support the Department's interdiction efforts. S&T delivers this report in response to the Committee's request for an update on the research and development (R&D) of methods and technologies to support rapid scanning, detection, and interdiction of illicit drugs.

S&T is executing several project initiatives focused on development and demonstration of fast and accurate technologies for high-volume screening at U.S. ports of entry. Presently, no single technical approach meets the demands and challenges of the Department's counterdrug mission. Current detection strategies rely on a tiered approach that uses advanced information, drug-sniffing canines, X-ray image-based screening, and search and examination by hand. S&T's R&D efforts are focused on advancing technology within this tiered approach. To enable inspection of a higher volume of items more efficiently, S&T is enhancing X-ray screening technologies with algorithms to automatically recognize potential threats, like drugs that are hidden within an item being screened and to alert the operator that an additional inspection is required. To reduce the need for manual searches and improve safety, S&T is developing technologies that use distinct physical and chemical properties of illicit drugs that can be detected without having to open the package to automatically clear or confirm those alerts. Lastly, to support confident interdiction decisions, S&T is improving the detection equipment used during manual examinations to test the contents of an item for illicit drugs.

This report summarizes program accomplishments and details the status of current project initiatives. The report also includes a discussion of synergistic R&D opportunities, such as those focused on explosives detection, that could be leveraged to reduce potential duplication of effort, to accelerate development timelines, and to enable Department-wide strategic sourcing.

Drug trafficking trends and threats are dynamic. S&T's R&D efforts to advance screening and detection capabilities enable the Department to fulfill its mission to secure U.S. borders and reduce the supply of illicit narcotics that enter the United States.



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I. Legislative Language

The Joint Explanatory Statement accompanying the Fiscal Year (FY) 2023 Department of Homeland Security (DHS) Appropriations Act (P.L. 117-328), includes the following requirement.

Opioid and Fentanyl Detection.—S&T shall provide a report to the Committees within 180 days of the date of enactment of this Act on any research or development activity that incorporates rapid scanning into screening methods for drug interdiction.

II. Background

Over the past two decades, drug overdose deaths have continued to increase in the United States. The dramatic rise in fatalities from illicit synthetic opioids since 2013 has been particularly concerning. In April 2021, provisional data suggested that, for the first time, the number of U.S. overdose-related deaths had surpassed 100,000 over a 12-month period, with 75,673 of those attributed to opioids, particularly fentanyl.¹ Between 2019 and 2021, there was a 430 percent rise in Drug Enforcement Administration (DEA) seizures of illicit pills containing fentanyl, with the proportion of tablets containing a potentially lethal dose rising over the last few years, to about 40 percent.²

DHS has a significant role in countering the trafficking of opioids and other narcotics into the United States, including efforts to interdict illicit narcotics at or before they reach our borders, as well as investigative and intelligence efforts to disrupt and dismantle smuggling operations. However, efforts to combat opioid trafficking face numerous challenges. The high volume of mail, trade, and travel provide a multitude of smuggling points that must be accounted for and screened. High-value opioid shipments can be smuggled in very small quantities, making them difficult to detect and seize. The dearth of rapid and effective automated detection systems increases that difficulty. Lastly, due to the anonymity available through unregulated dark-web marketplaces and cryptocurrency, it has become even more difficult to discover and disrupt transnational drug trafficking organizations and networks.

The Science and Technology Directorate's (S&T) mission is to enable effective, efficient, and secure operations across all homeland security missions by applying scientific, engineering, analytic, and innovative approaches to deliver timely solutions. To support Departmental efforts to stop the flow of opioids and other narcotics, S&T established the Opioid/Fentanyl Detection Program in 2018 to deliver mission-critical counternarcotics solutions. Key requirements and strategies for the program were derived from: Executive Order 13784³; the International Narcotics Trafficking Emergency Response by Detecting Incoming Contraband with Technology (INTERDICTION) Act⁴; the Synthetics Trafficking and Overdose Prevention Act of 2018 (STOP Act)⁵; the National Drug Control Strategy, the National Southwest Border Counternarcotics Strategy, and the National Northern Border Counternarcotics Strategy; and direct collaboration with U.S. Customs and Border Protection (CBP) to complete a capability assessment report to identify priority areas for research and development (R&D) investment. S&T is committed to delivering mission-critical counternarcotics solutions while upholding privacy, civil rights, and civil liberties protections.

