Checking in with New Bomb Detection Strategies

by Mike Ellenbogen

On December 21, 1988, the unforgettable bombing of Pan Am Flight 103 in the sky over Lockerbie, Scotland, claimed the lives of 259 passengers and eleven victims on the ground. More than seven years later, airlines and regulators are still struggling with how best to protect passengers from the threat of terrorist attempts to plant explosives.Detecting explosives is more difficult than detecting weapons, because explosives are not metallic and do not appear in predictable shapes. Explosive materials can be easily molded into shapes that resemble common travel items such as food or plastic bottles. These substances are virtually impossible to detect with standard x-ray technology. Even the more advanced color x-ray inspection systems have proven ineffective for detecting explosives.

Progress is being made, however. Several promising technologies are being developed; some are already in daily use. But faced with the knowledge that no system yet provides an impenetrable shield, nations have taken distinctly different approaches to the problem.

The United States. In the United States, the Federal Aviation Administration (FAA), in accordance with congressional directives, has developed a set of criteria that bomb detection technologies must meet before they can be certified. The rules establish performance thresholds that detection technologies must achieve (the specific types, amounts, and configurations of explosives that must be detectable under the criteria are classified).

By law, the FAA cannot mandate use of any bomb detection systems until systems exist that meet the criteria. Given the testing time lines, a government mandate for system installation is not imminent.

To date, only one technology, a machine using computed tomography (CT), which is derived from medical CAT scan x-ray technology, has been certified. That system, CTX 5000 by InVision Technologies, Inc., is still being tested in airports to determine how it will function in the field and to assess probable installation and operating costs.

United Airlines was the first domestic-based carrier to begin trials in the United States. These tests took place in November 1995, at San Francisco International Airport. Delta Air Lines will be next, beginning in the early spring of 1996, at Hartsfield Atlanta International Airport. This experiment will be ongoing during the 1996 Summer Olympic Games being held in Atlanta. In addition, a test will be carried out by Northwest Airlines in Manila, Philippines.

Each of these tests, which will last about one year, will help refine the integration of certified explosives detection systems into existing baggage handling systems and verify the total estimated costs of wide scale deployment of such systems.

The FAA is still exploring if and when such systems might be deployed and how widespread that deployment might be. At the same time, in search of faster, cheaper solutions, the FAA is in the process of awarding grants to help companies explore the next generation of computed tomography technology. That process, including development and testing, is expected to take about twenty-four months.

A number of other technologies are also at some stage of development or testing. For example, at least two manufacturers, Vivid Technologies, Inc., and EG&G Astrophysics, are working with dual-energy or dual-beam x-ray technology in which luggage is subjected to two different x-ray energy levels to calculate the atomic composition, density, and other characteristics of objects in the bag. Computerized analysis of the data alerts operators to suspect materials that operators or other technologies can then further examine.

Backscatter technology offers a variation on this theme. In addition to transmitting an x-ray beam through the luggage, it places a receiver on the same side of the bag. The x-rays, which are scattered back, are then analyzed by a computer program. As with the dual-energy technology, a series of algorithms makes computations based on density readings and other factors to determine whether a material is suspect.

Backscatter technology is already used successfully by U.S. Customs Service personnel. The FAA has found it particularly effective for detecting items placed close to the surface of a bag, which other technology is not as adept at detecting, and several manufacturers are exploring backscatter in conjunction with dual-energy technologies.

Another detection method being tested is quadrupole resonance (QR) technology, derived from magnetic resonance imaging used in hospitals. In this case, the elements in a bag are subjected to radio frequency energy rather than x-ray beams. Each material sends back a unique signal rather than an image.

One such system manufactured by Quantum Magnetics completed a field trial at Los Angeles International Airport in early December. That test, explains Llowell Burnett, the company's chief technical officer, was to determine whether the system could function in a real airport setting, without being affected by such factors as radar signals. This trial was not a test of speed (baggage throughput rates), as the luggage was manually loaded. The company plans to test baggage handling speeds along with other factors during its second field trial to be carried out at an airport in the United Kingdom. That test may be completed as early as this month. (Separately, the company is also having a smaller version of the system tested as a potential screening device that could be used by any company for mail packages in an office environment.)

