

Dr Keith Ward, Chief of the R&D Section of the Chemical and Biological Division within the US DHS Science and Technology directorate, tells Gwyn Winfield about providing the next generation of chemical detectors

Casting a wide net



The DHS S&T is researching low vapour pressure chemical detectors – which will be invaluable in decontamination ©CBRNe World

GW: Many of the in-service detectors still rely on “old” technology such as IMS, raman or GC/MS, while other technologies – such as SAW – have failed to make good on their promise? What is behind this technological conservatism? Does it act as a brake on the sort of innovation that S&T is trying to provide?

KW: First I need to explain how our part of DHS, the S&T Directorate, which is responsible for doing the majority of R&D within DHS – is organised. There is the transition portfolio, a basic research portfolio and innovation. Most of our current funding is in the transition portfolio, comprising R&D that is aimed at providing new devices for our customers – in this case chemical detectors – in a 2-5 year timeframe. These are real detectors for real customers. Those projects are driven by customer needs; we have an elaborate procedure for identifying capability gaps and customer needs, so once we decide that our current chemical detectors are not up to snuff, and that we want to make one that can do better 48 months out, we use a process that ensures full and open competition for good new ideas. We publish broad agency announcements and encourage anyone with good technical approaches to submit proposals that are then reviewed by federal programme managers – not just within DHS, but from DoD and other federal agencies that have had a lot of experience managing projects in these areas. They review these proposals and a panel recommends a subset of

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these as being selectable for funding. A related process allows us to support some of those proposals, depending upon our budget for that year. This process drives the innovation that you asked about; there are a lot of things at the basic level that are not going to appear in detectors for 8-12 years, and those will be in our research portfolio but not in the real world detectors developed with our current transition funding.

Specifically, it is true that right now the detectors in use, and even that are under development, are using technologies like IMS – though they are pushing the IMS envelope and incorporating such things as differential IMS. There are deployed SAW detectors that suffer from the same deficiencies in terms of tending to false alarm more than we would like, as well as the problem of being confounded by interferent analytes. So developers have proposed various technology solutions to these deficiencies, and we have selected a few of these as we go through the process I described. Building real detectors from scratch and leveraging them as commercial-off-the-shelf (COTS) products within five years is a short time frame for innovation, so they can't be super innovative. In many programs we include a few new technologies along with improved technologies that are used in current DoD detectors to deliver a much-improved product to our DHS customers, while at the same time reducing the programmatic risks

We have a wide variety of customers, some of whom are similar to those of DoD, and some of whom are very different, so one of the challenges we have is starting programmes that are affordable, i.e., which have affordable R&D costs, and that in the end will provide a technology that as many of our customers as possible can use. The main technical drivers are to try and develop a single detector that can reliably detect conventional CWAs as well as a host of TICs, all using the same technology or set of technologies in a single instrument. The current DoD detectors don't do it nearly as well as our colleagues within DoD would like them to, so we are hoping a

number of maturing programmes will provide dramatic advantages, and they will bring to the fore improvements in conventional technology, as well as fine tuning detection algorithms to reduce the problems of false alarms.

GW: The difficulty would seem to be in setting the threat spectrum – it is very broad. That forces them down certain technological routes, such as GCMS, that have the ability to handle the bigger libraries but don't have that immediate point, shoot, answer capability...

KW: You have put your finger on one of the main challenges that we have at S&T, which is who our customers are. Many of the capabilities they would like to have that we could provide them with include fairly sophisticated and expensive technology. GCMS can do almost anything you want, even in terms of reducing false positives – or identifying analytes of interest in backgrounds of high interference, – but the limitations that almost all of our customers have are on the size and cost and the need to balance the two. Size, acquisition costs and operational affordability are the principal drivers for our customers, so we may have to give up some of the technology that we would prefer to use in order to meet those other criteria. Our challenge is to do that while at the same time producing a family of detectors that has much enhanced performance over our current detectors, and that is what our programme managers are working hard to do.

GW: Could we see a degree of modularity dependent on their role? So if they are police they get X plus Y, while Border would get X plus Z. It is the same fundamental technology, but with different mission related modules.

