# Chemical and Biological Warfare Detector Technology

Future opponents of the United States and its allies will engage in asymmetric warfare including unconventional weapons and terrorist/guerrilla tactics. This premise would predict the use of chemical warfare agents (CWA) and biological warfare agents (BWA) on potential military and civilian targets. CWAs, often referred to as the "poor man's nuke," may become the weapons of choice in the terrorist's arsenal. Biological weapons may also enjoy increased application because of the public concern and inherent instability they initiate.

Both BWA and CWA detectors must provide early warning to allow rapid response to BWA/CWA releases. The ability of these detectors to be configured to also detect toxic industrial chemicals (TICs) and toxic industrial materials (TIMs) adds collateral usefulness.

Following the Gulf War of 1991, U.S. representatives found CWA weapons in forward deployed positions primed and ready for use. Instructions for application and appropriate protective equipment, as well as antidotes, were in place for the Iraqi army's use.

The U.N. special commission reported in 1998 that Iraq had 25 SCUD missile-mounted biological warheads, and Iraqi officials admitted to having: 19,000 liters of botulinum toxin, 8,500 liters of anthrax and 2,200 liters of aflatoxin. The major concern resulting from the Gulf War experience was that Allied Force detectors were unsatisfactory for several reasons:

(1) Chemical detector units produced too many false positive alarms.

(2) "Man-portable" equipment was too heavy and uncomfortable.

(3) No automatic detection capability existed for BWAs.

Vast improvements have been made since the Gulf War. In the Operation IRAQI FREEDOM effort, the standard man-portable chemical detector was the M22 Automatic Chemical Agent Detector Alarm (ACADA). More than 6,200 units of the M22 ACADA were deployed, and the U.S. Army's SBCCOM reported that not a single false positive was registered during Operation IRAQI FREEDOM.

The U.S. military deployed, for the first time, the Joint Biological Point Detection System (JBPDS). While not man-portable, this system did place a biological detection capability into the battlespace.

There are three major differences to address in the detection development effort:

(1) Significant differences between chemical detection technology and biological detection technology.

(2) Differences between the requirements of Department of Defense (DoD)-developed equipment systems and those of commercial off-the-shelf (COTS) systems.

(3) Differences between fixed-site systems and man-portable systems.

The key parameters for detection of both chemical and biological agents are sensitivity, selectivity, detection time and consumables required for detection. Sensitivity refers to the lowest concentration of agent the device can detect. Because CWAs and TICs are not as lethal as biological agents, chemical detectors do not have to be as sensitive as biological detectors. Biological detectors must be significantly more sensitive for detection of the more virulent biological agents that might be used by an adversary. Selectivity refers to the ability of a detector to discriminate between a real event and the environmental background. The background for chemical detection is relatively simple, while the biological background is extremely complex. Because of this, chemical detectors do not require the high degree of selectivity that biological detectors require. The time to detection for chemical agents must be rapid because chemicals, such as nerve agents or pulmonary agents (chlorine), cause immediate effects. Biological agents, excluding toxins, operate much more slowly, and therefore it is not a strict requirement that biological detectors provide real-time or near-real-time response.

To limit the cost of detection by shortening the logistical tail of a detector, the goal for both chemical and biological detection technologies is to minimize consumables. Many chemical detectors meet this requirement using only power to detect and identify a CWA or TIC. Biological detectors lag far behind, requiring single-use reagent consumables for successful detection.

Three different types of chemical detection technologies are common. Ion mobility spectrometry (IMS) is a technology that can differentiate between various chemical vapors based on the time needed for the individual molecules to drift down a gas-filled tube. The

advantage of IMS systems is that they are generally small, can operate on batteries, exhibit sensitivities at or below levels that are immediately dangerous to life and health (IDLH) for most chemicals and exhibit relatively good selectivity. Gas chromatography-mass spectrometry (GC-MS) generally exhibits the best sensitivity and selectivity of all the detection technologies. In this technology, the GC separates and purifies each component, and then the purified components are injected into the MS portion for identification. GC-MS provides the greatest degree of sensitivity and selectivity of all analytical devices. However, the GC part requires an oven for the chromatographic column, and the MS part requires operation in a hard vacuum. These requirements pose a significant challenge to making a handheld GC-MS. Surface acoustic wave devices are a third type of detection technology. These devices utilize multiple piezoelectric crystals, each coated with different polymeric thin films that have different affinities for different classes of chemical vapors. The piezoelectric crystal's vibration frequency changes as vapor is absorbed by the polymeric film. By monitoring different types of polymeric films, each with a different affinity for a particular class of vapor, the vapor can be identified. Surface acoustic wave devices can be very small and readily man-portable. They do not generally exhibit the sensitivity or selectivity of other detectors.

There are several proven technologies for bio-detection. Real-time polymerase chain reaction (PCR) detectors amplify small amounts of DNA so they can be detected and identified by conventional techniques. PCR technology requires: a heat source that can be cycled; special reagents that are specific for the biological agent; and a method to detect the amplified DNA. Another means to detect BWAs is through immunochromatographic techniques. In this technology, antibodies sensitive to a particular biological agent are immobilized onto a strip of porous paper. Placement of a solution containing the biological agent onto the strip causes the formation of a visible band or color change, much the same way commercial home pregnancy kits work. The drawback to immunochromatographic techniques is the requirement for a specific antibody for each BWA. One final technology, optical waveguide immunochemistry, uses antibodies immobilized onto an optical fiber for detection of BWAs. This technique also requires a different set of antibodies for each BWA targeted.

DoD-developed systems have a focus of battlespace application with operation by a warfighter in that battlespace. Commercial systems intended for infrastructure protection or environmental compliance drive different operational requirements and use in a public environment. For example, a cloud or plume of bio-particles in a battlespace is assumed to be made up of released BWAs, allowing several steps of assay to be assumed. A similar bio-particle plume on the mall in Washington, D.C., on April 2 of any year has a high probability of being made up of cherry blossom pollen, thus requiring more in-depth assay. The warfighter may have limited space and weight transport capabilities, thus limiting the number of single-use reagent consumables, while the first responder or environmental compliance inspector may have considerably more available space for consumable storage.

The final challenge in both areas is the availability of the "science" needed to be engineered into deployable products in either the DoD or commercial arenas.

The ease of development of some CWAs, along with the worldwide availability of CWAs and BWAs, make concerns regarding attacks on the United States and its allies very real. Globally, there are continued occurrences of accidental chemical spills and releases—in many cases in un-regulated environments. Both military and public safety concerns will continue to provide the impetus for developing new or more enhanced detection capabilities for CWAs, TICs, TIMs and BWAs.

Detector technology advances will force the need to test detection system performance in operationally realistic environments, as well as to evaluate the performance not only in terms of the key parameters, but also in terms of reliability, sustainability and operability by deployed troops and first responders. ❑

*This article was contributed by Senior Research Scientists Dr. Ken Ewing and Greg Sanford, and Research Scientist Charlotte Lattin, from the Battelle Eastern Science and Technology Center, Aberdeen, Maryland. Dr. Ewing and Lattin conduct infrastructure protection analyses for Battelle; and Sanford is the lead of Battelle's BEST Center Design and Development team, which develops systems and products for infrastructure protection and Department of Defense military products.*

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