Dan Kaszeta offers his opinion of the value of CBRN detectors

How much value is that detector in the window?

I've been in the CBRNE business for twenty years now and I have spent altogether too much time on the subject of detectors and detection. One problem that I have come across time and time again is that many people, whether they are industry, end-users, scientists, procurement officials, or the ubiquitous 'experts,' often act as if detection and identification are an end unto themselves. The problem is somehow solved if we know what the problem is. As a recovering detector salesman myself and as a veteran of trade shows and exhibitions, I have seen detectors sold as the solution, not as a tool, and at times I too have been guilty of this sin. We all know that detection is but one discipline among many that are needed to resolve incidents, but how many times have we sent an entry team into the room or downrange onto the leaking tanker with a bag full of instruments, only to have them come back with ambiguous information that left us no closer to an answer to our problems?

It is important to remember that sensors, the term by which I will incorporate the whole sphere of detection, monitoring, and identification hardware, are only tools, and tools are only as good as the use to which they are put. Nobody in his or her right mind proposes that a screwdriver is ever the solution, only the route to a solution to a problem. Why should we treat CBRN sensors any differently, and more importantly, how do we select sensors correctly? How do we avoid a piss-poor solution to a real problem?

In any field of technology, mankind has access to a wide variety of tools, but since nobody has unlimited resources, it is necessary to make value judgments on which tools to buy. One could buy a twenty-pound sledgehammer to hang a few pictures on a wall, but we wouldn't do so because the sledgehammer is too heavy and too costly for the job that we want it to do, and CBRN sensors are much more complicated than hammers. We can't make easy value judgments while comparison-shopping for sensors – is a $100,000 sensor worth ten $10,000 sensors, or one hundred $1,000 sensors? The answer is that nobody knows; we just don't have the framework to do comparisons and we don't know how to apply simple principles of economics to the world of CBRN sensors. There's no '*Top Gear*' rating for detectors – you can't tell if you are getting value for money and there's no mile per gallon measurement that we can use. We can't measure value against price.

Let's try to dig into this. Sensors of any kind are really a form of information technology – they exist to provide information to the user, and they are only as good as the information they provide. The value of a detector, as opposed to its price, can only be determined by knowing the value of the information that it provides. The amount and value of information is notoriously hard to calculate because it is important to assess quality as well as quantity. A large amount of poor information has little value, and possibly negative value. I think that it's a bit foolhardy to try to directly measure the information coming from a detector, in fact, more is not always better. We need to find another way to calculate the value of a sensor by looking at the operational utility (i.e. the usefulness) of the information provided by a sensor.

Calculation by Subtraction: It's my opinion that the true operational value of a sensor can be inferred by subtraction. A specific operational scenario involving a sensor or sensors can be examined. We can take the sensor out of the equation and ask the responders what they would do differently in its absence. The difference in the responders' course of action is a measurement of the utility of the information provided by the sensor.

The PID / 4-Gas example: A simple example that we can examine is the photoionization detector (PID) and four-gas meter, now ubiquitous around the world in Hazmat teams and fire brigades. It is capable of providing cheap, quick, and intrinsically safe measurements of volatile organic chemicals, carbon monoxide, hydrogen sulfide, oxygen, and combustible gases. It is also relatively cheap and has become the default initial monitoring tool for thousands around the globe.

A simple PID / 4 gas meter scenario involves a fire brigade Hazmat team arriving at the scene of an industrial accident. Half a dozen employees have fled a room in the factory where a drum is leaking a liquid. The employees all have varying degrees of skin irritation and respiratory distress. There seems to be a high degree of confusion about what the chemical may be or how much may be leaking, as the facility uses literally hundreds of different products and the two workers who know for certain are in no condition to speak. The Hazmat team does an initial two-man entry in gas-tight (level A) PPE, carrying their PID and four gas meter. In this situation, they are immediately able to ascertain the presence of a high level of volatile organic chemicals, but a lack of combustible gases. This leads to the presumptive conclusion that the unknown chemical may very well be toxic and corrosive (this having been deduced by assessing the victims), but that no fire or explosion hazard was imminent. The Hazmat team can continue to operate in the room without fear of fire or explosion.

If we subtract the detector from the equation, we have a situation where the Hazmat team either has to be brave or paralyzed. Most modern Hazmat teams around the world operate under a health and safety regime that strictly proscribes the actions that the team can take in the absence of information. Structural firefighter's gear is normally considered inadequate for the presence of high concentrations of toxic and/or corrosive vapours, while gas-tight or splash-proof suits (US level A or level B) are clearly inadequate protection in the event of flame or explosion. Most Hazmat teams will only be able to make the quickest and bravest entry to have a quick peek at the problem, but some will not be able to do so, or a significant delay may occur. The value of the PID/four gas meter in this situation is clear. It allows for an initial entry to be made and it allows for informed decision-making by the local commander on how he can use his Hazmat team and what gear they need to wear. If rapid actions were needed to save life or prevent further damage to property, they could be accomplished in a relatively safe manner. The value of the instrument is clearly measureable in terms of responder safety and speed of response in this (admittedly) simplistic scenario.

