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Explosives Detection Keeps Pace With Modern Technology

Sniffers, based on nuclear physics or the nose of a well-trained dog, are used to protect aircraft passengers against terrorist bombs. Unfortunately, military and intelligence organizations continue to create materials for clandestine operations — explosives that cannot be detected.

by

Frank G. McGuire
Editor and Publisher
Security Intelligence

Explosives detection technology is currently epitomized by the backscatter X-ray system used by the U.S. Secret Service at the White House and used by other nations for equally important security screenings.

There are also sniffers and particle-detection devices that analyze air samples surrounding a package or container. These are used at many embassies, airports and other critical worldwide locations for explosives detection, as distinguished from metal weapons detection, which almost any X-ray machine can accomplish.

The next generation of explosives detection technology is likely to be a highly advanced device that once would have been limited to a scientific laboratory. In the future, dozens of such inspection units could be in service at each major airport, and at least one machine in smaller airports to supplement existing X-ray machines.

Detection Technologies Create Bewildering Choices

At a professional conference on explosives detection several years ago, someone in the audience asked a speaker, who was an FBI expert, to briefly consider the cost and effectiveness of various means of detecting explosives, and to recommend a solution to the problem. The FBI expert thought for a moment, then said: "Buy a dog."

Although the situation has improved since then, the degree of change is viewed differently by various interests within the aviation security community. The industry has greatly expanded the potential number of technologies that can sense explosives. But engineering these technologies into usable and cost-effective configurations is often difficult or impossible.

In November 1991, the U.S. Federal Aviation Administration (FAA) held a conference at its technical center in Atlantic City, N.J., to discuss explosives detection technologies. Listed in the program abstracts were 14 papers on nuclear techniques, at least 30 papers on vapor detection, 14 papers on combinations of X-ray and nuclear techniques, and nine papers on electromagnetic techniques.

Technologies described at the FAA conference included:

- Thermal neutron analysis (TNA)

- Advanced X-ray techniques
- Chemiluminescent detectors
- Mass spectrometry
- Gamma ray resonance absorption
- Pulsed fast neutron technology
- Biotechnological detection
- Millimeter wave radar
- Nitrogen ‘camera’
- Neutron elastic scatter
- Radio frequency quadrupole
- Proton accelerator
- Computerized tomography (CT)
- Numerous others, as well as variations on the above

After a look at this list, buying a dog may have its merits. But even the dog has some major drawbacks, although it continues to be a serious and valuable tool in the fight against terrorist bombs.

Which are the most promising technologies? Which can help us soonest? What are their benefits and drawbacks?

Statistics Play Vital Role

According to a report issued recently by the U.S. Congress’ Office of Technology Assessment (OTA), there is more to an explosives detection system than one might believe is necessary. There are statistical levels of performance that must be established and agreed by everyone involved. Statistics are necessary, for example, in deciding on what combination of detectors to use with a passenger flow rate for a given airport during a given period.

Statistics play an important role in the development and selection of explosives detection systems because of the huge numbers of passengers involved, the variability of system parameters and the catastrophic consequences that can occur when even a single bomb gets through a security screen without being detected.

An explosives detection system (EDS), as its name implies, is more than a single machine sitting at an airport. It is a system that must be integrated with other aspects of the overall air transportation environment, such as check-in facilities, conveyor belts, baggage-handling areas, other screening devices, and the physical layout of the airport area. It must be able to handle peak passenger flow without slowing the overall terminal operations and it must also be extremely reliable and consistent — one failure has a terrible price.

The detection probability and the false alarm rate (or false positive rate, as it is sometimes known) are the two key technical parameters of an EDS. The best detector is the one that has a detection rate of 100 percent, with a zero false alarm rate. But high detection sensitivity and low false alarm rates are not easily combined into a single system.

