Brian O'Shea looks at the world of radiological detection in the fast lane

It's the physics, stupid

Commerce never sleeps. Ports, rail heads and motorways work on a 24-7, 365-day basis. We all need our strawberries, kumquats and orchids, and we need them NOW. This desire for speed of turnaround puts a great strain on all elements of the logistic chain. What can't be automated needs to be computerised, and the fat needs to be flayed from the bone until the leanest, most efficient system is left. Into this world comes CBRN detection – the world of false alarms and scientific certainty, all guaranteed to slow everything down, provide a chokepoint where there was none before, to wilt our orchids. Yet, if we are to believe the pundits, terrorism doesn't sleep either – they absolutely, positively have to get that dirty bomb there on time..

When it comes to CBR detection and mass transit – whether that is of goods or people –the only game in town is radiological. Chemical requires lengthy sampling and opening of containers, while bio... well, none of us would ever see an orchid if we wanted to subject commerce to biological detection. So in terms of providing an efficient, automated and capable detection system, it has to be rad. And, when we say radiological, we are only really talking about gamma. As the Litvinenko assassination proved, if you want to get alpha particles into the country there really is nothing stopping you. The chances of you bringing the free world to its knees are based around you getting enough of the stuff into the food system – it is not impossible, but it is easier to improve security at the comestible facilities than it is to try and laboriously scan every inch of every item of commerce.

Those who have never tried to detect alpha might not appreciate how difficult it is; by way of illustration, ideally the detector window needs to be held only a few milimetres off the surface you want to monitor. If you then accidentally make contact with the contaminated area, the detector surface needs to be wiped clean before you can get accurate results. Beta particles are better; you might be able to detect the source from a few centimetres away, but you still have to cover a large area with a small detector. Gamma detectors not only circumvent this problem, being able to pick out a nice, healthy gamma source at a useful distance, but there is also the advantage of gamma being externally (behind fissile) the more dangerous of the sources.

Yet radiation detection is an established art . While chemical and biological detectors and identifiers are forever flirting with new technology, radiological detectors are happily established – with the same technology being used now that was used 50 years ago. While solid-state detectors provided a fair improvement on its more elderly relatives, things have largely essentially remained the same. What has changed, and has proven to be a positive mid-life crisis, is the inclusion of better processing power into the detectors – so a lot of the information that was always there within the detector can now be brought to the operator's attention.

But many users of the new generation of radiological detection don't want to know – which is at least a novel problem. Historically the user worked in the nuclear power generation industry, and exact information and detail was their stock in trade. Now first responders, and port and customs officials, want to know whether there is a source that shouldn't be there – but it is less important to determine exactly what it is. Much of the detailed identification of radionuclides can come with more specialised equipment and users; for the person on the harbourside, the fact that there is something out of the ordinary is enough. The improvement in processing power has now managed to weed out a lot of the false alarms that first dogged radiological detectors in the counter-terrorist world – previously items like bananas, ceramics and granite would have provided nice fat peaks that would have had officials wondering about this yellow, crescent-shaped weapon of mass destruction. Now

Portal monitors need to be backed up by identifiers, they are not a solution in themselves ©CBRNe World

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detectors can distinguish their potassium 40 (that occurs naturally in bananas) from their caesium, ensuring smoothie production continues apace. Yet there are still some common sense lessons that need to be applied to ensure human error doesn't overcome mechanical accuracy. Water, for example, is an excellent shielding material, given enough of it. This means that, when the tide goes out, you get a peak in natural background radiation – something which has to be factored in before the big red button is pressed.

Shielding used to be the bugbear of detectors – and still is to a degree – yet detectors are now subtle enough to pick up the trail. Previously, before the Viagra of computing power entered the world of radiological detection, the method of detection was based on watching the count increase – which was a good way of detecting generic radionuclides. Now detectors have a spectral capability the spectrum can be analysed to allow you to make predictions as to what might be behind the shielding – by looking at the distribution of energies as a way of detecting the hidden source(s).

