Technical Problems Slow Development and Approval of U.S. Airport Explosive Detection Systems

The FAA should purchase current off-the-shelf systems for use by U.S. air carriers at three or four non-U.S. airports, where the FAA believes the threat to aviation is greatest, according to an official U.S. report.

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A report by the U.S. General Accounting Office (GAO) on the status of efforts by the U.S. Federal Aviation Administration (FAA) to have new explosive detection equipment in place at airports has resulted in recommendations to the Secretary of the U.S. Department of Transportation (DOT) regarding airport testing of the performance and reliability of new explosive detection devices, the evaluation of software when reviewing system design and the placement of greater emphasis on integrating devices during development.

After the terrorist bombing of Pan American Flight 103 in 1988, the U.S. Congress passed the Aviation Security Improvement Act of 1990, which required the FAA to accelerate research and development of new technologies to protect civil aviation from terrorists. The act set a goal for the FAA to have new detection equipment in place by November 1993.

"[The] FAA has made little progress toward meeting the act's goal for deploying new explosive detection systems," the GAO report said. "Although several devices show promise, technical problems are slowing the development and approval of devices. [The] FAA's Aviation Security Research and Development Scientific Advisory Panel estimates it could take [the] FAA two to five years to approve new devices for airlines' use."

The GAO also criticized the FAA for not having "a strategy that articulates important milestones, [that] sets realistic expectations, and [that] identifies resources to guide efforts for implementing new explosive detection technology."

The FAA is responsible for the safety and security of civil aviation in the United States and plays an important role in the development of new security technology. "To develop new

security technology, [the] FAA (1) establishes performance standards for equipment, (2) selects the mix of technologies for development, (3) provides oversight and technical assistance to contractors, (4) tests equipment to ensure that it meets the performance standards, and (5) certifies (approves) the equipment as suitable for airlines' use," the report said.

As a result of the Aviation Security Improvement Act of 1990, the FAA has been provided with about US$130 million for security research. In 1989, the FAA's security research, engineering and development (RE&D) funding was $9.9 million. In 1994, the funding was $35.9 million. The FAA Technical Center in Atlantic City, New Jersey, is responsible for administering the security RE&D program.

The FAA research program is covering a range of efforts. "Before the Pan Am 103 incident, [the] FAA focused primarily on developing weapons detection systems and the thermal neutron analysis device," the report said. "Currently, [the] FAA is helping to develop new explosive, weapons, and trace detection systems and methods to increase aircraft survivability. It is also conducting research on human factors and on the security of FAA and airport facilities."

The report added: "The airline industry is skeptical about [the] FAA's ability to develop effective explosive detection systems because [the] FAA was previously unable to develop an effective thermal neutron analysis device. The airline industry criticized [the] FAA for not rigorously testing this equipment before mandating its use. Thermal neutron analysis had dominated [the] FAA's RE&D expenditures in the mid-1980s. In 1985, [the] FAA awarded a design contract and in 1988 awarded a production contract for this equipment. [The] FAA purchased six machines for airport testing and intended to require U.S. airlines to deploy the systems at domestic and international airports over a five-year period, at an estimated cost of about $897 million.

"In its May 1990 report, the President's Commission on Aviation Security and Terrorism objected to the deployment of thermal neutron analysis devices because the equipment could not, without an unacceptably high rate of false alarms, detect the amount of material widely believed by investigators to have destroyed the Pan Am 103 aircraft. … [The] FAA continues to test the thermal neutron analysis device because, according to officials, it is the only device that can detect all types of explosives as specified in [the] FAA's requirements and is 'still as good' as any other automated device when processing over 500 bags per hour."

In 1993, the FAA published standards for new explosive detection systems for checked baggage. These standards require the new systems to detect different materials and smaller quantities of explosives than current airport systems. "Current airport X-ray systems can detect only metal objects — not sophisticated plastic explosives," the report said. "Pan Am 103 illustrated the need for security devices to detect small plastic explosives. The plastic explosive suspected in that incident is virtually odorless; difficult to detect; [and] can be molded into a shape that appears as a common, harmless item on X-ray screens and placed in baggage lining."

The new FAA standards require the new detection equipment to rapidly screen baggage for explosives with a high detection rate and a low false alarm rate. To speed baggage screening, the FAA wants automated explosive detection systems that will initially detect the explosives and sound an alarm so a human operator can screen the baggage.

The GAO report stated: "[The] FAA, the [U.S.] National Academy of Sciences, airline industry representatives, and others agree that no single explosive detection device can currently meet all of [the] FAA's new requirements for screening checked baggage. … [The] FAA is focusing on the development of two types of devices: (1) bulk detection devices, including X-ray and nuclear projects that screen baggage for explosives and weapons, and (2) trace detection devices that 'sniff' baggage, people, and electrical items for chemical particles used in explosives."