Research indicates that the FAA minimum threshold level for detection of explosives with the TNA machine is significantly higher than the amount of explosive required to destroy a modern airliner. Although much depends on where the bomb is located within the airframe, sudden overpressure from even a small bomb may be

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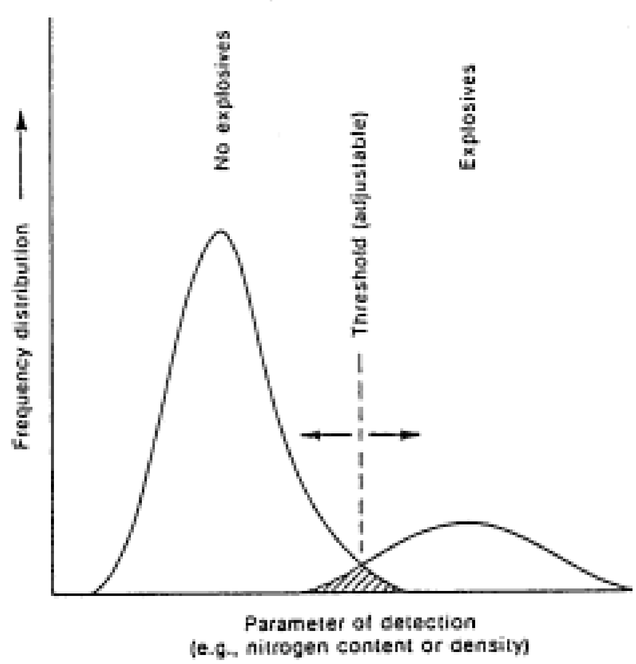
Generic Frequency Distributions of Detection and False Alarms



SOURCE: Office of Technology Assessment, 1991

Figure 1

enough to cause destruction of an aircraft.

Lowering the threshold to detect very small quantities of explosives also produces a higher false alarm rate. As illustrated in Figure 1, the curve on the left represents baggage that contains no explosive.

The curve on the right represents bags which a detection system would indicate contain a bomb. The smaller levels of explosive are at the left edge of the right-hand curve which overlaps the other curve where the bags contain no explosives. The cross-hatched area is where the machine would normally be at the limit of its ability to detect explosive and, therefore, might sound an alarm where there is actually no explosive. The threshold is adjustable — as it is on weapon detection magnetometers, X-ray machines and similar devices. As a result of setting high or low thresholds (moving the threshold left or right in Figure 1), some explosives would be undetected or a higher false alarm rate would have to be accepted, respectively.

The technique of profiling passengers in combination with X-ray inspection of carry-on bags yields better results than either technique alone.

Accepting higher false alarm rates may seem a trivial price to pay until one considers the number of passengers in a large airport during a combination of bad weather and peak travel periods. This is a scenario which severely taxes an airport's staff. A high false alarm rate is most burdensome with its increased requirement for hand-checking bags during increased traffic periods.

Even in optimum situations, a major expense in the operation of any airport or airline is the cost of staff. The more people required to hand-check baggage, the higher the cost of operation. Every organization attempts to minimize this. The desire of airport and airline managers to keep the threshold for explosives detection systems at the high end of acceptability is a consequence of economics. At the same time, security and government interests want to keep the threshold low to make sure that even a small bomb does not escape detection.

EDS design tries to keep the peaks of these two curves as far apart as possible, so that explosive-free bags are definitely identified and those with bombs are also definitely identified. The closer the peaks are, the "fuzzier" the distinction made by the EDS equipment, a situation that is generally unacceptable.

Several Systems Prove Best

One way to overcome the ambiguities of some systems is to use several different types of independent technologies in tandem. This approach uses the strong points of one system to offset the weaker points of another. TNA machines, for example, were supplemented by X-ray units that were deployed as the first level of the screening stage in field tests.

By using the more sophisticated (and usually more expensive and slower) technology as the second line of defense, and sending only suspect bags or containers to that machine, the advantages of both technologies can be realized and baggage inspection delays can be minimized. This also means fewer second-level machines are necessary.

Such a theoretical system might involve profiling, X-ray, vapor detection and a TNA or CT machine. Each system element has its own threshold of detection and false alarms, and when all the technologies are linked in tandem, the overall system rate is very high. The technique of profiling passengers in combination with X-ray inspection of carry-on bags yields better results than either technique alone.

The combined probability, OTA pointed out, is always smaller than individual values, and the report also warned that all such calculations were conducted under ideal conditions. "The true combined detection probabilities and false alarm rates can only be determined by measurements in an operational environment. Because of real interferants ... the combined probabilities will never be as good as the theoretical ideal," the OTA report cautioned.

