United States General Accounting Office

GAO

Report to Congressional Requesters

September 1996

TERRORISM AND DRUG TRAFFICKING

Technologies for Detecting Explosives and Narcotics

G A O

75 years

1921 - 1996

GAO/NSIAD/RCED-96-252

GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and International Affairs Division

B-272630

September 4, 1996

The Honorable Benjamin A. Gilman
Chairman
The Honorable Lee H. Hamilton
Ranking Minority Member
Committee on International Relations
House of Representatives

The Honorable Alfonse M. D'Amato
United States Senate

The ability to detect explosives and narcotics is increasingly important to U.S. national security. Explosives are the terrorist's weapon of choice. Their use against commercial aircraft have led to loss of lives and weakened confidence in the security of air travel. Likewise, narcotics trafficking ruins lives, drains billions of dollars from the economy, and spawns violence that threatens U.S. communities.

As you requested, we have developed information on explosives and narcotics detection technologies that are available or under development. More specifically, this report discusses (1) funding for those technologies, (2) characteristics and limitations of available and planned technologies, and (3) deployment of technologies by the United States and foreign countries. The appendixes provide detailed information on the most significant types of technologies available and under development, including brief summaries of their characteristics, their current status in terms of development or deployment, the estimated range of prices for the technologies, and the amount of federal funds spent on the technologies between fiscal years 1978 and 1996.

This report is one of a series you requested on the role of technology in explosives and narcotics detection.[1] In recent testimony, [2] we concluded that an approach should be developed immediately to address the actions needed to reduce vulnerabilities in aviation security identified in our classified reports. This report provides a summary of technologies that should be considered in addressing the actions needed. A subsequent

[1]Terrorism and Drug Trafficking: Threats and Roles of Explosives and Narcotics Detection Technology (GAO/NSIAD/RCED-96-76BR, Mar. 27, 1996). Other reports have been classified by executive branch agencies.

[2]Aviation Security: Immediate Action Needed to Improve Security (GAO/T-RCED/NSIAD-96-237, Aug. 1, 1996).

report will address issues related to governmentwide coordination of technology development and deployment.

Background

The increased threat of terrorism is an urgent national issue. The President directed the establishment of a commission on July 25, 1996, headed by Vice President Gore, whose charter included reviewing aviation security. The commission was charged with reporting to the President within 45 days its initial findings on aviation security, including plans to (1) deploy technology capable of detecting the most sophisticated explosive devices and (2) pay for that technology. In a classified report, we made recommendations to the Vice President, in his capacity as chairman of the commission, that would enhance the effectiveness of the commission's work. Detection technologies are also important in the effort to stem the flow of drugs into the United States.

Detection technologies are typically developed for specific applications—some for aviation security, some for drug interdiction, and some for both. The major applications for the aviation security efforts of the Federal Aviation Administration (FAA) include the screening of checked baggage, passengers, cargo, mail, and carry-on items such as electronics, luggage, and bottles. FAA's need for detection technology comes from its security responsibilities involving more than 470 domestic airports and 150 U.S. airlines, annually boarding over 500 million passengers with their checked baggage and carry-on luggage, and transporting mail and cargo.

Some advanced detection technologies are commercially available to serve aviation security applications. However, only one technology is currently deployed in the United States. That technology is being operationally tested at two U.S. airports.

Major applications for the drug interdiction efforts of the U.S. Customs Service include screening of cargo and containers, pedestrians, and vehicles and their occupants. Customs' need for detection technology emanates from its responsibilities to control 301 ports of entry. Currently, over 400 million people, almost 120 million cars, and 10 million containers and trucks pass through these points each year.

Currently, Customs' screening is done manually by inspectors with relatively little equipment beyond hand-held devices for detecting false compartments in containers.

The challenges in detecting explosives are significantly different than the challenges in detecting narcotics, as are the consequences in not detecting them. Customs and other drug enforcement agencies are concerned with much larger quantities than are aviation security personnel. Consequently, greater technical challenges are posed in attempting to detect explosives that might be used to bring down a commercial aircraft.

Two general groups of technologies, with modifications, can be used to detect both explosives and narcotics. The first group uses X-rays, nuclear techniques involving neutron or gamma ray bombardment, or electromagnetic waves, such as radio frequency waves. These technologies show anomalies in a targeted object that might indicate concealed explosives and narcotics or detect actual explosives and narcotics. The second group, referred to as trace detection technologies, uses chemical analyses to identify particles or vapors characteristic of narcotics or explosives and deposited on, or surrounding, objects, such as carry-on electronics or surfaces of vehicles. In addition to technologies, dogs are considered a unique type of trace detector because they can be trained to respond in specific ways to smells of narcotics or explosives.

