In the first of a three-part expose, Pat Nelson discusses the changes needed in radiological detectors as they move from military to civil markets

From Hiroshima to Hoboken

The world's military organisations have long dominated the development and design of detection systems used to alert their troops to the malicious use of weapons of mass destruction, be they biological, chemical or radiological in nature. Current detection systems range from small badges worn by personnel that change colour in the presence of their target substrate (ie glorified pH detectors) to large, interconnected systems that monitor entire battlefield theatres to ensure troop forward movement and mission success. But now the threat of the intentional release of a WMD has moved from battlefields to boulevards, traditional detection methods are now being challenged by a whole new set of performance requirements that even the most tried and true technologies are having difficulty meeting.

In this three-part expose, we will examine traditional and innovative CBRN (and even take a peek at the 'e') detection methods as they have evolved from battlefield use to the routine screening and reactive activities of our civilian response units. We will begin with the maturation and adaptation of radiological/nuclear detection technologies into civilian use, and then move toward chemical detection and finally end with perhaps the most complicated civilian detection challenge – biological.

Civil defence forces are faced with a particularly difficult challenge when one considers that radiation and nuclear contamination do not produce a cloud of sweet-smelling vapour, or come concealed in a white powder wrapped up in an envelope. Yet many consider nuclear weapons as the greatest life threat of all the weapons of mass destruction. When the 20-kiloton (kT) nuclear bomb was dropped on Hiroshima, everything was destroyed out to a radius of 1.6km. In his book titled Flying Tigers, Daniel Ford estimates that, despite the "small" blast area, approximately 87,000 people died from the initial blast, 19,000 within the four months following, and another several thousand from various cancers caused by minimal exposure to the fallout. While these numbers may appear low at first, they are highly substantial when you consider the population of Hiroshima was estimated to be approximately 255,000. And this appears to be a conservative number. If employed, these weapons could cause mass casualties among the world's populace by cross contamination and minimal exposure of its large-scale infrastructure, and this damage could take weeks, months or years to fully come to fruition.

Have you got the X Factor? What do detectors need to transition from military to civil?
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Nuclear threats are by nature less worrisome to civil defence units – however great their destructive potential – than radiological threats, since nuclear materials are far more difficult to procure and terrorist cells are less likely to have the resources for the necessary engineering, construction, transportation and triggering technologies required. Although the effects of employing a radiological WMD apparatus are considered far less destructive than one constructed with nuclear materials, it is, however, a much simpler matter to construct a "dirty" bomb by pairing radioactive materials from sources such as medical or industrial facilities with an chemical explosive to create a dispersion mechanism. Cheaper and much more readily available, the radioactive material in a dirty bomb could extend several miles out from the initial blast zone depending upon the radioactive material used, wind conditions and the characteristics of the

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explosive used. Its effects would still be devastating and far-reaching. A recent report by the National Defense University states that, with the correct wind conditions, an explosion at the top of Manhattan Island would extend into the middle of Central Park (FAS, 2002).

When you look back at the detection technologies developed more than 50 years ago in response to the threat of the use of nuclear weapons during the Second World War, the laundry list of radiation detection instrumentation reads like a 1950s science fiction novel, with a myriad of terms some of which are immediately recognisable and others of which require a high level physics degree to decipher: photography, calorimetry, colour dosimetry, Geiger Mueller counters, ion chambers, electrometers, proportional counters, barium platinocyanide, radiophotoluminescent, thermoluminescent (and optically stimulated luminescent) dosimeters, photodiode arrays, direct ion storage, bubble and cloud chambers, electrets, scintillation counters, bubble dosimeters and the human senses. All these technologies were developed, with the exception of the human senses (and even that is arguable), with a two-fold military job requirement to: monitor and identify nuclear and radiological materials prior to an attack; and to measure the intensity and accumulation of radiation fields once the device has been employed.

Battlefield conditions were considered during the developmental stages of early radiation detectors, along with the assumption of the close proximity of the soldier to the contaminated area. This early, militaristic theorem of detection conditions does not work well for civil defence forces, and newer technologies are finally expanding detection capabilities to meet these diverse requirements. These innovative technologies and systems have been adapted to meet their widely varying application requirements – from the screening of cargo containers at various ports of entry to the needs of the first responder coming onto the scene of a radiological attack. Current detection technologies for civilian authorities must be highly versatile detection tools that can be used in a myriad of environs to detect, monitor and quantify exposure, and must have the ability to detect nuclear weapons and radioactive dispersion devices, as well as the materials required to construct them – and must be able to do so no matter how they are concealed or used.

Due to these widely diverse needs of the civilian units, new detectors often utilise a “system” of technologies wrapped up in a big grey box that communicates to other grey boxes, relaying information back to the user of another grey box in the command centre (please note here that the colour of these system boxes is very important in establishing the detector as a civil defence tool as opposed to a military device. This becomes ever more important for chemical detectors for civilian forces, which will be reviewed in the next article). If, for example, a dirty bomb is used in the downtown centre of a large city, civilian defence forces need to know, from both remote sensors and personal detectors, the type of radiation and the intensity or amount of the radiation remaining after the blast in order to alert local hospital and ambulance units of the possibility of cross-contamination from the transport of victims and from the walking wounded. That information would then be fed into a weather simulator to predict wind currents, so people downwind from the attack site(s) may be evacuated. It is a highly complex operation to contain the contamination, treat the wounded without cross-contaminating the ambulance services, predict wind patterns, evacuate as-yet unaffected citizens and all the while co-ordinate response units and collect evidence – all of which is highly dependent upon immediate and accurate detection.

All these scenarios for detection systems thus far have centred on a “blast” dispersing the radioactive material into the air. But what happens if non-explosive dispersion methods are employed? In a 2004 study, Zimmerman suggested that if a non-explosive radioactive weapon was used in the middle of a large city, it would take civil response units weeks before detecting the release and by then hundred of thousands of people would have been exposed and the economic costs would be in the billions. With the installation of new innovative radiation monitors, however, the death toll, and subsequent economic cost, would be averted.

Not only do current radiation detectors attempt to meet a wide range of criteria for civilian application needs, they must also have the ability to distinguish the nuclear material or weapon above natural background radiation. These configurations include determining the type of nuclear material present, the shielding used to encase it, the distance from the source and the background radiation. In addition, requirements in the field are different from static applications, and detection technologies are usually divided into two classes. The first class is sensor-type detectors that respond to and/or absorb radioactive emissions from its source. The second are image-based radiography systems using either X-ray or gamma ray technology. These are large systems that can examine the entire contents of sea container and land cargo containers.

These two classes of radiation detection often involve an engineering feat in design and optimisation, and generally with one application optimisation another is lost. It is a trade off of performance versus reliability versus total cost. Field detectors must factor in environment conditions, such as humidity and temperature, while also considering vibration and storage issues. Static detectors must emphasise user training, reliability, consumable costs and calibration. Logistics is always a concern for all applications, as is maintenance and costs.

Radiological detection on the battlefield appears a simple application when compared to civilian response requirements, and all the variables that must be addressed above and beyond simple detection that become part of a critical system. But of all the CBRN detection systems, radiation and nuclear detection systems have made the most strides towards providing solutions for our civil defence units.