¹ National Center for Health Statistics. Drug Overdose Deaths in the U.S. Top 100,000 Annually; 2021. Available at: https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2021/20211117.htm

² Drug Enforcement Administration. Counterfeit Pills Fact Sheet; 2021. Available at: https://www.dea.gov/sites/default/files/2021-09/DEA_Fact_Sheet-Counterfeit_Pills.pdf

³ Executive Order 13784: Establishing the President's Commission on Combating Drug Addiction and the Opioid Crisis (2017) and subsequent Initiative to Stop Opioid Abuse and Reduce Drug Supply and Demand.

⁴ H.R.2142: INTERDICTION Act (2018), P.L. 115-112.

⁵ H.R.5788: STOP Act (2018).

A major focus of the Opioid/Fentanyl Detection Program has been improving capabilities for screening international mail at ports of entry. When the program was established, the postal system was exploited regularly, and there were no other S&T programs addressing this smuggling vector. Evidence indicates that most illicit fentanyl now enters the United States through southwestern border land crossings.⁶ However, all development efforts have incorporated the principle that technologies and approaches should be applicable to other ports of entry and border checkpoints) if necessary.

Early technology scouting and assessment efforts demonstrated that no currently available technologies would meet specific needs to: increase the amount of mail inspected at international mail facilities (IMF) to near 100 percent; screen incoming packages at the speed of commerce—within the constraints of cost, labor, or time available—to identify suspect packages for manual or intrusive inspection; or reliably detect small quantities or mixtures containing less than 10 percent of the drug of interest. Recognizing these challenges, the Opioid/Fentanyl Detection Program sought partnerships with other federal agencies, academia, and industry to develop better technologies in four general areas:

- High-throughput screening, nonintrusive inspection, such as image-based scanning of containers and international mail, to rapidly and automatically identify anomalies and alert the operator of suspected narcotics concealments;
- Detection of distinct physical and chemical drug properties to provide more specific information to assist the operator in determining whether an anomaly is a false alarm or illicit drug, without having to open or physically handle the shipment;
- Improved effectiveness of commercially available handheld and portable detection devices to analyze and identify a drug, even small amounts or when mixed with other compounds; and
- Standard methods and safe test materials that technology developers and end-users can use to test and validate detection equipment performance to provide confidence in the effectiveness and usability of deployed equipment.

In 2019, S&T partnered with CBP, along with the U.S. Postal Inspection Service and the Office of National Drug Control Policy to conduct the Opioid Detection Challenge (ODC)⁷ to address drug trafficking via international mail. The most promising solutions were awarded a grand prize and runner-up prize, totaling \$1.55 million. DHS worked with select finalists to develop their prototypes into the next generation of opioid interdiction tools. Beyond the finalist prototype technologies, the ODC also highlighted additional promising areas for rapid screening capabilities.

⁶ Commission on Combating Synthetic Opioid Trafficking: Final Report; 2022.

⁷ <https://www.opioiddetectionchallenge.com/>

III. Opioid/Fentanyl Detection Program: Current Activity

The status of S&T Opioid/Fentanyl Detection Program’s current initiatives to address shortfalls in opioid and other illicit drug detection capabilities is detailed below:

Project Title	Integrated X-ray System for Mail Screening
Project Description	This project is investigating an integrated computed tomography (CT) with X-ray diffraction system (XRD) to demonstrate the potential of a layered approach to enhance the probability of detection, to reduce false alarms, and to reduce the need for manual inspection.
Project Specifics	ODC grand prize winner Integrated Defense and Security Solutions (IDSS) partnered with ODC runner-up Halo X-ray Technologies to develop and demonstrate a proof-of-concept fused system that could support both DHS counternarcotic and aviation security missions. In this approach, the CT system is used for initial interrogation of a package to locate and target suspicious materials; upon alarm, the package is automatically diverted to the XRD to determine if the material is a drug or explosive threat. The project is focusing on both the mechanical engineering to link the two systems, as well the software engineering for system-to-system communications and graphical user interface. The fused solution will be evaluated against narcotics and explosives concealed within stream of commerce items and luggage.
Activities and Milestones	A single prototype system has been developed. In the first quarter of FY 2023, the system was delivered to the Transportation Security Laboratory (TSL) for data collection with explosives and a limited set of synthetic opioids. S&T is currently working with DHS Components to test and demonstrate the fused system in an operational environment. In the third quarter (Q3) of FY 2023, the system will complete a carry-on baggage data collection at an airport checkpoint. Subsequently, the system will be installed at a southwest border port of entry to collect additional data on stream-of-commerce items and real-world seized narcotics samples.
Obligations	\$3,733,676.66 (This project is jointly funded by two S&T Programs: the Opioid/Fentanyl Detection Program and the Baggage, Cargo, People Screening Program)
Project duration	Project period is FY 2021 to FY 2024.

