SEEING THE INVISIBLE

Advances in hardware, software and analytics have increased the speed, accuracy and cost-effectiveness of mass screening technology

Dr Arnab Basu *explains how radiation detection technology is keeping us safe from conventional and radiological weapons*

The power to see the invisible was once limited to the realms of mystics and weird fiction, but today it is a reality. The technology that allows us to see what is hidden gives us a powerful weapon in the fight against terrorism, allowing police, military and civilian security staff to identify and neutralise potential threats. These threats are continually evolving because terrorism takes many forms; from a lone wolf wielding a knife to a network of terrorist cells plotting a mass bombing, technology aids and complements intelligence gathering and intervention. The machines used to see the invisible now employed in the security world were often developed from science initially used in healthcare. Radiation detection technology has transformed healthcare and is doing the same for security, protecting the public against conventional weapons and radiological materials.

The roots of modern security scanning technology date back to the late 19th century, starting with Alexander Graham Bell's first crude metal detector using electromagnetic waves. Adopted for military and industrial purposes, the metal detector came into widespread use in the sixties and seventies, for security in airports and public buildings. Deployed as a hand-held unit or walk-through scanner, the metal detector remains the most commonly used security-screening device, but it can only detect metal. As threats evolved, new technology was required to supplement the humble metal detector.

> THE LATEST DEVICES ARE THE SIZE OF A PHONE AND CAN BE WORN BY LAW ENFORCEMENT OFFICERS

Like metal detectors, x-ray machines also have their roots in the late 19th and early 20th centuries thanks to scientists such as Wilhelm Roentgen who discovered x-rays and the pioneering work in radiation by Marie and Pierre Curie.

From the mid-seventies, they were deployed to protect borders by screening baggage at airports, initially under pressure from changes in the law in the US. The need for more security created a demand for progress in scanning technology, and the industry responded with advances in capability, usability and cost-effectiveness. In the case of air travel, a balance had to be struck between security screening and time. One of the drivers of growth is the push by transport regulators to minimise the inconvenience and cost of delays to passengers by adopting cutting-edge technology.

CHANGING FACE OF DETECTION

The fight against terrorism has involved security measures that cause inconvenience, such as the removal of coats, shoes and belts during security, and limits on the number of liquids that can be carried in hand luggage. Passengers will be familiar with the inline x-ray scanners used at airports to scan their hand luggage and understand that the limitations of the machines mean specific objects must be placed separately on a tray for examination. Such machines are now so commonly deployed at the entrances to public buildings such as courts, museums and entertainment venues that their use barely warrants a second glance. Unfortunately, as we now know, there are few events, no matter how innocent, that a fanatical terrorist will not consider a legitimate target. X-ray detection technology is also used at ports and border crossings, to prevent the smuggling of people and other contraband. Postal services use it too.

Checked-in baggage is also screened, but often by more sophisticated computed tomography (CT) scanners (still using x-rays) that were originally developed for medical use and can produce highly detailed 3D images.

The liquid explosives plot in 2006 drove the need for equipment to identify liquids. Kromek met this need with a unit that combined advanced x-ray detection technology and sophisticated algorithms to detect liquid explosives. Now deployed at 50 airports in 11 countries, it can tell the difference between benign and dangerous liquids without having to open a bottle.

Airports are increasingly putting in place full-body security scanners that can detect metal and non-metallic objects. One system uses 'backscatter' x-rays that emit a low dose of ionising radiation. Although there have been some concerns about potential health risks, the levels of radiation are much lower than normal background radiation, and any risk must be measured against the wider benefits from improved public safety. Another system is the millimetre wave scanner that does not use x-rays, but instead employs radio wave frequencies to detect concealed items and has been in use at airports since the turn of the millennium. One of the concerns about body scanners is that they create a 'virtual strip search' and potentially embarrassing images, but the industry has developed software that displays a generic outline.

INCREASING THE RESOLUTION

A major advance in security screening is the use of cadmium zinc telluride (CZT) as a semiconductor in x-ray or gamma-ray detectors instead of commonly used scintillator-based detectors. The advantage of CZT is that it offers a high resolution and can operate at room temperature, producing high-resolution, information-rich images, which enable superior performance and better detection of threats. This has made it highly desirable for use in medical equipment. It is now widely used in the early-stage diagnosis of osteoporosis and will also accurately detect other diseases such as cancer, cardiac conditions and Parkinson's, resulting in better patient outcomes and lowering the overall cost of care. The same desire for speed, accuracy and cost efficiency also applies to homeland security.

Police and security services not only have to be vigilant at all times for the possibility of a terror attack using conventional weapons, but there is also the threat from the use of radioactive materials mixed with explosives to create a so-called radiological dispersion device (RDD) or 'dirty bomb'. The US Nuclear Regulatory Commission has described dirty bombs as: "Weapons of mass disruption" rather than weapons of mass destruction. While they might not cause severe damage to

Picture credit: Laurence Sweeney Photography buildings or widespread loss of life, they could potentially contaminate an area for a very long time, leaving cities uninhabitable and those exposed to radiation at risk of serious illness. Worryingly, there have been disturbing cases of terrorists plotting such attacks, and as recently as 2016, police in Georgia broke up three separate groups of smugglers attempting to traffic nuclear materials – and there are likely other such attempts that we don't know about. It is possible that without the use of radiation detection technology, an RDD could be detonated without the victims or emergency services realising that radioactive material has been released into the environment until it is too late.

THE LIQUID EXPLOSIVES PLOT IN 2006 DROVE THE NEED FOR EQUIPMENT TO IDENTIFY LIQUIDS TOO

While there is no substitute for eagle-eyed policing, technology gives us the ability to monitor our cities, public spaces and transport networks for any evidence of increased radiation levels that might be linked to a terrorist attack. The types of detector currently employed for nuclear security purposes came from the civil nuclear industry and are physically bulky and can only be used by highly trained operatives, an example being large hand-held radiation isotope identification devices (RIIDs).

However, the use of better sensor components, powerful software, artificial intelligence and Big Data throws open the opportunity to build smaller RIID-like devices that can be used with minimal or no training, generating information automatically and sending it to a central computer for analysis by experts or AI.

This new generation of networked devices like Kromek's D3S wearable RIID feature a gamma neutron detector that is the size of a smartphone and can be worn by a law enforcement officer, fitted to a building or a drone. The D3S can be used as a standalone device (alerting the user to the presence of suspect material) or deployed in large numbers to create a network that can map a large area and feed information in real-time to a remote server. To prevent false alarms the D3S can distinguish between natural background radiation and the presence of radioactive materials used legitimately in medicine or those for which there is a more sinister purpose.

HELPING HAND

In 2016, the US Defense Advanced Research Projects Agency (DARPA) took delivery of 10,000 D3S detectors as part of its Sigma programme to develop a network of sensors. It has since been field tested in Washington DC, where they were used during President Trump's inauguration, and deployed by the New Jersey Port Authority. Authorities in Belgium also used them during President Trump's visits to Brussels in 2017 and 2018.

Although DARPA has made public announcements about its plans, the US is not the only country that needs these types of devices. This is not to be a replacement for the hard work done by law enforcement and security services, but it is important that we have all the tools available in the constant arms race against terrorists.

One of the exciting things about working in this industry is that the technology and the uses to which it can be applied are constantly evolving. Advances in hardware, software and analytics have increased the speed and accuracy – and cost-effectiveness – of mass screening services for millions of people, items of luggage and goods on the move every day. The result is to make our world safer ●

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The D3S wearable RIID can be used as a standalone device or as part of a network to monitor nuclear threats

Picture credit: Kromek