Results in Brief

Aviation security and drug interdiction depend on a complex and costly mix of intelligence, procedures, and technologies. Since 1978, federal agencies have spent about $246 million for research and development on explosives detection technologies and almost $100 million on narcotics detection technologies. Most of this spending has occurred since 1990, in response to congressional direction, and has been for technologies to screen checked baggage, trucks, and containers.

Difficult trade-offs must be made when considering whether to use detection technologies for a given application. Chief among those trade-offs are the extent to which intelligence-gathering and procedures can substitute for technology or reduce the need for expensive technology. Decisionmakers also need to evaluate technologies in terms of their characteristics and limitations. Some technologies are very effective and could be deployed now, but they are expensive, slow the flow of commerce, and raise issues of worker safety. Other technologies could be more widely used, but they are less reliable. Still others may not be available for several years at the current pace of development.

Despite the limitations of the currently available technology, some countries have already deployed advanced explosives and narcotics detection equipment because of differences in their perception of the threat and their approaches to counter the threat. Should the United States start deploying the currently available technologies, lessons can be learned from these countries regarding their approaches, as well as capabilities of technology in operating environments. FAA estimates that use of the best available procedures and technology for enhancing aviation security could cost as much as $6 billion over the next 10 years or alternatively about $1.30 per one-way ticket, if the costs were paid through a surcharge.

Spending on Detection Technologies

Since 1978, the federal government has spent about $246 million for research and development (R&D) on explosives detection technologies, including over $7 million for ongoing demonstration testing at the Atlanta, San Francisco, and Manila airports. During the same period, the government has spent about $100 million for R&D on narcotics technologies and a little more than $20 million procuring a variety of equipment to assist Customs inspectors, such as hand-held devices for detecting false compartments. The majority of the spending has occurred since 1990.

As shown in table 1, annual R&D spending on explosives detection technologies fluctuated from $23 million to $28 million during the first part of this decade, before increasing to $39 million for fiscal year 1996. The $14 million, or over 50 percent, increase from fiscal year 1995 is due principally to FAA's funding of demonstration testing of a technology for screening checked baggage and to the funding of a counterterrorism application by the Technical Support Working Group (TSWG).[3]

[3]The Technical Support Working Group is a National Security Council-sponsored interagency forum for coordinating research and development on counterterrorism.

Table 1: R&D Spending on Detection Technologies for Fiscal Years 1978 Through 1996[a]

Millions of current-year dollars

Technology	FY78 to FY90	FY91	FY92	FY93	FY94	FY95	FY96	Total
Explosives	$78	$23	$28	$28	$25	$25	$39	$246
Narcotics	2	14	16	18	20	14	17	100
Total	**$80**	**$36**	**$45**	**$46**	**$45**	**$39**	**$55**	**$346**

[a]Spending for explosives technologies is based on estimates provided by FAA and TSWG, while narcotics spending is based on estimates by Customs, DOD, and the Office of National Drug Control Policy (ONDCP). Customs was unable to provide estimates of spending prior to fiscal year 1988. Spending by DOD and ONDCP did not begin until fiscal years 1991 and 1992, respectively.

Note: Totals may not add due to rounding.

Annual spending on narcotics detection technology increased during the first part of the decade from $14 million to a peak of $20 million in fiscal year 1994 and then dropped $3 million from that peak, or 15 percent. The reason for this decline is reduced spending by the Department of Defense (DOD) as it shifted emphasis from one type of narcotics detection technology to other, less costly types of technologies to satisfy Customs' needs.

Congressional Direction

The spending on detection technologies that has occurred since 1990 has been due in large part to congressional direction. The Aviation Security Improvement Act of 1990 (Public Law 101-604) directed FAA to increase the pace of its R&D. The act also set a goal of deploying explosives detection technologies by November 1993. However, it prohibited FAA from mandating deployment of a particular technology until that technology had first been certified as capable of detecting various types and quantities of explosives using testing protocols developed in conjunction with the scientific community.

FAA initially concentrated its efforts on developing protocols and technologies for screening checked baggage to address one of the security vulnerabilities that contributed to the bombing of Pan Am flight 103 in December 1988. However, the goal of deploying such technology has still not been met. FAA has certified one system, and it is being operationally tested at two domestic airports and one airport overseas.