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As of December 1993, the FAA had 40 research explosive detection projects, including 14 prototype units, four of which are suitable for screening checked baggage. "Our review of the developmental status of the 14 prototypes showed that nine had been delayed — by one to 18 months — because of technical problems," the report said. "Furthermore, [the] FAA had conducted laboratory tests on only seven devices; none fully meets [the] FAA's performance standards. Airline security experts who are familiar with [the] FAA's program are concerned about the agency's lack of progress, and one official noted that [the] FAA has not approved a single device for screening checked baggage that differs from the equipment in use before the Pan Am 103 incident."

There are advanced X-ray devices that can detect more sophisticated explosives; however, these devices are too slow or have high false alarm rates. "According to Air Transport Association (ATA) officials, these deficiencies could cause delays in processing baggage that would have a devastating effect on airlines' ability to dispatch aircraft on time," the report said.

The GAO report cited the following four examples to illustrate the types of problems experienced by the FAA with the new X-ray technologies:

- "In March 1993, [the] FAA tested a computerized X-ray system that cost about $4 million to develop. This project was delayed about one year because the equipment was too slow in processing baggage. [The] FAA is continuing to refine this system to increase its speed and efficiency. According to FAA officials, this is the most promising technology to date."

- "[The] FAA spent about $4 million to develop a coherent X-ray scatter system. This project was delayed about one year because the equipment did not meet [the] FAA's criteria for detecting specific amounts of explosive materials. [The] FAA has decided to stop work on this contract, but officials believe the technology shows promise and will continue to pursue it at a later date."

- "[The] FAA has invested about $2.1 million in a multiview, dual energy X-ray system, but the system has a high false alarm rate. As of July 1993, this project was on schedule. FAA officials told us that recent upgrades in the device's hardware and software have improved performance."

- "[The] FAA tested a high-resolution X-ray system in its laboratory and at two airports. A contractor provided the equipment at no cost to [the] FAA to conduct the tests. Although [the] FAA found that this equipment demonstrated better detection capability than that currently used at airports, it had a high false alarm rate."

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The FAA is also reviewing the use of nuclear and trace technologies for explosive detection. "At the end of fiscal year 1993, [the] FAA had spent over $20 million on nuclear technologies but, aside from research data, had little to show for the investment," the report said. "[The] FAA's research shows that current nuclear technologies are too expensive, too large, and much too heavy for use in airports. After spending about $11 million over five years on a nuclear resonance absorption project, the biggest investment in any one technology, FAA canceled the project in July 1993."

The U.S. National Academy of Sciences concluded that using trace technology as a primary screening device is not effective because these devices may have high false alarm rates and are not suitable as a primary method for detecting explosives in checked baggage. "FAA officials believe that trace technology may ultimately prove useful in detecting explosives on individuals or in small objects," the report said. "[The] FAA is working to develop protocols for a trace detection system for carry-on baggage as well as a trace portal system for screening passengers."

The report added: "In April 1993, [the] FAA conducted a detailed review of eight trace systems. [The] FAA concluded that four systems may have future potential, but it is considering canceling the other four projects (whose total costs exceed $5.6 million). Meanwhile, [the] FAA plans to award a $1.6 million grant to a university to continue research on the use of dogs to detect explosives."

Another part of the FAA's responsibility is to protect commercial aircraft from an internal explosion. "[The] FAA's security RE&D program includes research on blast-resistant luggage containers and techniques to harden aircraft structures," the report said. "Because [the] FAA does not fully understand the specific amounts, types, and locations of explosives that may cause catastrophic damage to commercial aircraft, the agency has started to gather empirical data on the vulnerability of aircraft to explosives. If [the] FAA finds that an aircraft cannot be made to withstand an explosion, then detection devices will have to be as or more sensitive than [the] FAA now requires."

The FAA has budgeted $27 million through 1998 for research on blast-resistant luggage containers, to assess the vulnerability of aircraft to different types and quantities of explosives, and to identify techniques to harden aircraft structures to withstand explosions. "Although [the] FAA may complete its efforts to develop more blast-resistant luggage containers in fiscal year 1994, it will probably not demonstrate its efforts to harden structures until the next generation of aircraft enter service," the report said.

