EXPLOSIVES DETECTION

# Explosive Threats: Technologies and Techniques

## Past, Present, and Future in Explosive Detection

**The number of options available to terrorists is far greater today than ever before, but the most widely used, and therefore the most significant threat for Counter-Terrorism and security professionals worldwide, is exactly the same as it was centuries ago: explosives. The threat compounds and methods of delivery have evolved over time, as have the technology and techniques to detect them. In many respects, it is a high-tech game of cat and mouse.**

Insert swipe to start analysis.


Colourimetric response confirm explosives, minimising training burdens.


The XD-2i Explosives Trace Detector utilises analytical explosives detection chemistry to ensure reliable detection of 40+ explosives in 1 to 12 seconds. This is the first explosives detector capable of detecting trace or bulk explosives.

Explosives have been around for centuries: the Chinese, for example, used them in the form of black powder to make weapons which propelled arrows from bamboo tubes. Black powder is still in use today as a propellant in some firearms as well as in fireworks. The evolution of explosives has always been driven by need, technology, and serendipity. As an example of the latter, Christian Schonbein discovered guncotton, also known as nitrocellulose, as the result of an accidental explosion. Ascanio Sobrero created nitroglycerin (NG), the first liquid explosive. Alfred Nobel is the inventor of dynamite, a more stable formulation of nitroglycerin which is safer to handle and use a big step for both commercial and military applications. TriNitroToluene (TNT) has always been a widely used military explosive and is still found in combination with the "plastic" explosives RDX and PETN. Plastic explosives first found use with the military during World War II.

### The Situation Now

Let us fast forward to the world we presently live in. It is one of suicide bombers wearing vests, even shoes, which have been made into improvised explosive devices (IEDs). Do not forget car and truck bombs, and the classic pipe bomb. Today the threat list is much greater and varied than ever before. This is not limited to the type of explosives used but the manner in which they are delivered and deployed, as well. It is not too long ago that Nitrates, Peroxides, and myriad other homemade explosives were not even considered threats. However, recent events and the subsequent use or attempted uses of these kinds of explosives have had a great effect upon the development of explosives detection technology and overall security measures worldwide.

Explosive threats have most definitely evolved in size and in scope, and in response to these changes so have the techniques and technologies for their detection. One of the first explosive "detection systems" developed and still utilised today is the no-tech canine. Dogs, in conjunction with their handlers, have been trained and used by the military for years as a simple yet extremely effective explosives detection system. Some of the earliest technical detection systems were laboratory instruments modified to be used in a security environment. This trend is still present, with many new and novel technologies coming out of academic, industrial, and government labs. An explosives detection system is usually a bulk or trace detector. Bulk detectors detect bulk quantities of explosives while trace detectors are able to detect the invisible residues of explosives on vehicles, persons, packages, mail, baggage, and other items handled by a person who has been exposed to explosives. In general, most bulk detectors today screen cargo, and baggage. The most common use of trace detectors is in aviation security for carry-on bags, checked bags and cargo. Each technology has its place in an overall security plan and the effective design of a screening facility and checkpoint.

## Threats and Technology

One needs to balance the various threats in table 1 with numerous technology factors. These factors are comprised of, but not limited to, system effectiveness, cost, throughput, maintenance, size, complexity, cost of ownership, safety, privacy issues, public perception, and the ability to deal with new forms of threats. There exists no silver bullet. There is no perfect explosives detection system. Each detection system is a tool security professionals will find necessary to have in their toolbox. Having the right tool for the job it is expected to perform is extremely important. One size does not fit all. This is why a variety of technologies is the only way to establish an effective explosives detection programme which must also include appropriate screening policies, procedures, and checkpoint design. Detection programmes vary according to the mission. End users of explosives detection technologies need to identify explosive threats based upon available historic data as well as multiple sources of current intelligence. The most common approach includes manual searches, metal detectors, x-ray machines, Explosive Trace Detectors (ETDs), canines, and other technologies used in an overall security systems approach for explosives detection.

The above technologies range in price from under ten thousand to over one million dollars. The only detector that detects both trace and bulk explosives is still the canine. "Where is Rover when I need him to come over?"

Most security checkpoints incorporate a conventional x-ray system in which a human operator is essentially the explosives detector. There are also automated machines, which detect the presence of possible explosive material and display an image of the potential explosive to the operator. Presently the only technology to receive certification for the detection of explosives by the Transportation Security Administration (TSA) is Computer Tomography (CT), a system based on x-ray technology. It is important to keep in mind that at the present time, no systems detect other possible security threats such as guns, knives, and ammunition.

Today the most widely deployed trace detectors are Ion Mobility Spectrometry (IMS) based. Recently a new Surface Acoustic Wave (SAW) and Explosives Detection Chemistry (EDC) systems have appeared on the market. The SAW is small and easy to use and maintain. Explosives Detection Chemistry (EDC) quite possibly has the greatest potential due to its ability to detect a very long and impressive list of compounds. It is also easy to use, has high sensitivity, high reliability, and a very wide dynamic range. Its low instance of false alarms, extremely high probability of detection, modest price and low operating costs makes it one to keep a close eye on. There have been attempts to bring Mass Spectrometry (MS) out of the lab and into the field for security applications. MS holds great promise for a next generation system, but there are still challenges to overcome before it can be considered a reliable detection device.

Fluorescence systems are extremely sensitive to TNT and its derivatives, and this author is anxiously waiting to play with a new and improved device which claims to have the ability to detect other threat compounds as well. Chemiluminescence came out of the lab and into the field for a short time but has now been returned to the lab for further work. Electron Capture Detectors (ECD) emerged from the laboratory many years ago and into explosives detector portals but have a limited capability and future. Attempts have been made to employ other technologies such as Field Ion Spectrometers (FIS), Gas Chromatography (GC)/Mass Spectrometry and Thermo-Redox, but so far they have been limited in their capability and have not met with much commercial success.