Congress tasked DOD in 1990 to develop narcotics detection technologies for Customs and other drug enforcement organizations. DOD has focused on developing "non-intrusive inspection" technologies to screen containers without the need for opening them. Customs is deploying a DOD-developed technology for trucks and empty containers, but it rejected another DOD-developed technology for fully loaded containers (see p. 8). Customs has identified containerized cargo at commercial seaports as its greatest unsolved narcotics detection requirement. According to Customs, it may be necessary to explore new methods of financing the systems that are technologically feasible for seaports, but high in cost.

Characteristics and Limitations of Detection Technologies

Both aviation security and drug interdiction depend on a complex mix of intelligence, procedures, and technologies, which can partially substitute for each other in terms of characteristics, strengths, and limitations. For example, FAA evaluates information from the intelligence community in determining a level of threat and mandating security procedures appropriate to a specific time and place. These security procedures include bag matching and passenger profiling.[4] FAA estimates that incorporating bag matching in everyday security could cost up to $2 billion, while profiling could reduce to 20 percent the number of passengers requiring additional screening. The Customs' drug interdiction task has an analogous set of procedures and technologies and trade-offs.

Relevant trade-offs in selecting detection technologies for a given application involve their characteristics and costs, including issues of their effectiveness in detecting explosives or narcotics, safety risks to users of the technology, and impacts on the flow of commerce. For example, some highly effective technologies could be deployed now, but they are expensive, raise safety concerns, or slow the flow of commerce. These trade-offs are required for each of the major detection technology applications for FAA and Customs.

While areas of overlap exist, FAA's aviation security applications generally relate to checked baggage, passengers, and carry-on items, and Customs' drug interdiction applications generally relate to screening of cargo, containers, vehicles, and baggage. In addition to detection technologies, teams of dogs and their handlers are used for both aviation security and drug interdiction applications.

[4]Bag matching is a procedure to ensure that a passenger who checks a bag also boards the flight; if not, the bag is removed. Profiling is a method of identifying potentially threatening passengers, who are then subjected to additional security measures. Profiling reduces the number of passengers requiring additional security measures.

Aviation Security Applications

Checked Baggage

A system is available today for screening checked baggage that has been certified by FAA as capable of detecting various types and quantities of explosives likely to be used to cause catastrophic damage to a commercial aircraft, as is required by the Aviation Security Improvement Act of 1990. However, the certified system is costly and has operational limitations, including a designed throughput of about 500 bags an hour with actual throughput much less than that number. Other less costly and faster systems are available, but they cannot detect all the amounts, configurations, and types of explosive material likely to be used to cause catastrophic damage to commercial aircraft.

FAA's plans for developing detection technologies for checked baggage include efforts to improve the certified system, develop new technologies, and evaluate a mix of technologies. FAA believes that an appropriate mix of systems that individually do not meet certification requirements might eventually work together to detect the amounts, configurations, and types of explosive material that are required by the act.

Appendix I provides additional information about the various types of technologies available and under development for screening checked baggage, including the characteristics and limitations of those technologies, their status, the estimated range of prices for the technologies, and federal government funding for the technologies.

Passengers

The National Research Council recently reported that X-ray and electromagnetic technologies produce images of sufficient quality to make them effective for screening passengers for concealed explosives.[5] Future development efforts by FAA and TSWG are generally focusing on devices that detect explosives on boarding documents passengers have handled and portals that passengers would walk through. One type of portal uses trace detection technologies that collect and analyze traces from the passengers' clothing or vapors surrounding them. The other type uses electromagnetic waves to screen passengers for items hidden under clothing.

The National Research Council also recently observed that successful deployment of these technologies is likely to depend on the public's

[5] Airline Passenger Security Screening: New Technologies and Implementation Issues. Washington, DC: National Academy Press, 1996.

perception about the seriousness of the threat and the effectiveness of devices in countering the threat, which might also be considered intrusive or thought to be a health risk. (See App. II for more information about the various types of technologies available and under development for passenger screening.)

Carry-on Items

Technologies available today for screening carry-ons for hidden explosives include conventional X-ray machines, an electromagnetic system, and trace detection devices.[6] FAA has recently developed trace detection standards for inspecting carry-on electronics for explosives. In addition, FAA has "assessed as effective," but not certified, three trace detection systems to be used during periods of heightened security. FAA expects to soon "assess as effective" three more trace detection systems. The more expensive trace technologies used for carry-on baggage are capable of detecting smaller amounts of explosives and narcotics. FAA's future efforts are expected to include developing an enhanced X-ray device and screeners for bottles. (See app. III for more detailed information about technologies for screening carry-on items.)