KW: That is a good idea and we have considered that approach... but it sounds easier than it is in practice. For chemical detection we would like to make a single detector that can be used by many customers in many scenarios. There are some customers who we are developing for that don't have such a wide list of threat agents, so we might develop some specific detectors just for them, but that is an unusual approach.

GW: Where is the division of labour with chemical detection between stand-off or point?

KW: The answer to that question is what the customers tell us they need. There are primarily two types of DHS customers. The first are people who work for other DHS components such as the Coastguard, Customs and Border Protection, FEMA, etc. We look at what they say they need, based on what they are currently doing, what they would like to do better, and what they can't do presently; generally it turns out they need better point detectors. Then there are those special customers who do have an interest in stand-off, but their interest is in stand-off primarily looking at chemical contamination on the surface at a distance of several metres, which is slightly different to stand-off requirements in the DoD. Generally we don't have new needs for stand-off in terms of detecting chemical clouds from some distance away, because our concepts of operation (con-ops) are different. The con-ops – the way in which different customers want to use the different detectors – is quite varied, so it is crucial that the programme managers who are developing new technology to deliver to the customers a couple of years hence know what those con-ops are. The decisions we make on the technology that we decide to fund – and the target goal of the research programme – is dependent on how the detectors will be used. It may be that the eventual customer doesn't need to know the exact identity of the agent, just that it is a nerve agent, while others might need to know the identity and yet others might like to know that but if having that capability is too expensive, then they could live without it. We are currently developing detectors in three major programmes: a handheld chemical detector; a new family of detectors that can be put in buildings and provide a rapid detect-to-warn capability; and a low vapour pressure chemical detector, that is primarily interested in detecting contamination on surfaces covered with chemical analytes with such low vapor pressures that conventional chemical detection methods are not applicable.

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GW: The threat and con-ops are not the only important factors; you also have to consider the existing assets, and your customer base has widely different assets. The Coastguard, for example, has fixed wing and rotary assets, as might the NYPD, but Arkansas PD might not. How do you plan with such a diverse range of standard equipment?

KW: That is one of the problems we face with our diverse customer set; not only do they have these different assets, but their budgets might also be quite different. Or they might not need chemical detectors and would rather spend their money on radios, for example. Most of our customers have budgets that stretch across the whole gamut – not just chemical detection. So first responders, for example, who are a large, diffuse customer set, need to decide each year whether they need to buy a new radio, or a new chemical detector or something else. What we offer them goes back to the fact that it needs to work better than what they currently have and is also affordable. Another important driver is that most of our customers want something that looks like something they already have, or they want it to fit into the same space in the back of their vehicle and have similar training requirements, etc. It is a challenge, particularly when we are looking at new technical approaches.

GW: Could the technology be incorporated into those other requirements such as police vehicles or radios? Integrate a chemical detector into their radios, for example, much like tele-dosimetry – you can then hand off data and or warnings to all essential parties...

KW: That is a concept we have considered quite a bit at S&T. There are programmes in the directorate, with the Innovation Division, that are aiming to take steps down that concept road and to think about what technology might be incorporated into existing devices such as cell phones or pre-existing detectors. So one of the things we are doing is beginning to understand how you would integrate detectors of various kinds. We have projects aimed at understanding how you would incorporate chemical,

biological and radiological detectors in an integrated system. In the perfect world that would be a box that could do it all, but early on it is more likely to be a set of boxes that can detect various threats, and the challenge is how to integrate the output of those boxes into a common operating picture so that the decision makers can make sense of and use all of those data inputs. So we have some programmes aimed at integration of CBR detectors, which is somewhat related to your question. As we begin to understand how to integrate new technology into an existing device, or to lash up a number of current detectors in a way that is more useful, details of what standard interface protocols are used becomes more important. So instead of using proprietary protocols we are using open architectures; the DoD has already done a lot of work on this and we are working very closely with them. In a few years we hope we will have a lot of these decisions made, so anyone who comes to the table with new technology will also have some guidance on how to make their systems compatible.