The first round of nuclear techniques and technologies also did not fare well. Their performance was limited and in addition to high cost, public perception was not good. There are presently a number of novel nuclear systems being developed that may prove very capable as stand-alone systems or as part of an integrated solution. Both Microwave and Millimeter Wave portals for screening people are in the very early phases of testing, deployment and adoption into security operations. Research and Development to improve these technologies will continue well into the future. All of this technology is meaningless without sufficient training, maintenance, and proper use by security personnel. Human factors can either enhance or drastically reduce the effectiveness of any system and play a vital role in their success.

There are things that every person within an organisation needs to be aware of when designing a security checkpoint. The most important thing is confidence in the equipment, systems, and the Concept of Operation (ConOps) in place. ConOps are required and must be vigorously enforced. The best way to make certain that ConOps, policies, procedures, equipment, and security personnel are all working properly is to test the entire system. These "Red Team" exercises can be simple or complex. Depending on the situation you, your staff, or an outside contractor with training aids or real threats can conduct these exercises. Experience conducting "Red

**Table 1: Explosive Threats**

| Explosive | Commercial | Military | Homemade | Availability |
|---|---|---|---|---|
| Black Powder | Yes | No | Yes | High |
| Gun Powders | Yes | Yes | Yes | High |
| Nitrates | Yes | No | Yes | High |
| Peroxides | No | No | Yes | High |
| Azides | Yes | Yes | Yes | High |
| Fulminates | Yes | Yes | Yes | High |
| Chlorates | Yes | No | Yes | Moderate |
| Picrates | Yes | Yes | Yes | Moderate |
| Nitroglycerine | Yes | No | Yes | Moderate |
| TNT | Yes | Yes | Yes | Moderate |
| Nitromethane | Yes | No | Yes | Moderate |
| RDX | Yes | Yes | Yes | Low |
| PETN | Yes | Yes | Yes | Low |
| Tetryl | No | Yes | Yes | Low |
| Miscellaneous | Yes | Yes | Yes | Low |

**Table 2: Explosive Technologies**

| Technology | Bulk/Trace | Costs | Ease | Size | Speed | Privacy | Effectiveness |
|---|---|---|---|---|---|---|---|
| Canine | Both | High | Very | Small | Fast | ? | High |
| CT X-Ray | Bulk | High | Med | Large | Mod | No | High |
| Automated X-Ray | Bulk | High | Med | Large | Fast | No | Med |
| Conventional X-Ray | Bulk | Med | Med | S-L | Slow | No | Med |
| Explosives Detection Chemistry | Trace | Low | Very | Small | Fast | No | High |
| Chemiluminescence | Trace | High | Med | Med | Fast | No | Med |
| Fluorescence | Trace | Low | Very | Small | Fast | No | Med |
| IMS | Trace | Med | Med | Small | Fast | No | Med |
| Thermo-Redox | Trace | Low | Very | Small | Fast | No | Low |
| GC/SAW | Trace | Med | Med | Small | Fast | No | Med |
| SAW | Trace | L-M | Very | Small | Fast | No | Med |
| FIS | Trace | Low | Very | Small | Fast | No | Low |
| MS and GC/MS | Trace | L-H | Med | S-M | Fast | No | High |
| ECD | Trace | Med | Med | Large | Fast | No | Low |
| Nuclear | Bulk | High | Med | S-L | S-F | No | Med |
| Microwave | Bulk | Med | Med | L | Fast | No | Med |
| Millimeter Wave | Bulk | High | Med | L | Fast | ? | Med |

Team" exercises illustrates the point that the equipment is typically not the weak link. The unfortunate fact is that when a real threat actually presents itself, security personnel panic, and the ConOps which were so carefully crafted and meticulously taught go out the window, with the result that the entire security system breaks down. In other words, "Green Lights Don't Mean Good To Go!"

## A Look into the Future

What predictions can be made today with respect to explosives threats and technologies of the future? There will certainly be new types of explosives, both developed and improvised, which will be delivered in even more novel and ever-evolving ways. For every system and device we implement, the bad guys will find a way to deflect and evade detection, and the game of cat and mouse will escalate as they try to keep one step ahead by changing the type of explosives they use and the method in which they are delivered. On the technology side of the equation, there are many techniques in development at this time. Some are almost ready for field-testing while others are still years away. Future systems include the potential for standoff detection of explosives as well as the incorporation of multiple sensors in a "suite" of technologies and techniques which afford detection not only of the "E" in CBRNE, but all of the CBRNE components as well. Peering into the author's crystal ball, the future will see not only the screening of persons, vehicles, baggage, mail, and the like for explosives, but also the continuous monitoring of the environment where these systems are located for Chemical, Biological, Radiological, and Nuclear (CBRN) threats. All of this data will be transmitted back to a command and control centre via a wired or wireless network so that security personnel, law enforcement, and even first responders will have immediate access to information in case of an adverse event. More systems will be automated, which will reduce manpower requirements. Complex or multiple systems and/or applicable components of larger systems, will be customised and integrated into a total security solution package according to the specific needs of the end user. As the technology improves, a customised system will afford the user increased detection capabilities and higher probability of detection and lower false alarms. "False positives you can live with through good ConOps, but false negatives can kill you and others!"

It is an exciting time in the field of explosives detection and technology. We are increasing our ability to reliably detect the ever-increasing variety of explosives and in the not so distant future the technology will catch up with the need. Perfecting our ability to identify and deter the method of delivery will prove to be the bigger and more elusive challenge and one which we may never be able to fully solve.

**John Avolio**


### The Author

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