Drug Interdiction Applications

Containers

Tests have shown that fully loaded containers can be effectively screened for narcotics with available high energy X-ray technologies (about 8 million electron volts or the equivalent of 50 to 70 times the energy of a typical airport-passenger X-ray). However, Customs rejected a DOD-developed high energy technology because it cost $12 million to $15 million per location, required a large amount of land for shielding, and raised safety concerns. Available low-energy technologies (the equivalent of 3 to 4 times the energy of a passenger X-ray) are less costly and safer but cannot penetrate full containers, so their use is limited to screening for hidden compartments in empty containers and objects concealed in trucks and trailers. About 4 to 25 containers per hour can be processed through low- and high-energy X-ray technologies depending on their configurations.

According to DOD and Customs officials, future efforts in container screening will include developing less expensive X-ray systems with higher energy levels, mobile X-ray systems, and more capable hand-held trace

[6] We previously reported on limitations in performance of conventional X-ray machines and their operators.

detection systems. Those efforts will also include evaluating nuclear-based techniques for inspecting empty tankers at truck and rail ports.[7] (See app. IV for additional information about technologies for screening cargo and containers.)

Dog Teams

Dogs can be trained to alert their handlers upon detecting explosives and narcotics. FAA-certified dogs are trained to detect various types of explosive substances that might be concealed in aircraft, airport vehicles, baggage, cargo, and terminals. Customs' dogs are trained to detect narcotics and in 1994 almost 6,000 drug seizures were attributable to dog teams. Currently funded projects include efforts to develop methods of bringing air samples to the dogs, or swabs from objects they are to inspect.

Current Deployments of Detection Technologies

Despite the limitations of currently available detection technologies, other countries have deployed some of these technologies to detect explosives and narcotics because of differences in their perception of the threat and their approaches to counter the threat. These countries' experiences provide opportunities to learn lessons about operational measures taken to deploy detection technologies, such as the amount of airport modifications needed to incorporate new technologies and the types of training provided to the operators of the new equipment, as well as the actual effectiveness of the technologies.

While Customs has deployed equipment such as hand-held devices, it is also deploying up to 12 low-energy X-ray systems to screen empty containers and trucks for narcotics along the Southwest border. On the other hand, some countries are using high-energy systems to screen fully loaded containers. The high-energy systems installed at ports of entry in the United Kingdom, France, Germany, and China would have similar uses at seaports here, but Customs officials told us that the systems are too new for reliable operational data. They also told us that tests have not been conducted against Customs' requirements and the technologies would also be too expensive in the quantities needed for nationwide deployment.

[7]As mentioned earlier, overlap exists in technology applications for drug interdiction and aviation security. FAA's future air cargo screening efforts will also include nuclear technologies. Appendix IV shows that FAA has spent over $5 million developing one specific nuclear technology for cargo screening, while DOD has spent about $19 million developing the same technology for narcotics screening.

A high-energy nuclear system is being considered for deployment at the Euro Tunnel between France and the United Kingdom. The system would be used to screen for explosives concealed in trucks and their cargo being transported under the English Channel. This system could also be used to detect narcotics.

In the United Kingdom, Germany, the Netherlands, and Belgium, we observed governments working closely with airport authorities to deploy explosives detection technologies. In two countries, airport authorities have generally embraced an approach that entails successive levels of review of checked baggage to resolve uncertainty about checked baggage. This approach can require complex systems for tracking throughout the entire baggage handling system. Instead of using only the FAA-certified system for checked baggage, these countries are using a mix of technologies. Their approach has been to implement technology that is an improvement on existing technology or procedures, rather than waiting for perfected technology.

Officials in the two other countries are waiting for the next generation of explosives detection technologies. They believe that X-ray technologies have generally reached their limits in detecting explosives.

All of the countries have also deployed trace detection technology for screening checked baggage or carry-on items, especially electronics.

FAA officials told us they cannot mandate the types of approaches used by other countries, although airlines could voluntarily adopt them, because of the statutory prohibition against mandating technology that is not certified.

With a combination of the best available technologies and procedures, including the use of the certified system for screening checked baggage, FAA estimates the incremental cost of the most effective security system for U.S. air travellers to be $6 billion over the next 10 years. On a per-passenger basis, FAA estimates the equivalent cost to be about $1.30 per one-way ticket.