Yet there are fundamental laws of physics that will ensure radiological detectors seem stolid and dependable compared to their flighty biological and chemical cousins – size counts. The larger the detector, the more interaction it has and the more counts it then receives. The smaller the detector, the more likely it is that it will need to stare at a source/container for longer, and the more likely it is to generate a false alarm. Docks, however, have the advantage of size and, as more detectors have found their way into the hands of the user, so better places have been found to house them. The current favourite, and likely to remain so, is the gantry crane that lifts the containers from the ship. This allows them a fair amount of time in close proximity to the detector, and also frees the space envelope from needing to be mounted on a man or saloon vehicle chassis. The ultimate desire – and this is being examined fervently in the US – is to be able to detect the source before it even gets to the harbour – while it is still afloat.

This is likely to pose a major challenge, however. You could do it with UAVs, but this comes back to the issue of size – and many of the smaller UAVs will have a small space envelope to fit the detector; this brings back the problem of longer scanning times, meaning the system has to be able to hover and withstand the movement of the ship afloat when it does so. There have been systems that have attempted to do this from buoys or ships, but the level of signature needed to do this is such – and the containers are so numerous – that it becomes a retrograde step. Retrograde, that is, at the moment; one of the major research drives is for stand-off radiological detection. There are a variety of projects underway (see CBRNe World Winter 2006) for this, but the problem lies not only in the detector but also the platform.

Stand-off radiological detection is very difficult – on a par with stand-off bio (and we all know how well that is going) – yet there are some lab-based systems that are finding their way out into the field. One of these shows the problems inherent in doing these sorts of things afloat. The US' Technical Support Working Group (TSWG) had combined a stand-off radiological detector with an unmanned vehicle (a "robotic" boat), since they don't really want a paid individual sitting in a boat all day every day. Sadly the boat sank, for reasons unknown, and X thousand dollars worth of equipment sat on the bottom. This is offered purely as an example of the difficulties of having these sorts of systems afloat. When a UGV stops working it sits and waits for you to come and get it. When a UAV stops working you at least have the chance of easily salvaging the wreckage. But do you really want expensive laser systems out in all weather, being slopped around and perhaps becoming the next artificial reef?

In terms of being able to accurately screen individuals during transit, you are still rubbing up against the laws of physics. Detecting sources on humans is usually done via portal detection – a radionuclide detector in a doorframe – yet this requires the person to walk through slowly. This is fine for airports and government offices, yet poor for stadiums and large public events. However, there is a chance that people who have received diagnostic or theraputic treatment using iodine or technetium for example, will set the alarm off – thus tying up resources and slowing the process down.

To a certain extent this is going to have to be factored in, and false alarms managed rather than eradicated. Experts will always be required to bring in higher-end identifiers, like intrinsic germanium-based detectors, to confirm without a shadow of a doubt whether a source is suspicious; the challenge is not one of detection but of procedure to ensure this process is extracted from the rest of the chain – allowing the rest of the commerce process to go on unhindered. It is difficult to see any technology change in the short to medium-term that will make a major difference to the way we detect these radionuclides. Some elements of industry are starting to use gamma cameras, where they overlay video footage on top of detector readout but this is again only repackaging the information we already have in a new way rather than a new means of detection.

Stand-off detection will be something new, but it is hard to get excited about it. Chemical stand-off sort of works (Bruker's Rapid works well, while other stand-off detectors less so...); biological stand-off sort of doesn't work, as operational and technical challenges conspire to provide too high a challenge level; and radiological stand-off is less well researched and tested than either of them. There are many false dawns still to come. Still, QDR has made it a priority, so no doubt the good people at DARPA, DTRA and TSWG will receive increased funding to move it up the Technology Readiness Level ladder – the scientific shotgun approach.

Yet it is not all bad news. At least with radiological detection you are dealing with a finite number of sources – usually americium and caesium –meaning the detector can be finely tuned. This means stand-off systems might become highly attuned to these sources and leave the rest of the spectra to the detectors on the gantry crane. The better the capability can become attuned to the rhythms of commerce, the more effective a system it will be (early radiological portals that scanned trucks got accidentally wiped out by truckers who were concerned they were being irradiated!) and the safer we will all be.