GW: Are we approaching the computing and technological stage where we can collect and analyse samples at the crime scene, but hand-off the data for identification in the lab? This would mean we need to divert attention to automatic sample collection and analysis, rather than detection and identification – that way we can continue to use existing technology for remote, no-notice detection.

KW: That concept is certainly being discussed, but it brings with it its own concept of operations problems. We are certainly interested in both biological and chemical sampling. We are engaged in an inter-agency consortium project that is addressing chemical sampling across the spectrum, so that when we do have the requirement to take environmental samples back to labs for analysis we use the same protocol in every lab. That is an interesting concept compared to what DoD has done in the past – many labs in the US make their living by doing chemical analysis, yet few of them have had the ability to analyse CWA samples because they have not had the protocols, they were not properly trained or they simply didn't want those



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compounds in their labs. There is a subset of labs that can do that, so one of our projects is making sure that set of labs is using a common set of operational protocols which the EPA has approved for analysing classical chemical warfare agents (CWA). It all sounds straightforward, and it is not very flashy from a technical standpoint, but it is a major problem and we have made a lot of important advances in this area.

GW: How much work are you doing on surface detection – ie the ability to quickly analyse at the scene how much agent is on a surface without it off-gassing or needing to take a sample and analyse it?

KW: That is a real problem – a major capability gap for some of our customers. If you need to know something rapidly about the presence of chemical substances on surfaces fairly soon you're in a world of hurt. Right now the best way to do it is to take samples and swabs, but once you have the swab you need labs qualified to analyze these samples. Then, even if you are using that technique, the most appropriate statistical measure is unclear. If you want to know whether a wall is contaminated, do you have to analyse every square inch, or can you only do half the table and have statistical confidence there is no contamination? All those issues are thorny ones that we are trying to address. We would love to have the technology that didn't require swabs samples – that would allow us to stand one metre off and scan, by some stand-off technique, and detect some appropriate level of chemical contamination. That is a long way off, but we have some programmes aimed at solving that problem.

GW: How much of chemical detection is filtering into explosive detection, and vice versa? There is a need for high fidelity explosive detection for scene assessment to find out what the purity of explosives is and how much are they likely to have made, etc. While they are different fields, it is all chemicals at the end of the day...

KW: That's right. I am a card-carrying chemist – as are many of the scientists and programme managers working in



DHS S&T is trying to get new technology into the hands of first responders as quickly as possible ©CBRNe World

this area. Some of them managed or worked in programmes in explosive detection before they joined DHS. Much of the technology designed for explosive detection can directly address some of our chemical detection requirements, particularly in the area of low vapour pressure detectors. So we work closely with another DHS S&T division – the Explosives Division. Programme managers (PM) from there work closely with our own chemical detection PMs. We help review each others' research proposals, and in some cases I think we might co-fund some projects that both the explosive and the chemical detection teams know will be useful to both.

GW: So what do you think will be the next breakthrough chemical detection technology? Either for the three chemical projects or generally... What is the rising star?

KW: I don't have one to give you! I don't want to prejudge what the breakthroughs might be. We let researchers and developers who come and brief us and who eventually may submit proposals to us, guide us in that direction. One of the gaps we do need to address is this issue of how to do very rapid detection of chemical analytes with low pressure on surfaces. There are no good, affordable ways of

doing that quickly now, so we are looking at a wide range of technological approaches. I will not know what that will be until we see some more data from current performers or published in the literature. There are some technologies that by their nature might be able to better address issues of false positives in the presence of interferants. Mass Spectrometry (MS) may be one of the approaches for getting around these issues. Mass spectrometers are currently too large, too delicate, too expensive and require too many ancillary items like vacuum pumps to meet many of our customer's needs. But a number of groups are looking at smaller, more affordable mass spectrometers. They are not quite at the stage where they meet our requirements, but every year they get closer and closer. For example, one of the problems with MS is the problem of getting a sample from ambient conditions into the MS, and there are a number of approaches that people are taking that are looking at ways to sample under one atmosphere of pressure. If breakthroughs can be made here, as well as smaller vacuum-generating pumps and getting size and cost down, then it would be marvellous. They are not there yet, but maybe will be with five years or so.

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