Customs and FAA have deployed dog teams widely. Customs has deployed about 450 dog teams to airports, seaports, and land border ports. The cost to train a Customs' dog and handler is about $6,000. FAA's canine explosives detection program includes 29 U.S. airports with a total of 72 FAA-trained and certified dog teams. Of the 19 largest U.S. airports, 14 have

FAA-trained and certified dogs. The five airports without certified dogs are Washington-National, Washington-Dulles, Baltimore-Washington International, New York-John F. Kennedy, and Honolulu. According to an FAA official, these airports do not have FAA-certified dog teams because airport officials are concerned about cost. The cost to train an FAA dog and handler is about $17,000 and the annual operating cost of a team, including the handler's salary, is about $60,000.

Agency Comments

Five agencies—FAA, DOD, Customs, TSWG, and ONDCP—provided comments on the technical accuracy of information contained in a draft of this report. We have incorporated their comments in this final report where appropriate.

Scope and Methodology

To determine the amount of federal government spending for R&D on explosives and narcotics detection technologies, we obtained funding information from Customs, FAA, DOD, ONDCP, and TSWG covering periods as far back as the information was available. Although we identified the historical and current levels of funding, we generally focused on the period 1990 to the present because most technologies were developed and deployed during this period.

To obtain information on the characteristics and limitations of available and planned technologies for containers, checked baggage, passengers, and carry-on items, we requested project information from the same five agencies for each detection technology project they had undertaken since 1990. Additionally, we received briefings from developers of technology and manufacturers of equipment currently available on the market.

We analyzed major categories of technologies to identify a few characteristics common to each that can be used in making comparisons. We did not attempt to evaluate the effectiveness of the technologies, nor did we assess whether the current funding level is adequate to develop reliable detection technologies.

We interviewed officials and gathered data primarily from the FAA, DOD, Customs, ONDCP, and TSWG to develop information on available and planned detection technologies. We also interviewed officials and visited ports of entry in Miami, Florida; San Juan, Puerto Rico; and Otay Mesa, California; and airports in Belgium, Germany, the Netherlands, United Kingdom, and the United States.

We are sending copies of this report to the Vice President of the United States; Chairmen and Ranking Minority Members of appropriate congressional committees; the Secretaries of Treasury, State, Defense, and Transportation; the Attorney General, Department of Justice; the Administrators, FAA and Drug Enforcement Administration; the Commissioner, U.S. Customs Service; and the Directors, ONDCP, Central Intelligence, and Federal Bureau of Investigation.

If you or your staff have any questions concerning explosives detection technology, please contact Gerald L. Dillingham at (202) 512-2834. If you have any questions regarding narcotics detection technologies, please call David E. Cooper on (202) 512-4841. Major contributors to this report are listed in appendix V.

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Contents

Abbreviations

DOD	Department of Defense
FAA	Federal Aviation Administration
IMS	Ion Mobility Spectroscopy
KeV	thousand electron volts
MeV	million electron volts
ONDCP	Office of National Drug Control Policy
R&D	research and development
TSWG	Technical Support Working Group

Application: Checked Baggage[a]