The FAA began testing prototype blast-resistant luggage containers in 1992. Initial tests indicate the feasibility of containing the effects of an explosion. The airline industry is concerned about the cost, weight and durability of these containers. The GAO stated that "the containers that [the] FAA is testing would add an average of 3,200 pounds [1,451 kilograms] to an aircraft's weight, thereby increasing fuel usage and operating costs. [The] FAA is conducting research to reduce the cost and weight and ensure the durability of the containers."

Another problem with the blast-resistant containers is their size, which limits the use of these containers to wide-body aircraft. About 29 percent of aircraft worldwide are wide-body aircraft. "However, nearly 75 percent of the 57 bombings known to have taken place between 1971 and 1991 occurred on narrow-body aircraft that do not use containers to store checked baggage," the report said. "Therefore, it is questionable whether hardened containers will have a major impact on increasing aircraft survivability until more wide-body aircraft

are in service. FAA officials also pointed out that in about half of all successful bomb attempts, the device was not placed in the cargo hold."

The FAA believes the hardened containers could still be effective, because most aircraft flying from Europe (a high-threat region) are wide-body aircraft. Some narrow-body aircraft may be able to use the new containers, and the United Kingdom is conducting research on containers for narrow-body aircraft, the report said.

A gradual phase-in of the new containers could be accomplished as airlines replace the current plastic and aluminum containers. Current containers have a useful life of four years. The report noted: "Some FAA officials believe that airlines will purchase the new containers without [the] FAA's mandating their use if questions about the containers' cost, weight, and durability can be resolved."

The FAA is also conducting an analysis of how explosions affect commercial aircraft structures. This analysis, known as vulnerability assessment, will direct future efforts on aircraft survivability but will not be completed until 1996. Aircraft survivability improvements could include special linings in baggage compartments, special composite materials to harden aircraft structures, blow-out panels in the airframe and protection for such critical subsystems as flight controls, the report said.

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In support of this effort, the FAA awarded a $3.8 million contract to the U.S. Air Force to assess the vulnerability of commercial aircraft and to provide assistance in developing a plan to implement new techniques. The Air Force is also conducting explosive tests on retired military aircraft to better understand how explosions affect structural integrity.

The GAO added: "[The] FAA has been trying to obtain design data from aircraft manufacturers to assess the vulnerability of commercial aircraft to explosions. However, the manufacturers, who claimed that aircraft design data represent proprietary information, were initially reluctant to provide the data to [the] FAA, thereby delaying the program about one year. To resolve the problem, [the] FAA sponsored the formation of the National Institute for Aerospace Studies and Services that comprises three aircraft manufacturers. In 1993, [the] FAA awarded the group a $1.6 million grant to assess the vulnerability of a wide-body aircraft to an internal explosion."

The report expressed concern that even if new aircraft-hardening techniques are developed soon, these techniques will not be able to be incorporated into new aircraft such as the Boeing 777, which is expected to be certificated in 1995.

Concerns have been expressed that the FAA has not proposed any immediate or near-term solutions. The GAO cited a report by an FAA scientific advisory panel: "A terrorist attack could occur at any time and it is only a matter of time until a new terrorist act against civil aviation involves the significant loss of American lives. No new devices will be available in the foreseeable future that are both 100 percent effective and reliable. [The] FAA could take an additional two to five years to approve equipment for airlines' use under its existing process. [The] FAA could use commercially available equipment as an interim threat response measure."

The advisory panel recommended that the FAA purchase explosive detection systems for use by U.S. air carriers at three or four foreign airports, where the FAA believes the threat is greatest, and 200 hardened luggage containers at a total cost of $10.4 million, the report said.

The GAO concluded that the FAA should adopt a dual-track strategy that "could test commercially available equipment at airports while also continuing to develop, evaluate, and certify advanced explosive detection equipment and methods for improving aircraft survivability." The report also recommended that the FAA "assess the effectiveness of commercially available explosive detection equipment for screening checked baggage by acquiring and testing such equipment at a limited number of domestic airports."

It added: "[The] FAA concurred with our recommendation concerning the testing of commercially available technology for screening checked baggage, but noted that recent tests conducted at a foreign airport indicate that such equipment did not perform as well as expected."

The FAA also agreed that there have been obstacles in developing new explosive detection technology, but "pointed out that the development of new detection equipment requires significant research and entails considerable risk. Technologies that appear to have promise in the early stages of development may eventually prove ineffective. Some technologies turn out to be cost- or size-prohibitive."

The GAO said it identified several weaknesses in the FAA's process for certifying new explosive detection equipment: "[The] FAA's process does not include testing the new systems at airports as a condition of certification, [the] FAA's performance standards do not set reliability criteria for new devices, and [the] FAA has not developed performance standards for trace technology."