It is essential that the two technologies be independent of each other in the system, OTA said, and two systems with individually high false alarm rates could be combined to yield an acceptably low rate. If each had a 20 percent false alarm rate, for example, their combination would have a false alarm rate of only four percent, or below the nominally acceptable maximum of five percent. This is the level specified by FAA for the EDS standard applied to the TNA unit.

The word "acceptable" in terms of detection capability and false alarm rates is not easy to define. Detection probability is a subjective life-and-death matter of acceptable risk, while false alarm rate, as noted earlier, is more an operational problem.

If in a single year 10 bombing attempts are aimed at the 40 million international passenger boardings, a detection rate of 0.90 would permit one dangerous situation (or possibly more) to go undetected, according to the OTA. If there was only one bombing attempt per year, that statistical level would allow one attempt to go undetected every 10 years.

Two questions must be asked. Would such levels of detection deter a terrorist group or individual, and would the flying public consider such levels to be safe?

Field Tests Create Surprises

When TNA machines were installed at several airports for field tests in 1990 and 1991, passenger bags were placed on a conveyor belt with an airline standard spacing of 36-inches (approximately one meter) center-to-center. With a belt speed of 30 feet per minute, this meant that the TNA would receive 10 bags per minute to screen. The process was actually much slower.

It was found that because the TNA unit uses a radioactive source, it has three doors which must close to prevent a radiation hazard to the public during the inspection scan. So the bags had to be spaced on the conveyor belt at a 52-inch to 60-inch (132-cm to 152-cm) center-to-center distance to allow the radiation-barrier doors to close. The change cut the throughput from 10 bags to six or seven bags per minute, which had major implications for airport traffic flow.

This is called operational experience and it supports the OTA statement that the effectiveness of a system can only be determined in an operational environment. One airport with a specific EDS configuration may have a specific throughput, while another airport with a different configuration could have a dramatically different situation.

However, if the slower machine is a second-level element, it probably will not be handling the volume of the first-level machine. Thus, speed is not a major obstacle and a slow, high-cost final-stage machine may be perfectly suitable for a specific situation.

Dogs Remain Key Assets

Dogs have made major contributions to the war against terrorism, and this contribution is most noteworthy in finding hidden explosives. "Despite the best efforts of many talented scientists and technicians, there is no machine that is as widely used and accepted as is the dog for the detection of explosives," the OTA report said.

But dogs also have disadvantages. They:

- are expensive because there are costs for acquisition, dog and handler training, salaries, veterinary services and other requirements;
- cannot operate alone;
- get bored;
- are dependent upon the judgement of their human handlers;
- have a limited attention span;
- cannot be worked non-stop as a piece of machinery;
- can be distracted by noise, lights, fatigue and scents;
- have personality quirks;
- may respond to the wrong stimulus;
- may defecate and urinate in public areas of airports;
- are unpredictable; and,
- their skills are unquantified.

By "unquantified" OTA asks, "How does a dog do what it does?" This may seem a frivolous question, but it is actually one that cannot be completely answered with today's knowledge. Yet, the dog is one of the best explosives detectors around — despite its disadvantages.

The advantages of dogs outweigh the disadvantages in many situations. Dogs:

- are effective;
- are more accurate, fast, sensitive, mobile, flexible and durable than machines;
- can often find TNT (trinitrotoluene), Semtex, PETN (pentaerythritol) and RDX (plastic explosive ingredient) when machines cannot;
- need no electricity or batteries;
- can go anywhere humans can go and operate under the same conditions, although performance degrades in high temperature and humidity;
- can be transported by car, truck, helicopter, airplane and boat;
- seldom break;
- have a service life of six to nine years and although expensive, are cost-effective;
- do not use penetrating radiation (therefore

warrants are not required for their searches); and,

- are socially acceptable.

However, dogs may also have idiosyncrasies that affect the consistency of their results. The U.S. Secret Service found that some of its dogs were indicating explosives where a certain kind of tape was used on presidential aircraft. Investigation determined that the tape had a cellulose nitrate base that emitted a smell similar to that of an explosive. Explosives technicians must therefore be careful when evaluating what a dog has sensed.