Project Title	Development of Synthetic Narcotic Library Reference Data
Project Description	S&T worked in cooperation with Pacific Northwest National Laboratory (PNNL) and detection technology vendors to collect library reference data (e.g., spectral libraries) on narcotics of interest to the Homeland Security Enterprise for use by vendors and government partners. In the second phase of the project, PNNL is assessing detection performance of commercially available field portable detectors against multiple synthetic opioids, in pure form and in dilute mixtures.
Project Specifics	DHS Components and first responders use a wide range of commercial-off-the-shelf chemical detection technologies for field analysis of substances that may contain one or more drugs. Despite their widespread use, little independent testing information is available to characterize their performance for screening unknown substances, especially “real-world” samples. These types of complex samples, such as low-purity drug mixtures, may affect equipment performance during field screening, resulting in a false positive, false negative, or no result at all. Furthermore, many new and emerging synthetic narcotics are not in spectral reference libraries for commonly used field detection equipment. To address these shortfalls, PNNL worked with industry partners to collect reference spectra for approximately 50 DEA restricted substances, including fentanyl, fentanyl analogues, and other emerging illicit drugs on 18 different field portable detectors currently deployed for operational use. The detection technologies include Raman spectroscopy, gas chromatography mass spectroscopy, high-pressure mass spectroscopy, ion mobility spectroscopy, and Fourier transform infrared spectroscopy. In FY 2023, PNNL will follow the S&T-sponsored American Society for Testing and Materials (ASTM) “Standard Specification for Field Detection Equipment and Assays Used for Fentanyl and Fentanyl-Related Compounds” to assess the performance of those instruments against complex sample mixtures, which will provide the interdiction community a broad understanding of the capabilities and limitations of current field detection products. This project supports efforts to address recommendations and requirements outlined by the Office of Inspector General (OIG) ⁸ and Congress. ⁹
Activities and Milestones	DHS will maintain ownership of the newly generated reference libraries, which will be provided as a free upgrade by the vendors to any tribal, local, state, or federal agency that currently uses these technologies. The performance assessment report will be made publicly available at the conclusion of the project in FY 2023.
Obligations	\$3,137,462
Project duration	FY 2020 to FY 2023

⁸ OIG. February 2019. “Limitations of CBP OFO’s Screening Device Used to Identify Fentanyl and Other Narcotics.” OIG-19-67.

⁹ 116th Congress. DHS Opioid Detection Resilience Act of 2019. P.L. 116-254.

IV. Results

By the end of the second quarter of FY 2023, S&T had transitioned numerous opioid/fentanyl detection technologies and knowledge products, including:

High-throughput screening, nonintrusive inspection:

- X-ray CT imaging systems with automated narcotics detection algorithms developed using training data collected at the TSL. Through the DHS Border Security Technology Consortium Other Transactional Authority, CBP deployed CT systems for operational pilot programs. For example, the IDSS DETECT 1000 was deployed by CBP in FY 2021 to select operational facilities, with additional planned deployments in FY 2023.
- A technical assessment of the Thruwave, Inc. millimeter wave technology that enables rapid screening and detection of certain types of metal objects, such as blister packs of pills, Mylar bags, and weapons hidden within shipments at IMFs, provided to the CBP Office of the Commissioner Innovation Team. S&T supported CBP by conducting a unique data collection in FY 2021 Q3 at the TSL to provide training data to the developer and a test event to assess system performance in FY 2022.
- A technical assessment of a nuclear quadrupole resonance-based prototype for detecting concealed drugs, provided to CBP's Laboratories and Scientific Services (LSS). The Opioid/Fentanyl Detection Program funded follow-on development of One Resonance Inc.'s Quadrupole Resonance Opioid Detector, the runner-up in the ODC, expanding the narcotics library in conjunction with LSS, and conducting a test event at the U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC).