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
X-Ray				
Computerized Axial Tomography (CAT Scan)	X-ray source rotates around a bag obtaining a large number of cross-sectional images that are integrated by a computer, which displays densities of objects in the bag. Automatically alarms when objects with high densities, characteristic of explosives, are detected. Relatively slow throughput; certified system requires two units to meet throughput requirement.	Commercially available. Achieved Federal Aviation Administration (FAA) certification in December 1994. FAA currently funding operational testing at three airports and also funding projects to improve throughput rate, reduce unit cost, and improve overall capabilities. Department of Defense (DOD) recently tested technology for detecting drugs in small packages.	$850,000 to $1 million	$22.2 million (FAA)
Dual-energy X-rays	Two different X-ray energies determine the densities and average atomic numbers of the target material. Currently none of the X-rays in this group meets certification standards for checked bags because they do not detect the quantities and configurations of the full range of explosives specified in the standards.	Commercially available. FAA is developing an enhanced version that may meet certification standards. The U.S. Customs Service (Customs) plans to test this technology for drug detection.	$400,000	$2.1 million (FAA)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
X-rays with backscatter	Backscatter detects reflected X-ray energy, providing an additional image to highlight organic materials such as explosives and drugs near the edge of a bag. This group of X-ray devices generally does not automatically alarm and therefore requires an operator to interpret the image.	Commercially available. FAA has several projects aimed at assisting this group of X-ray devices meet certification standards.	$100,000 to $140,000	$100,000 (Customs) $2.2 million (FAA)
Coherent X-ray Scatter (also known as X-ray Diffraction)	Technology is based on the detection of scatter patterns as X-rays interact with crystal lattice structures of materials.	FAA and Customs terminated projects due to significant technical problems. A foreign government and contractor are supporting development of this technology.	NA[b]	$4.5 million (FAA) $270,000 (Customs)
Nuclear				
Gamma-Gamma Resonance Imaging	Accelerator produces gamma rays that penetrate bags to detect presence of chlorine compounds in narcotics. Eventual system expected to be very expensive.	DOD is building a prototype to demonstrate proof-of-principle for airport baggage carousel application. Demonstration is expected in December 1996.	NA	$8.6 million (DOD)
Thermal Neutron Analysis	Neutrons from a radioactive source probe bags for presence of nitrogen or chlorine compounds. Automatically alarms on explosives or narcotics. Cost, size, and false alarm rate were of concern to airline industry, President's Commission on Terrorism and Aviation Security, and Customs.	Six machines built and tested since 1989. FAA discontinued checked baggage portion of project in 1994, but it is now investigating carry-on application. DOD contractor now using FAA machines to test drug detection.	$1 million	$6.6 million (FAA) $280,000 (DOD) $27,000 (Customs)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Electromagnetic				
Quadrupole Resonance	Radio frequency pulses probe bags to elicit unique responses from explosives and drugs. Nonimaging technology that provides chemically specific detection and automatically alarms on explosives or drugs. Currently does not meet FAA certification standards. Detection of certain cocaine compounds needs improvement.	Commercially available. FAA has a prototype capable of detecting two types of explosives. Customs has a prototype capable of detecting cocaine base.	$340,000	$1 million (DOD) $350,000 Office of National Drug Control Policy (ONDCP) $0.7 million (FAA) $1.6 million Technical Support Working Group (TSWG)

[a]The Funding column indicates whether a specific technology was developed or is being developed for explosives detection, narcotics detection, or both. Generally, FAA and TSWG funding has supported explosives detection, while funding by DOD, Customs, and ONDCP has supported narcotics detection. Where a technology funding cell shows FAA or TSWG in combination with DOD, Customs, or ONDCP, that technology is generally capable of detecting both narcotics and explosives.

[b]Not available.

Application: Passengers[a]

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Electromagnetic:				
Magnetic Resonance for Drug Swallowers	System is nonimaging, but will automatically alarm if drug is detected in the digestive tract of a swallower. Requires about 30 seconds to screen a suspect.	Prototype developed and tested at an airport. Project was terminated because system emitted radio frequencies that interfered with airport operations and Customs decided against spending additional $165,000 on needed shielding. System is now sitting idle at a Customs' storage facility.	NA[b]	$1.3 million (ONDCP) $123,000 (Customs)
Dielectric Portal	System will scan 360 degrees around a passenger and automatically pinpoint the location of all undeclared objects on the surface of the body. System will be capable of processing 500 passengers per hour.	Under development by FAA. Factory and airport testing to occur in 1997.	$110,000 to $200,000	$1.6 million (FAA)
Millimeter Wave Portal	System provides 360-degree imaging of the human body in order to detect weapons, explosives, and drugs concealed underneath clothing. System does not provide automatic detection, but relies on an operator to spot the contraband. System expected to process 360- 600 passengers per hour.	Under development by FAA. Fieldable prototype to be completed mid-1997 with airport testing to follow.	$100,000 to $200,000	$5.3 million (FAA)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Trace				
Chemiluminescence Portal	Vacuum wands touching clothing collect vapor and particles while passengers are walking through the portal. System will automatically alarm if explosive is detected. Throughput is estimated to be 360 per hour.	Under development by FAA. Fieldable prototype completed in 1995. Factory and airport testing will begin in late 1996.	NA[b]	$4.0 million (FAA)
Ion Mobility Spectroscopy (IMS) Portals	Air flow dislodges vapor or particles from passengers walking through portals to test for explosives. Systems automatically alarm if explosive is detected. Throughput goal is 360 per hour.	Two prototypes are being developed by FAA.	$300,000 to $500,000	$2.5 million (FAA)
IMS Passenger Scanner	Trace samples collected from passengers' hands either through a token or document. System will automatically alarm if explosive is detected. Throughput is estimated to be 425 per hour.	Under development by FAA. Field prototype to be available sometime in 1996.	$65,000 to $85,000	$125,000 (FAA)
IMS Document Screeners	Collects trace samples from passengers' documents. System will automatically alarm if explosive is detected. Throughput is estimated to be 450 per hour.	Under development by TSWG. Project started in April 1996 and to be completed in 1998.	$65,000 to $85,000	$430,000 (TSWG)