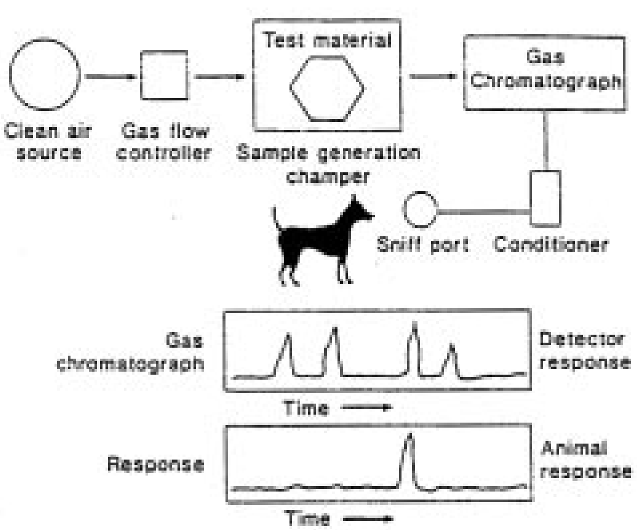
Dogs have been used in police and security work for decades. Their continued use indicates that dogs obviously have many attributes as explosives detectors.

The U.S. Secret Service has the largest single canine bomb detection squad in the United States, and its performance is mirrored in similar organizations in other nations, such as the Royal Ulster Constabulary, the Royal Canadian Mounted Police and others. (The Irish Republican Army is reported to have given up searching for a masking scent that will fool bomb-sniffing dogs.)

Studies Focus on Promising Technologies

Within 10 years, some scientists claim, there will be mechanical devices to rival the advantages of dogs.

Determining the Components of a Volatile Mixture to Which a Trained Dog Responds



Source: Institute for Biological Detection Systems, Auburn University, April 1990

Figure 2

One of the experimental programs now under way is an effort to discover how the dog senses smell. Figure 2 is a schematic illustration of how this critical parameter is being determined.

OTA comments on various non-canine technologies are noteworthy, especially considering that the office had the benefit of assessments conducted by many experts in the field. The following are some OTA comments on various technologies:

- Computerized tomography (CT) “may find its niche in the coming year”;

- X-ray technique for identifying bomb components (wires, batteries, detonators), aside from the explosive bulk itself, “may prove valuable, if its performance can be properly defined”;

- Pattern recognition in X-ray technologies “should be further evaluated”;

- TNA systems (advanced designs competing with the initial technology) “should be encouraged (and brought) to the test phase where their capabilities and performance can be assessed”;

- All the nuclear bulk detection methods depend upon development of an acceptable particle accelerator, and until this is developed, they are merely interesting ideas;

- Passenger profiling deserves increased attention and further development of this technique by skilled security officers “is desirable”;

- Passenger luggage-matching at the entry to the airport “is another need”;

- A totally integrated airport security system is also “of prime importance”; and,

- Aircraft hardening to withstand effects of bomb explosions is a “high priority area.”

The OTA envisions that high-technology explosives detection systems will begin having an impact on aviation security before the end of 1993.

But these, too, could soon become obsolete.

At the same FAA technical conference in 1991, where explosives detection was addressed, discussions were held among those who have contracts with various military and intelligence organizations to create materials needed for clandestine operations.

Their mission? To make an explosive that cannot be detected.◆

About The Author

Francis ("Frank") G. McGuire has been a journalist writing and editing almost exclusively about aviation, law enforcement and security for more than 30 years. He is founding editor & publisher of Security Intelligence Report, *a biweekly newsletter focused on worldwide ideological and political violence around the world.*

A past president of the Aviation/Space Writers Association (AWA), the award-winning writer has been an accredited correspondent to the U.S. Congress for more than a dozen years.

A revised edition of his standard reference work, Who's Who in Terrorism: A Security Intelligence Sourcebook, *was published in 1989 and included in-depth profiles of terrorist groups and their leaders. His 100-page report* Aviation Security — Strategies for the 1990s *was published in 1989 by McGraw-Hill Information Systems Division.*

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