Detection of chemical properties of concealed drugs:

- A briefing and report on preliminary narcotics algorithm development results for an alarm resolution system that can detect the presence of concealed opioids and other narcotics based on how materials diffract X-rays passed through the parcel, was provided to CBP. The TSL collected data for synthetic opioids and stream-of-commerce items concealed in parcels to inform narcotics algorithm development for Halo X-Ray Technologies' XRD system.
- A report on trace opioid signatures on package surfaces, provided to the DHS Countering Weapons of Mass Destruction Office (CWMD). This report, summarized research performed at the Massachusetts Institute of Technology (MIT) Lincoln Laboratory, quantified the trace residue and vapor chemical signatures of various opioid concealments within packages. These studies were critical because they established the requirements for limits of detection of trace detection systems. Based on these results, the MIT Lincoln Laboratory developed technology roadmaps to guide development and implementation of the most promising trace detection solutions for screening and interdiction missions.
- Reports and journal publications on sampling and analysis of ultra-trace vapor-phase fentanyl compounds to indicate the presence of concealed opioids provided to CBP LSS. PNNL studied vapor pressure, ionization chemistry, and limits of detection for synthetic

opioids, optimizing sampling, collection, and desorption techniques that had been applied to previous studies of low-volatility analytes such as explosives.

- Narcotics detection capability for an active infrared spectroscopy system for real-time standoff detection and identification of trace chemical residues on surfaces, which transitioned to CWMD and S&T's Physical Security Program for further development. S&T collaborated with the Intelligence Advanced Research Projects Activity, within the Office of the Director of National Intelligence, on the final phase of its Standoff Illuminator for Measuring Absorbance and Reflectance Infrared Light Signatures Program, sponsoring library development with frequently encountered illicit drugs and common cutting agents, and an assessment of the capability of this optical technique for noncontact detection and identification of opioids, cocaine, and methamphetamines on the surfaces of packages.
- A briefing and report describing background trace signatures collected from three ports of entry at the southwestern land border, provided to CBP LSS. Researchers at the National Institute of Standards and Technology applied their sampling and analysis protocols to assess the potential for trace chemicals in operational environments to interfere with deployment of trace detection technologies.

Improved effectiveness of commercially available handheld devices:

- Reports describing research using modified handheld devices to detect opioids present at low concentrations, and to detect unknown fentanyl analogues provided to CBP LSS. S&T funded multiple projects at DEVCOM CBC towards improving the capabilities of commercial field portable detection systems.

Standard methods and improved safety:

- Three new ASTM standards for fentanyl detection, published as ASTM E3243-21, ASTM E3289-21, and ASTM E3290-21 in July 2021. PNNL led the development of these standards to support repeatable, consistent evaluation of field detection equipment for synthetic opioids, including dilute fentanyl mixtures. These standards were informed and reviewed by a working group of subject matter experts from the government, industry, and end-users.
- Reports describing safer opioid surrogates for testing and development of detection systems, provided to the Defense Threat Reduction Agency, and published in peer reviewed journals. The U.S. Naval Research Laboratory identified and screened low toxicity substances that could be used in place of dangerous illicit drugs for purposes of training users and improving established detection technologies.
- A Master Question List (MQL) for synthetic opioids, published¹⁰ in September 2021, in collaboration with the Chemical Security Analysis Center, the Hazard Assessment and Characterization Technology Center, the Probabilistic Analysis for National Threats Hazards and Risks program, and Emergency Response Tips. The MQL is a reference guide to assist emergency responders and the research community by providing critical and scientifically vetted information about the chemical and physical properties of synthetic opioids and the hazards they pose in operational settings.

¹⁰ <https://www.dhs.gov/publication/st-master-question-list-synthetic-opioids>

In addition, researchers funded by the program have published 9 peer-reviewed journal articles and delivered presentations at conferences, communities of interest, and working groups on multiple R&D efforts towards advancing detection of fentanyl and other narcotics.

V. Discussion

Under the S&T Opioid/Fentanyl Detection Program, multiple rapid screening approaches have been demonstrated for drug interdiction, specifically in the international mail environment. Though largely focused on synthetic opioids, like fentanyl, all approaches evaluated may be applied to methamphetamines, cocaine, other controlled drugs, and other chemicals of concern. The goal is a layered system-of-systems to offset inherent limitations of technological approaches. For example, a single approach may enable high-speed screening, but may lack any resolution or identification of the threat, necessitating a manual inspection of the contents. A single approach may be able to provide an identification but too slowly to be considered as a primary screening approach. A layered approach enables both high-throughput screening with increased positive detection and reduced nuisance detections.