(Table notes on next page)

[a]The Funding column indicates whether a specific technology was developed or is being developed for explosives detection, narcotics detection, or both. Generally, FAA and TSWG funding has supported explosives detection, while funding by DOD, Customs, and ONDCP has supported narcotics detection. Where a technology funding cell shows FAA or TSWG in combination with DOD, Customs, or ONDCP, that technology is generally capable of detecting both narcotics and explosives.

[b]Not available.

Application: Carry-on Luggage[a]

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Trace				
Ion Mobility Spectroscopy (IMS)	Measures mobility of various chemicals through a gas in an electrical field. Fast, portable, and inexpensive. Lower chemical specificity than mass spectrometry.	Commercially available. For example, 125 units of a particular IMS system have been deployed overseas.	$45,000 to $152,000	$2.3 million (FAA)
Combination Technologies	Combines gas chromatography and mass spectrometry or chemiluminescence that separates mixtures using an absorbent material. High sensitivity and chemical specificity. Produces evidence acceptable in court. Expensive, slow, and bulky.	Commercially available. For example, 154 units of a chemiluminescence system have been deployed overseas.	$100,000 to $170,000	$2 million (FAA) $230,000 (TSWG)
X-rays				
Enhanced, low-energy X-rays	Do not automatically alarm, so dependent on operator interpretation of enhanced images. Limited penetration of target objects.	Under development.	NA[b]	$325,000 (FAA) $250,000 (TSWG)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Electromagnetic				
Quadrupole Resonance	Radio frequency pulses probe hags to elicit unique responses from explosives and drugs. Nonimaging technology that provides chemically specific detection and automatically alarms on explosives or drugs. Detection of certain cocaine compounds needs improvement.	Commercially available. A field prototype capable of handling small size packages was tested in Atlanta during the Olympics by airlines to screen electronics.	$65,000	This is a product derived from funding the same technology listed in appendix I.
Dielectrometry bottle content tester	System uses microwave technology to penetrate bottles and will discover when bottles do not contain the liquid that is expected. It is basically a discovery rather than detection system. System does not identify the liquid in the bottle. System throughput is expected to be 720 bottles per hour. However, system is unable to penetrate certain types of bottles.	This is an FAA in-house project working with a commercially available device. FAA is currently testing field prototypes.	$19,000 to $25,000	$77,000 (FAA)
Magnetic Resonance for bottle screening	Automatically alarms if explosives detected. Analysis time varies between 20 and 70 seconds per target. Manufacturer is working to shorten analysis time.	Prototypes are available.	$75,000 to $125,000	$974,000 (FAA)

[a]The Funding column indicates whether a specific technology was developed or is being developed for explosives detection, narcotics detection, or both. Generally, FAA and TSWG funding has supported explosives detection, while funding by DOD, Customs, and ONDCP has supported narcotics detection. Where a technology funding cell shows FAA or TSWG in combination with DOD, Customs, or ONDCP, that technology is generally capable of detecting both narcotics and explosives.

[b]Not available.

Application: Containers, Trucks, and Cargo[a]