With regard to testing new systems at airports, the GAO said it observed that "during … [the] FAA's tests on four

devices at Miami International Airport, which were conducted in the baggage area underneath the terminal, we noted heat, humidity, and dirt — factors that can and did affect performance and reliability."

The FAA, as an alternative to conducting its own certification tests, requires contractors to test equipment at airports and to submit the results to the FAA. The GAO found several weaknesses that could affect the outcome of the results:

- "First, [the] FAA expects the contractors to screen passengers' baggage. The contractors will not test baggage with either real or simulated explosives. Therefore, the contractors cannot provide [the] FAA with data on the equipment's detection performance."

- "Second, [the] FAA does not require contractors to use a prototype model representative of a production unit or to gather data on the equipment's reliability as part of the test. An FAA official told us that the performance and reliability of a laboratory model could differ significantly from those of an advanced prototype."

- "Third, [the] FAA does not plan to witness any of the tests to verify the results."

The report also found that "[the] FAA does not plan to test the detection equipment's reliability during the certification process and did not include specific criteria for reliability in its certification standard. Therefore, [the] FAA cannot assure airlines that equipment will operate without failure for a reasonable period of time and will not disrupt airport operations."

Trace detection technology is also being considered by the FAA, but performance standards to evaluate the ability of this technology to detect explosives are difficult to develop. The U.S. National Academy of Sciences has advised the FAA that the equipment needed to test trace detection devices is not available, the report said.

"Although [the] FAA has not defined performance standards for trace detection equipment, it plans to invest about $5 million in fiscal year 1994 on such devices," the report said. "FAA officials noted that although concerns exist about the feasibility of using trace detection technologies to screen checked baggage, such devices show promise for screening passengers, carry-on baggage, and electrical items. DOT officials are concerned that [the] FAA is attempting to develop this technology without providing vendors with specific performance requirements for its development."

Several weaknesses were also identified in the FAA's security RE&D program that the GAO said hindered its ability to guide investment decisions and to speed the development of new technology. The report said: "[The] FAA does not conduct software reviews to evaluate automated functions that control the performance of equipment, [does not] give sufficient attention to integrating different technologies into a synergistic system, and [does not] place adequate emphasis on human factors when developing new detection devices."

The report criticized the FAA for reviewing features of hardware design without determining whether the system's performance can be optimized and development costs reduced by changing the software's design. The report also noted that personnel within the FAA security RE&D program lack the necessary expertise to evaluate software.

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Systems integration could overcome some of the shortcomings of individual detection devices, the report said. "For example, a device that is slow in processing baggage but can reliably detect explosives can be combined with one or more devices that are faster but more prone to false alarms. If the bag sets off an alarm, then the slower but more effective device can be used to investigate the baggage. However, [the] FAA is not emphasizing integration because the agency believes this task should be left to the airlines to perform."

The GAO report raised several concerns about the ability of the airlines to decide which devices meet their needs. One of the concerns was "whether the airline industry has the financial resources to conduct the analysis and research needed to craft an acceptable system."

Human factors was the third critical area in the FAA's security program outlined by the report. The FAA plans to automate new airport screening devices. Nevertheless, the report found that it was unlikely that human screeners could be replaced in the near term. In an effort to double its human factors effort, the FAA plans to examine and enhance the proficiency of screening personnel, the report said.

In January 1994, the FAA formed an in-house task force to accelerate its short-term efforts to approve new explosive detection equipment. "This task force will (1) assess current explosive detection technology, (2) develop information for certification testing, and (3) simulate, through computer modeling, explosive detection systems and their impact on airport operations," the report said.

The GAO made three recommendations to the FAA to improve its certification process for new explosive detection technology:

- "Require operational tests of the performance and reliability of explosive detection systems at airports during certification."

- "Include reliability criteria in the certification standards during certification."

- "Discontinue the development of trace technology for screening checked baggage until certification standards have been established."

To improve the FAA's security RE&D program, the GAO made three additional recommendations:

- "Evaluate software when reviewing systems' designs."

- "Place greater emphasis on integrating devices when initiating developmental projects."

- "Focus on human factors associated with using new devices, especially on how operators will work with the new technology, through the development process."

The report provided a summary of the FAA's comments on the GAO's conclusions and recommendations: "[The] FAA did not concur with the need to test new explosive detection devices at airports as part of the certification process. FAA officials noted that passenger activity, distractions, and stress situations common to the airport operating environment are extraneous variables when testing fully automated equipment; indeed, their existence is the reason that [the] FAA requires new systems to be automated."