By partnering with industry to expand and provide access to chemical detection libraries, S&T is vastly increasing the efficacy of commercially available detection technologies. The program's support for development and publication of ASTM standards for fentanyl detection provided the first standardized guidance for evaluating field portable detectors against synthetic opioids, driving cost-effective, informed procurement, since federal, state, and local entities now have reliable ways of evaluating technologies prior to purchase. The publication of results from S&T's comprehensive testing activity will enable direct comparison of detection performance – against samples at less than 10 percent opioid purity as well as pure samples – which may further promote competition and spur innovation within the industry to develop effective detection solutions. Further, S&T supports a cross-agency Illicit Drug Detection Working Group, comprising representatives from CBP, U.S. Immigration and Customs Enforcement (ICE), Homeland Security Investigations (HSI), Transportation Security Administration, U.S. Coast Guard, DEA, Combating Terrorism Technical Support Office, and Defense Advanced Research Projects Agency, to promote the sharing of information between the relevant stakeholders from DHS Component organizations and other federal agencies and to provide direction in the development of enterprise-wide requirements and technological solutions for the detection of illicit drugs.

The S&T Opioid/Fentanyl Detection Program has largely focused on technologies to address interdiction challenges in the international mail vector. While the mail remains a conduit for smuggling of illicit drugs and precursors, current trends indicate a shift from traditional shipping methods to the southern border. Many of the technologies evaluated under the Opioid/Fentanyl Detection Program could be applied to additional missions and environments. The body of knowledge and technologies developed to date should be leveraged for these vectors, though some additional evaluation may be required to ensure that specific operational requirements are met.

Collaborative projects, such as the integrated X-ray system for mail screening described above, demonstrate that other existing S&T programs focused on the scanning of cargo, vehicles, and on-person or personal property (e.g., Air Cargo Security, Screening at Speed, Multi-energy Portal) for explosives, weapons, and other contraband can be expanded to include narcotics to increase DHS screening and interdiction efforts. For example, S&T's Screening at Speed

program is funding PNNL to develop an X-ray imaging system in which patterned lead/aluminum gratings (grids) are used to produce phase contrast and scattering signatures, in addition to an absorption image. These features may provide more material discrimination features than CT X-ray systems. With additional funding from the Opioid/Fentanyl Detection Program, PNNL is obtaining gratings-based X-ray images for illicit drug simulants and will assess the feasibility of this approach for narcotics detection.

VI. Conclusion

Because of changes in DHS Component priorities, the S&T Opioid/Fentanyl Detection Program began sunseting R&D technology for illicit drug screening and detection in FY 2021. S&T has transitioned solutions and knowledge products to CBP, which is already fielding solutions identified and developed under this program, including the winning ODC solution, IDSS DETECT 1000. Other promising solutions have been transitioned to ongoing R&D efforts for advanced development.

As detection-focused work transitions, the Opioid/Fentanyl Detection Program has expanded its focus to fulfill ICE HSI priority needs for improved intelligence and investigative capabilities to counter illicit drug trafficking. S&T is developing advanced analytical tools to assess the quality of evidence and conduct automated discoveries of high-value targets, to assist agents in investigations and support prosecution. S&T is also developing methods to process unstructured data from seized dark-web marketplaces to support HSI investigations of the illicit drug trade. The overall goal of these efforts is to provide ICE with the knowledge and tools to identify patterns, participants, and methods used by drug trafficking networks to disrupt and dismantle drug trafficking organizations and stem the flow of illicit drugs into the United States. These efforts complement the Department's physical screening approaches for illicit materials by generating key information to improve pre-screening and targeting of high-risk smuggling attempts for more effective and efficient interdiction efforts.

During FY 2023, the Opioid/Fentanyl Detection Program is working with DHS's Homeland Security Operational Analysis Center to survey counternarcotics efforts across the Homeland Security Enterprise and produce a holistic counternarcotics roadmap that will inform future program direction. This approach will provide a more agile and consistent mechanism for S&T to ensure that cutting-edge rapid-scanning technologies are at the forefront of the Department's screening methods for drug interdiction.

Appendix: Abbreviations

Abbreviations	Definition
ASTM	(Formerly) American Society for Testing and Materials
CBP	U.S. Customs and Border Protection
CT	Computed Tomography
CWMD	Countering Weapons of Mass Destruction
DEA	Drug Enforcement Administration
DEVCOM CBC	U.S. Army Combat Capabilities Development Command
DHS	Department of Homeland Security
FY	Fiscal Year
HSI	Homeland Security Investigations
ICE	U.S. Immigration and Customs Enforcement
IDSS	Integrated Defense and Security Solutions
IMF	International Mail Facility
LSS	Laboratories and Scientific Services
MIT	Massachusetts Institute of Technology
MQL	Master Question List
ODC	Opioid Detection Challenge
OFO	Office of Field Operations
OIG	Office of Inspector General
PNNL	Pacific Northwest National Laboratory
Q3	Third Quarter
R&D	Research and Development
S&T	Science and Technology Directorate
TSL	Transportation Security Laboratory
XRD	X-Ray Diffraction