Negative value: Of course, using this subtractive evaluation scheme, an instrument can have negative value. This phenomenon highlights one of the '800 pound gorillas in the room' in the detection world. Some sensors do not help a situation. Some instruments do more harm than good. I've personally been at training exercises and incident scenes where a detector has sown confusion, ambiguity, and delay. An example of this sort of scenario is the false positive or false identification. If a chemical warfare agent detector of some type is presented with a commercial or industrial chemical and alerts and identifies a military chemical warfare agent (mustard or sarin, for example), all kinds of bad things can happen. In one incident in the late 1990s in the Washington area, a military chemical detector was used at a suspicious liquid incident in the mailroom of a government building. It detected G-series nerve agents. The situation began to escalate, particularly as the responders reported this erroneous detector reading over radio nets.

The Biological Detection Scenario: A clear illustration of negative value is the 'white powder' anthrax scare, where a dodgy looking powder and a threatening letter, claiming that the powder is *bacillus anthracis* is posted to a government building. Panic ensues and the local Hazmat team or WMD task force is dispatched to the scene. Armed with the latest anti-body based hand-held assays and a very expensive DNA PCR detection device, they proceed to screen the powder for anthrax. Both of these technologies are quite useful for the detection of anthrax, however, they also pose great potential for providing ambiguity. Both antibody-based and PCR-based detectors are agent specific, limited to the number of assays that you have in inventory (dozens for antibody, typically five to six for PCR). More importantly, they cannot tell the difference between living or dead microbes. As anyone who has watched CSI in the last decade can tell you, dead things still have DNA. If the team tests for anthrax and gets a negative result, they cannot declare the powder to be safe. This is because they cannot rule out the presence of other bad substances outside the inventory of their antibody assays and PCR reagents. If the team gets a positive alert for anthrax, the situation could still be quite safe if that anthrax is dead. So, either way, the team has lost at least an hour and still has to send the powder to the lab, which is what we did in the old days without the detection equipment. In this situation, detection equipment has added ambiguity and uncertainty and delayed a resolution of the incident. If we take the detectors out of the scenario, the sample may get to the lab an hour sooner.

Synergistic value: The more I've thought about detectors and monitors using this subtractive scheme, the more I have come to notice that there are useful synergies to be had. By this I mean that there are many scenarios where the use of two or more different instrument gives you an amount of useful information greater than the sum of the individual instruments. The combinations and permutations grow immensely in complexity, so I think that it would be hard to carry this through to its logical connection in this article. However, I think that the important point is not to evaluate your equipment in a vacuum but to consider the reasonable mix of equipment you are likely to use together.

The Unidentified Liquid/Powder Scenario: Synergistic value is easily demonstrated in the characterization and identification of unknown liquids and powders. Twenty years ago, when I first got into this business, this was the 'holy grail' in the response business and mostly couldn't be done unless you got very lucky, picked the right Dräger tube by luck, or the leaking drum was correctly labelled. A well-equipped responder now has access to an alphabet soup of technologies (PID, FTIR, IMS, SAW, Raman, etc.), and can apply multiple detection approaches to a problem. For example, a response team arrives at the site of a transportation accident and numerous drums are loose on the motorway and are leaking. As is customary, there is uncertainty as to which drum is which or what is in them, as the driver is dead, unconscious, or has already been whisked to the hospital. This is good, honest Hazmat Technician work for an entry team, straight from the training course. The workhorses of such scenarios are Fourier Transform Infrared (FTIR) and Raman devices. Both technologies are capable of giving multiple answers to the same question. You are likely to get a list of ten possible matches. By overlapping the list of answers from FTIR and Raman devices, you can greatly increase the confidence in your answer, but please, use the FTIR first if you think it might be an explosive material! In this type of situation, I think that FTIR and Raman devices, if used together, have a greater value than the sum of their individual values.

Proper Employment: I think that it is very important that the benefit or value of a sensor is rather contingent on how it is used. Intelligent tactics, techniques and procedures can increase the value of an instrument, while poor working practices will subtract value. It is difficult to make a blanket comparison across agencies and response disciplines, though it is important to consider your employment tactics when you engage in this subtraction exercise. As an interesting corollary, a responder might want to consider modifying tactics, techniques, and procedures to get more useful information from the same instrument. This can be as simple as the old US Army CDTF trick of employing a bucket to concentrate the vapour from a low vapour-pressure substance (VX, in the case of the CDTF) to gather up enough vapour to do some useful detection.

Software and Models: As a matter of interest, this model works for other types of information tools that are used by the responder. I think that this can be most relevant in terms of software and plume models that responders might use to manage an incident. These are very much like sensors in that they provide information to support decisions. I was quite an infamous curmudgeon on the subject of plume models back in the day, but I still adhere to the belief that they often create more confusion rather than less. Subtract the plume model from a decision-making process, and probably half the people who use them aren't actually doing anything different, except maybe waiting for the plume model. This is a good subject for another day's discussion.

The moral of the story and the author's advice: The moral of the story is that you need to know what you are doing with the sensor before you buy it. A sensor is only going to give you useful answers if you have a practical understanding of what to do with the information it gives you. It is probably worth your time to sit down with your responders and work through a few scenarios, but beware of the detector that does more harm than good. Based on the many conversations I've had and the operations I've witnessed, I fear that the availability of sensors that promise a large amount of information may be leading some on-scene commanders down a wrong path. Waiting for perfect 'situational awareness' and the exact identification of the threat can mean delay, which can mean the problem gets worse rather than better.