The FAA also disagreed that reliability criteria should be part of the certification standard. "FAA officials said that the issues of equipment availability, reliability, maintainability, and operating efficiency are not fundamental to their certifying the detection capabilities of the equipment," the report said.

The FAA concurred with the GAO's recommendation that the development of trace technology be discontinued until standards for that technology have been developed. "However, FAA officials noted that trace technologies may prove useful for screening passengers and some carry-on items," the report said.

The report added: "Although [the] FAA agrees that software plays a critical role in the new detection equipment, it

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disagrees with our recommendation that it should evaluate the software of new explosive detection devices. [The] FAA believes that the industry should be responsible for evaluating the software systems that perform explosive detection system functions."

The FAA concurred with the GAO's recommendations to place greater emphasis on systems integration and on human factors in developing new detection technology. However, the GAO noted: "FAA officials did not believe that our report had provided adequate information on their new initiatives to develop detection technology."

The GAO report expressed concern about airline industry costs of purchasing and operating new detection devices, which could range from US$250,000 to over $1 million per device. The report concluded that airlines cannot plan or budget for new security equipment because the FAA does not have a plan or strategy to guide either government or industry efforts.

The report said airline officials were interviewed and expressed several concerns about the cost of purchasing new equipment:

"Because new devices probably will have to be used in combination, the costs of a single integrated system could be significant; in excess of $2 million at one location, at one airport," the report said. "At one foreign airport, a contractor is testing a system that cost about $500,000, according to FAA officials.

"Second, airline officials point out that costs for explosive detection equipment will have to be considered at each airport (both domestically and internationally) at which [the] FAA requires screening of checked baggage. Furthermore, a DOT official pointed out that problems with reliability may force airlines to acquire significant numbers of back-up systems to ensure that equipment is available to screen baggage.

"Lastly, airline security officials recognize that explosive detection technology is evolving and that improvements will continually need to be made and, perhaps, mandated by [the] FAA. Airline security experts are concerned that [the] FAA may mandate the use of one system and one to two years later mandate the use of another."

Because the airline industry is concerned about the costs of new explosive detection equipment and the aviation community has little experience with the technology, the GAO said that the FAA should guide the industry with a plan that:

- "Articulates [the] FAA's role in developing and assisting the industry in implementing new technology."

- "Sets milestones indicating when airlines should be prepared to purchase and implement new equipment."

- "Identifies foreign and domestic airports that will be earmarked for priority implementation."

- "Lists contingency equipment that the airlines could use if an urgent threat arises."

- "Outlines anticipated procedures for using new equipment in the general framework for aviation security."

- "Identifies the government and industry resources (staffing and costs) needed to implement the new equipment."

In the past, airlines have been responsible for purchasing explosive detection equipment. In an effort to provide some relief from the high cost of purchasing this equipment, the U.S. Congress is considering legislation that would allow airports to purchase explosive detection equipment with Airport Improvement Program (AIP) grant funds. The GAO report cited three issues that would have to be resolved for this to occur.

First, the Federal Aviation Act of 1958, as amended, makes airlines (not airports) responsible for screening passengers and baggage. "FAA officials told us [the GAO] that airlines would have to enter into agreements with airports to use the equipment while maintaining the responsibility for screening passengers and baggage."

Second, the report said that the proposed legislation does not include the eligibility requirements for airports to purchase explosive detection equipment with AIP grant funds.

"Lastly, the impact on AIP grant funds could be significant. AIP provides airports with funds to enhance their capacity and safety, mitigate noise, and improve security. AIP has funded almost half of the $500 million in costs for airport computer access and control systems since 1989. Because [the] FAA has not analyzed the costs associated with new explosive detection equipment, the financial impact of acquiring this equipment is unknown," the GAO said.

The report also said that the FAA concurred with the recommendation to develop a plan to implement all new technology. The FAA strategic plan "provides a 'rough sketch' of both short- and long-term efforts in security research, and they have recently completed a list of contingency equipment that airlines could use if an urgent threat arises," the GAO said.

On the subject of costs the report said: "According to FAA officials, the airlines will find it difficult to accept the acquisition and life-cycle costs for new explosive detection systems, and airport authorities have already raised concerns about the difficulties they may encounter in installing new systems in existing terminal facilities. They acknowledged that the costs to the airlines for new devices will be significant. Therefore, [the] FAA expects that any mandate to use the new devices that are not funded by the government will meet stiff resistance from airlines. FAA officials noted that in the past, airlines and airports had resisted participating in demonstration projects fully funded by the FAA."

The GAO concluded that "the sooner [the] FAA provides the industry with such information, the sooner airlines and airports can begin to plan, budget resources, and set aside the necessary space for new equipment." ♦

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