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Nuclear				
Nuclear Resonance Absorption	An accelerator generates gamma rays to penetrate the object to be screened. The gamma rays are preferentially absorbed by nitrogen nuclei. A significant decrease in the number of detected gamma rays indicates the possible presence of explosives. System requires less shielding than other nuclear technologies.	Project was originally intended for checked bags and has been inactive since 1993. FAA may reactivate project for screening air cargo containers.	NA[b]	$12.1 million (FAA)
Pulsed Fast Neutron Analysis (8 MeV)	An accelerator generates neutrons for bombarding target; induced gamma rays are measured to detect presence of narcotics or explosives. System automatically alarms based on 3 dimensional images of elemental ratios of hydrogen, oxygen, nitrogen, and carbon. System takes 20 minutes per analysis and would typically be combined with an X-ray system to speed throughput. Requires a large amount of space and shielding, a radiation permit, and an FDA permit for use on food.	DOD completed the project, but the system was not transitioned to Customs due to Customs' concern with cost, size, operational, and safety issues. FAA conducted limited testing for checked baggage application in 1993 and it is now considering a new project for screening air cargo. TSWG is funding a counterterrorism application.	$8 to $10 million	$19 million (DOD) $ 5.3 million (FAA) $6.2 million (TSWG)
Pulsed Fast Neutron Radiography	Also uses an accelerator to generate fast neutrons to probe bags; measurement of the transmitted neutron spectrum is used to detect explosives.	FAA has two ongoing projects and now believes technology might be more suitable for screening air cargo or containerized checked baggage than individual bags.	NA[b]	$3.5 million (FAA)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Gamma Ray Scanning (Up to 10 MeV)	System is designed for propane and other gas or liquid tanker trucks but is adaptable to scan railcars. While open and unsheltered, system requires a radiation permit to operate.	Prototype being evaluated by DOD and Customs.	About $400,000	$382,000 (ONDCP)
X-Ray				
High energy, fixed-site systems (5 - 10 million electron volts—MeV)	Systems are designed to scan loaded trucks/containers and have throughput of 12-25 per hour depending on configurations. Required extensive shielding, radiation permit, and FDA permit if used on food. System relies on operator's interpretation of the X-ray images.	Commercially available. DOD completed the project in Tacoma, Washington, but system was not transitioned to Customs due to Customs' concerns with cost, safety, and operational issues.	$12 to $15 million	$15 million (DOD) $224,000 (Customs)
Low energy fixed-site system with backscatter (450 thousand electron volts—KeV)	System is designed to scan empty trucks or containers. Throughput is about six trucks per hour. Relies on operator's interpretation of the X-Ray images.	Commercially available. Customs has deployed one machine at Otay Mesa, California, and plans to deploy up to 11 more along the Southwest border.	$3 million	$3.7 million (DOD)
Mobile/relocatable systems (450 KeV to 2 MeV)	Systems are designed to scan empty or loaded trucks and containers depending on the energy level and to complement the fixed-site X-ray systems. A 1 MeV system is designed for aircraft size cargo containers. May also be useful for scanning passenger vehicles.	DOD is testing 450 KeV system and still developing machines at other energy levels.	$1.75 to $6 million	$10.8 million (DOD)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Electromagnetic				
Magnetic Resonance	Radio frequency wave probes objects, except that a magnet aligns hydrogen atoms prevalent in liquids. Abandoned FAA prototype for checked baggage was modified for Customs to scan frozen shrimp packages. Machine short-circuited during storm and Customs decided against spending for machine repair.	Abandoned machine is in storage at major Southeastern seaport.	NA[b]	$130,000 (Customs)
Trace				
Vapor/Particle Detection systems	Systems are based on gas chromatography, chemiluminescence, mass spectroscopy, surface acoustic wave, ion mobility spectroscopy, and biosensor technologies. Sample collection steps are highly critical for the effectiveness of systems. Most existing systems use vacuum or wiping with a swab. Most existing systems are not currently capable of detecting the extremely low vapor pressures of cocaine and heroin.	Many commercially available. DOD is developing some prototypes for use by Customs.	$2,500 to $170,000	$240,000 (Customs) $2.4 million (TSWG) $4.7 million (DOD)

(continued)

Technology	Characteristics	Status	Unit Price Range	Funding (FYs 78-96)
Barometric chamber with chemiluminescence detector	System differs from other vapor detectors in that it draws air sample from a barometric chamber into which the object to be inspected has been shaken and subjected to heat cycles. System automatically alarms if explosive is detected. System may not work on a tightly sealed object.	Under development by FAA. A fieldable prototype is expected to be tested by October 1996.	NA[b]	$1.8 million (TSWG)
High volume sample collection with a biosensor detector	System concentrates 400 litres of air to .5 cc of liquid. Biosensor specifically identifies the explosives detected. System is suitable for use in cargo holds and interiors of aircraft, etc.	Under development by FAA.	$35,000 to $42,000	$1.3 million (FAA)

[a]The Funding column indicates whether a specific technology was developed or is being developed for explosives detection, narcotics detection, or both. Genrally, FAA and TSWG funding has supported explosives detection, while funding by DOD, Customs, and ONDCP has supported narcotics detection. Where a technology funding cell shows FAA or TSWG in combination with DOD, Customs, or ONDCP, that technology is generally capable of detecting both narcotics and explosives.

[b]Not available.

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