According to Norman E. L. Shanks, head of group security for BAA plc, which manages several UK airports, QR looks promising at this stage but more data needs to be collected. After the UK tests, says Burnett, the company will determine how to proceed to meet the FAA certification standards.

The above technologies are being developed for screening checked baggage. For passenger screening, the FAA is exploring related technologies for use in walk-through portals. For example, they are working with two companies in the developmental stage to combine trace detection technology with metal detection for simultaneous weapon and bomb detection. Airport testing of at least one model is anticipated in late 1996 or early 1997.

The human factor. The FAA, through its Aviation Security Human Factors Program, is also researching ways to enhance the selection, training, and performance of security personnel who must operate explosives detection systems. Trials will involve the purchase, installation, and testing of various training and performance systems. Operational and cost data will be collected and analyzed to assess results. The demonstrations, to be conducted at the nineteen category X (high traffic) U.S. airports, are scheduled to begin in 1996.

Currently, the cognitive skills and processes for optimal detection of threat objects are poorly understood. Embry-Riddle Aeronautical University is developing a screener selection test battery that could be used to predict successful screener performance in the field. The tests examine two types of visual perception: the ability to detect hidden patterns and the ability to detect hidden figures. Tests will be given to job applicants prior to selection. The predictive validity of the results will be determined by correlating applicant preemployment scores with on-the-job performance.

A trial of the test's predictive validity for operators using conventional x-ray equipment is currently underway at the Chicago O'Hare Airport. A comparable test of the predictive capabilities for operators using CT technology will be conducted once that equipment is operational at the demonstration sites mentioned earlier.

The effectiveness of screener training methods will be evaluated by comparing the threat detection performance of personnel before and after training sessions. To make such a comparison, validated baseline data that accurately capture screener capabilities are needed. efforts are underway to determine the baseline performance of x-ray screeners faced with the job of detecting improvised explosive devices. These tests consist of a computer presentation of many digitized x-ray images, some of which contain improvised explosive devices. A similar test of performance using CT equipment will be performed.

Research is also being conducted regarding methods that might counteract normal human failings, such as inattention from repetition. Screener attention levels and detection performance have been found to degrade over time. An operational test will be conducted to determine if fictional threat objects can be used to motivate screeners and maintain screener attention and performance levels over time. The FAA is operationally testing a system called Screener Proficiency Evaluation and Reporting System Threat Image Projection (SPEARS TIP), which places an x-ray image of a fictional threat object onto the x-ray image of a bag actually being examined. After the SPEARS TIP device meets FAA functional requirements, it will be field tested at category X airports.

Currently, only a few manufacturers of x-ray equipment provide machines compatible with the SPEARS TIP device. To address this constraint, a feasibility study is being done on developing an interface so these devices can be connected to conventional x-ray machines.

Europe/United Kingdom. In Europe and the United Kingdom, airlines and regulators have taken a more incremental approach-installing the best currently available technologies and hoping to upgrade those systems as improvements are developed.

England has taken the lead with a regulatory goal of screening 100 percent of checked baggage by 1996. Their rationale is simple. If a technology can provide a significant improvement over the existing system and procedure, it should be used until the next significant advance in performance is achieved. "The legal framework in the U.S. works against this equipment being deployed because it is not certified, whereas within the U.K. and Europe, the view is being taken that...while it's being used, it will be developed further," explains the BAA's Shanks, "so that in time the security performance will be improved as part of the exposure into the operational area."

To meet the 100 percent goal using conventional or enhanced x-ray systems, the United Kingdom's regulatory authority ruled that at least 10 percent of all checked baggage must be hand searched. However, the hand search requirement would be waived if advanced technology systems became available.

With this incentive, airport operators throughout England have been exploring their options, such as the use of advanced "smart" x-ray systems that could be fully integrated into existing airport baggage handling systems.

One such integrated hold baggage screening scheme has been developed as a joint effort between BAA and Vivid, using the dual-energy x-ray technology mentioned earlier. The BAA is working with other manufacturers as well. Several of these systems have been in daily use in airports throughout the United Kingdom since 1993.

Similar implementation programs are in progress in virtually every European nation. The thirty-two-member European Civil Aviation Conference (ECAC) coordinates civil aviation security procedures for its members as well as for the European Union.

