Building a mobile radiation detector?
Dan Kaszeta offers some things to think about

DUI – Detecting Und Identifying!

There are many reasons why the security and antiterrorism specialists in the world may want to search a large area looking for a radiation source. An industrial radiation source may be stolen, a threatening message may be received claiming that a nuclear weapon has been placed in a city, or intelligence may give us dire warnings about dirty bombs. The smart response to such situations is to go out and have a look, but searching a large area is a complicated operation. And if the large area is a complex and urban environment, the problem is massive. One approach is to flood the city with lots of sensors. Giving radiation detection pagers to rank and file police officers for example is one approach; putting sophisticated sensors into place at critical facilities is another approach. But these tactics only provide a partial solution. There is a definite gap that can be filled by a mobile radiation detection system.

Using a vehicle platform gives you a lot of room for capabilities that you can't put into a handheld system. Since useful, passive "standoff" detection still eludes us, the types of equipment we would use in a vehicle are basically larger, amped up versions of handheld equipment. A radiation detector is a bit like a fishing net: the bigger the net and the finer the mesh, the greater the chance you have of catching the particles and rays that you want to catch. The average handheld radiation detector may be using a small, two-inch crystal of sodium iodide (NaI) or a 0.3-inch bit of cadmium-zinc-telluride (CZT). The size and weight available in even a small vehicle allows for a much larger array of equipment. You can have NaI crystals hundreds of times larger (You aren't going to get CZT hundreds of times larger any time soon, but that's another article), or you can use plastic scintillators and you can get them about as big as you want. A car or a van also allows the operator to cover an area much more quickly than someone on foot or a stationary sensor that has to wait for the radiation source to pass by.

Large detection systems are widely available in the form of portal sensors. The ports and borders interdiction mission requires very large arrays of radiation sensors to be able scan trucks, containers and rail cars. Experience has shown however, that you can't just stick a portal system on wheels and hope for the best. I started out in mobile detection by grabbing some gear and jumping in the car and driving around. I learned a lot of things by making some truly awful mistakes. This approach is not made better merely by using bigger tools. A good mobile radiation detector is more than a portal on roller skates. Most portals are used in controlled environments where the speed at which they work is controlled. For example, the port authority can ensure that trucks move at five miles per hour through a portal, if that's what you need to get the machine to work. Portals also sit in one spot and the background doesn't change very much. You can turn on the machine in the morning and collect a few minutes of background and things will probably turn out okay. Having a stable background is important for two reasons: first, you want to detect things that are not in the background; second, if you need to identify a source you want to subtract the spectra of the background out of the equation before you try to identify a threat, otherwise you get the dreaded 'isotope not on file' pop-up screen.

Driving around a modern city makes for an interesting radiation detection experience. We are bathed in natural background radiation from a variety of sources such as cosmic radiation and naturally occurring isotopes in the earth. Since we, as a species, like to dig up rocks and make buildings out of them, natural isotopes can be found in all kinds of building materials as well. A nice granite or marble façade to a building may include things like thorium or radium. Because gravel gets incorporated into paving materials and concrete even road surfaces are possibly a buffet of variable radiation sources. Unlike the traditional portal mission, where the background doesn't change all that much (the cosmic radiation still varies a bit), the minute you start driving around the background goes all over the place. It is not uncommon in major cities for gamma background radiation to vary by a factor of ten. I personally know of a few spots in some major US cities where the background varies forty-fold in a space of a few dozen meters. (Clearly, the old military rule about having a problem when you hit twice the background can't help us here.) Modern cities are also replete with legitimate sources of radioactivity for medical, scientific, and industrial purposes. A day's drive around town may have you detecting half a dozen different types of medical isotopes such as technetium for cardiac scans, fluorine 18 for PET scans, and iodine for thyroid procedures. These sources are often inside the body of the patient who may be walking, driving, or in a building – thus complicating the overall picture. There may even be industrial radiography occurring in the search area.

The way to manage this complex search problem requires a three-prong attack. You need a good operating concept (CONOPS), backed up with the right hardware and useful software. Failure in any of the three prongs means you've wasted time and money. First, let's look at the CONOPS. Above all else, you should always use count-rate as your measurement for search, not a dose-rate reading like mrem per hour. Most sensors are actually count-rate meters and they calculate an estimate of dose-rate. For reasons that I can't get into here, if you use dose-rate you are dumbing down your detector and you might miss something interesting. Save the dose-rate for health and safety monitoring.

The good news is that finding a dirty bomb is going to be relatively easy if it is just parked on the street or placed in a rucksack on a park bench. If a terrorist has assembled enough material to make a viable device, it is going to stand out like a sore thumb if you are using a large, sensitive detector, so much so that you should be able to detect it down the street. The problem will be finding lower-energy sources (like 'special nuclear material') or devices that are shielded by distance or intervening material: a device inside a heavy container inside a building, for example. We must assume terrorist are going to take precautions to hide their radioactive materials. One way to help this problem, while avoiding false alarms, is to map the background of the search area ahead of time. Then you can drive around searching not just for spikes in the count rate, but you can also look for differences from your mapped background. Of course, this means you have to actually map your background ahead of time, and this can be time-consuming and tedious. Based on my experiences in a few US cities, reckon on about 40 hours of work per square mile of city. This effort will pay off by greatly increasing your situational awareness. You will come across all the interesting radiation background in your area during your background collection effort. There's some tricks to doing this the right way, but I'm saving that for another day.

Vehicle borne radiation detection comes in all shapes and sizes ©CBRNe World

How do we build a system to live up to this CONOPS? The most important design consideration is to use the right tools for the right job. A mobile system needs good gamma counting, accurate isotope identification, and some way of detecting neutrons. There's no tool that will do all three jobs and do them all well. A dense brick of NaI is great for identification and it will work for detection, but good luck finding any NaI larger than a few house bricks. The secret to success is plastic: I found that using a massive plastic scintillator is better for the detection mission. Based on my own experience, NaI is less sensitive to some of the lower energy gamma rays than the less dense plastic. Remember also that bigger is better, and you can get a much larger detector for a fraction of the weight and cost. A larger detector will also let you detect while moving at a faster speed. Plastic won't identify isotopes, although you might be able to do some classification of high versus low-energy sources. It is also a smart allocation of resources. You will be detecting 100% of the time. The identification function is only a small fraction of your time, so use the big, cheap, efficient, effective tool as your workhorse and save the NaI for identification – it really works well. You can also splurge and use germanium. For neutron detection, a large Helium 3 tube is the state of the art, but it can be hard to get these days as there is a global shortage of He3.

The best hardware in the world will not provide good value if the operators can't use it efficiently and effectively. This is solved by software. Good software will do all of the heavy lifting and number crunching and feed the operators only the data they need to do their job. A useful user interface will be able to show the users the background radiation that they have mapped and highlight any differences. Isotope identification should be seamless and automatic. A library should tell the user what he needs to know about what he found out. I know that Selenium 75 is used for kidney scans, but I can't reasonably expect everyone else to remember that. I guess this a long-winded way of telling you not to spend all of your money on hardware and expect that it will all work out. The software affects the users the most and if the users think the system is a pain to use you will find it harder to mount an effective radiation search operation.

One last thing – have two operators. One to drive and one to detect. Don't drive and detect. Don't ask me how I know.