The thirty-two members of the ECAC are at various stages of implementing the 100 percent checked baggage screening programs, with many of them already screening a significant percentage of international baggage. Systems are screening baggage at Aberdeen, Amsterdam, Brussels, Edinburgh, Gatwick, Glasgow, Heathrow, Stansted, Southampton, and Zurich international airports.

In each of these cases, baggage is screened after check-in while it is en route to the aircraft. BAA's Shanks says that in addition to the main issue of detection levels (which aren't openly discussed), they are grappling with throughput and tracking.

Government, industry, and the manufacturers have been working together to perfect the process of moving bags through the line, fully integrating the detection technology into the existing baggage handling system "in such a way that would not reduce the existing baggage handling capacity," explains Shanks. It is also critical, he notes, "that once the bag has gone through the x-ray screening process, that we know exactly where it is at any point on that belt, so if we have to pull it off at some point for a further stage of screening, we can do that with 100 percent accuracy. "

Tracking is at the heart of a five-step screening process in use by BAA and other UK airport operators. In step one, all checked baggage where the systems are already in place go through initial screening, as with the dual-energy x-ray technology, automatically while en route through the handling system.

In step two, any bags designated as suspect are examined by a human operator. This second level of inspection can operate at a slower belt speed since it is only being used to examine bags rejected by the automated level-one system. Often, with a slower belt speed, higher image quality can be achieved for operator assisted screening.

Level two focuses the operator on the specific threat object, enabling more accurate and efficient inspection of the bag. The operator inspects the bag for additional components present in a functional explosive device, such as detonators, wires, batteries, and timing devices. The vast majority of bags are cleared by the level-two operator and sent on to the aircraft.

The industry recognized early in the development of the integrated screening approach that bags need not be subjected to the x-ray process at level one and again at level two. If the data from the level one inspection can be viewed by an operator at level two, the second x-ray system can be eliminated.

Matrixed workstations in the Vivid system, for example, allow the level-two operators to inspect bags rejected by the automated level-one system "on-the-fly, " or while the bags are en route to the aircraft. The system's configuration eliminates the need for a second conveyor belt or duplicate screening-reducing installation costs and additional space requirements.

The x-ray mainframe at level one continues to automatically screen bags while the operator uses the workstation for level-two inspection. Alarms from multiple level-one mainframes are dynamically distributed across a pool of level-two operators. The server communicates the results of the level-two inspection to the baggage handling system.

If the bag is not cleared by the human operator at level two, it is diverted to level three, where it is subjected to additional screening with trace detection technology or computed tomography, for example. As mentioned earlier, in the United States CT is the only FAA-certified technology. But it is slow. For that reason, Shanks says, "we see it very clearly as our third-stage" tool rather than as a technology for use in a high-volume level-one system.

In step four, a suspect bag is reconciled with the passenger if necessary and opened in front of the owner. Step five entails the treatment of problem luggage not given the green light through any of the prior steps.

Traditional hold baggage screening methods require multiple conventional x-ray imaging systems within the terminal building, in addition to a large staff of trained operators. This approach is not only expensive, but subjects passengers to an additional screening process and consumes a considerable amount of valuable floor space in the terminal that can be better used for retail and passenger service. Detection systems that are fully integrated into the existing baggage handling system save time and space. A single operator can effectively man each line, thereby significantly reducing recurring costs.

Putting detection technology into existing baggage handling systems has been a challenge, says BAA's Shanks, but it is working. "We've proved those [technologies] sufficiently to start preparing feasibility studies for those locations which we still need to introduce the screening in."

From the UK perspective, the view is "the equipment is out there," explains Shanks. "It is available. It is working very efficiently on a daily basis."

Back in the United States, the House International Relations Committee has asked the General Accounting Office to review bomb detection technology as part of a larger look at technologies that can be used to fight terrorism and drug trafficking. They plan to examine the threat scenario, the state of the technology, cost and performance issues, and whether government agencies are effectively coordinating research and development efforts. That report will not be completed until the fall, after which the committee will consider whether to hold hearings or take other action. In the meantime, checked baggage in the U.S. continues to go unscreened.

Mike Ellenbogen is marketing manager, Vivid Technologies, Waltham, Massachusetts. John E. Otto, director of corporate security for Delta Air Lines, Inc., Atlanta, Georgia, contributed to this report. Otto is a member of ASIS.